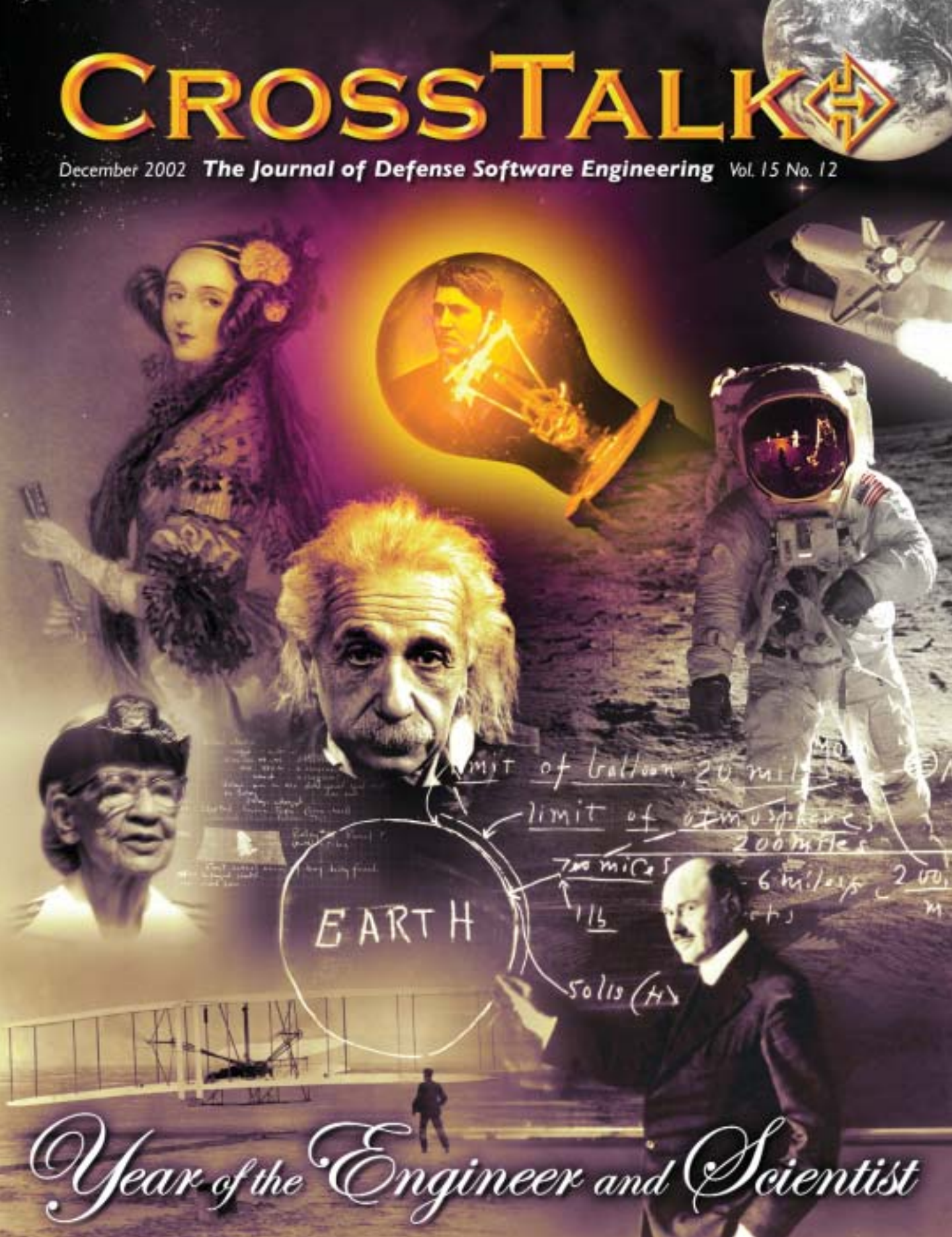


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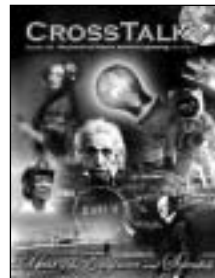
December 2002 **The Journal of Defense Software Engineering** Vol. 15 No. 12



*Year of the Engineer and Scientist*

## Year of the Engineer and Scientist

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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.



## Both Sides of the Fence



After graduating from college, I took a job with a major defense contractor working on a variety of defense software projects that ranged from aircraft modeling and simulation to laser communications research and analysis. After eight enjoyable years, my husband was faced with a job change that meant moving to another part of the country. I found myself searching for a new employer.

The biggest employer in our new location was the Department of the Air Force, and sure enough they were hiring engineers. With my résumé in the Air Force's personnel system I was asking myself, "How can I give up the green grass of the contractor side of the fence and work for the U.S. government?" The Air Force made me an offer worth considering: They matched my salary, paid for my move, and placed me in a high-maturity software development organization. Not such a bad deal and definitely worth a try.

I am happy to say that I recently celebrated my 10-year anniversary of working as a civilian engineer for the Department of the Air Force. Yes, it's a different side of the fence that has many stereotypes, but the change has offered me fun and challenging work. And currently, it is very rewarding to be in my *CrossTalk* position that is committed to helping the Department of Defense and industry understand and overcome software engineering challenges on both sides of the fence.

Today's scientific and engineering professionals make job changes much more frequently than was typical 10 to 20 years ago. Why? Many make the change to obtain a higher salary, gain a higher-ranking position, or fulfill a need to try something different. Due to this trend of career hopping, it is extremely challenging for any employer to keep its workforce happy. I believe this is even more of a challenge for the U.S. Air Force and government at large.

Because of the current and future expected shortage of engineers and scientists in the Air Force, Gen. Lester L. Lyles, commander of the Air Force Materiel Command (AFMC), declared 2002 as the Year of the Engineer and Scientist, or YES. Because of the importance of this initiative, we chose YES as the theme of this month's issue and begin with *Command Leaders Say YES to Engineers, Scientists* by Tech. Sgt. Carl Norman. In this article, Lyles and James A. Papa, AFMC Engineering and Technical Management director, comment on the YES initiative and how it's helping to focus the Air Force's attention on workforce training and development, workforce size and mix, and motivation.

This article is followed by Leif E. Peterson, AFMC's chief of Civilian Personnel and Programs Division, discussing the criticality of the scientific and engineering workforce along with staffing level predictions and initiatives such as phased retirement.

Besides the Air Force, the Army is also recognizing the importance of its engineers and scientists. In *Army Transformation: Uniformed Army Scientists and Engineers*, Lt. Col. Barry L. Shoop and Lt. Col. Kenneth L. Alford discuss a new officer career path. By creating a new functional area, the Army will support a core population of scientists and engineers who has been educated in applied physical sciences and who has advanced degrees in disciplines such as aeronautical engineering, computer science, electrical engineering, physics, and many more. Although we did not receive the Navy's or the Marine Corps' perspective on our theme topic, we are interested in learning of any similar initiatives in these services.

In addition to our YES section of articles, we have a great set of supporting articles this month. I offer a special thanks to these contributing authors: Jeffrey L. Dutton, Maj. Brian G. Hermann, Dr. Richard C. Shirkey, Melanie Gouveia, Grady Booch, and David B. Putman. Also, since we are wrapping up another calendar year at *CrossTalk*, we provide you with our 2002 Article Index. If there is an article that peaks your interest, don't forget to look it up on our Web site <[www.stsc.hill.af.mil](http://www.stsc.hill.af.mil)>.

You can form your own opinion about government vs. commercial employment. As for me, I really do enjoy working as a civilian engineer for the Department of the Air Force. I am also pleased with the current recognition of the Air Force's engineering and scientific workforce along with their increasing importance to our nation's security. If you do find yourself considering a job change, don't hesitate to look into a position in the Air Force or other services. You might find that the grass *is* just as green on the other side of the fence.

Tracy L. Stauder  
Publisher



# Command Leaders Say YES to Engineers, Scientists

Tech. Sgt. Carl Norman  
Air Force Materiel Command

*Today, scientifically developed precision-guided weapons and unmanned aerial vehicles help fight terrorism around the globe. However, Air Force leaders are battling a shortage of the very engineers and scientists who created this weaponry.*

The United States Air Force (USAF) is authorized to employ 13,300 military and civilian engineers and scientists. However, the service is short about 2,700 positions, or about 20 percent, according to Scott McLennan, Air Force Materiel Command (AFMC) system integration engineer. That is, if the USAF only had to fill current vacancies.

Another problem is also looming, says Gen. Lester Lyles, AFMC commander. A decade of downsizing and hiring freezes has made almost 70 percent of its civilian workforce, including engineers and scientists, eligible for retirement in the next five to seven years. This particularly concerns the AFMC because it employs the lion's share of Air Force engineers and scientists.

James Papa, AFMC Engineering and Technical Management director, reiterates this concern: "If we do nothing, we're going to see the whole problem aggravated by a continuing exodus of our senior people, and no seed corn to bring in behind them."

Another hurdle that AFMC and Air Force officials have to clear is competition for retaining engineers and scientists due to their demand in the outside commercial sector, says Papa. The nation as a whole has experienced lower and lower numbers of engineers coming out of colleges so engineers and scientists are becoming very valuable commodities, he says. "As a nation, we're going to be constantly fighting over a limited resource. In the case of the Air Force, we're going to be in the middle of that battle for talent."

If these trends are left unchecked, says Lyles, it could pose a possible readiness problem for AFMC and the Air Force. Losing its homegrown scientific and engineering capabilities could force the world's most prominent air power to contract out some of those needs, he warns.

"In AFMC, our mission is to provide the tools for the warfighter," says Lyles. "If we're not able to meet and understand the needs of the warfighter with our own organic capabilities, we're not going to be

as well off as we need to be. If we have to contract it out, I think we're going to lose. Whether it's in terms of dollars or the linkage to the warfighters and the rest of the Air Force, I think we will definitely lose."

Papa agrees, saying, "We're going to be taking on more and more risk of our development programs failing without proper oversight from our own organic workforce. We're going to be increasing the cost of doing business in some cases by having to contract out some of our engineering support. If we don't maintain

## The Solution

To help bring the situation to the forefront of the Air Force's, the command leaders', and everyone else's minds, and to find solutions, Lyles declared 2002 as the "Year of the Engineer and Scientist" – more commonly known by the acronym YES.

The hope is that this initiative will remind everyone that engineers and scientists take concepts and ideas borne in laboratories and turn them into active and working weapon systems, Papa says. "Then they'll sustain those systems on

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*"In AFMC [Air Force Materiel Command], our mission is to provide the tools for the warfighter. If we're not able to meet and understand the needs of the warfighter with our own organic capabilities, we're not going to be as well off as we need to be."*

— Gen. Lester L. Lyles, AFMC commander

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our own organic capability to oversee the people we're asking to build our systems, we lose the expertise to define what our systems ought to be, and to make sure they're done properly. Then we'll wind up with systems that don't meet cost or schedule or have performance problems.

"It's through the scientist and engineer corps that we sustain what's very important – technological dominance on the battlefield," Papa says. "It goes beyond just producing state-of-the-art systems. We need to have a robust engineer and scientist corps to be on the leading edge and stay ahead of our adversaries."

Papa says that if the shortage goes unchecked, it could pose a readiness issue of sorts for America's warfighters. "With current vacancies and a large number of retirements in the next half decade potentially deteriorating the weapons acquisition and oversight process, we're not at the point we'd like to be, and that could ripple out to the field."

through aging and retirement." Part of AFMC's YES initiative is designed to focus the Air Force's attention at all levels of the problem. Command officials are aiming at the following three main engineering and scientific recruiting areas: workforce training and development, workforce size and mix, and motivation, according to Papa. "We're currently working initiatives and legislation in all these areas," he says. "It's just going to take some time to get what we need in place, and up and running."

For people considering engineering and scientific work for the Air Force, Papa says there are a lot of opportunities available. People in these fields are involved in leading edge activity and get increased responsibility sooner in their careers, he says. They also get involved in some very exciting things and contribute to the country's strength, well-being, and military power.

"We're never going to offer the kinds of opportunities like stock options and

gigantic six-figure salaries that maybe young people feel they can have in the dot-com world and other higher risk businesses," Papa says. "But there are a large number of folks who find working for the Air Force a rewarding career, and they are the kind of folks we're looking for."

Workforce training and development has a three-pronged approach to mapping out the engineers' and scientists' career path, says Papa. They look at what kinds of experience engineers and scientists should have in their career; what kind of training they should have, and when they should have it; along with what kind of career paths and promotion potential they should have.

"If there are any obstacles to engineers and scientists advancing in those career paths, we need to find ways to solve those," he says. The AFMC initiatives to attack those obstacles include increased educational opportunities and improvements in career development for military engineering officers, and making sure there is consistency in what is expected of them in terms of time spent getting education for promotion, he says.

The motivation area deals with making sure engineers and scientists are recognized for their accomplishments and provided fair compensation, Papa says. "We've looked at market comparisons and what engineers in industry are receiving in terms of starting salaries and middle salaries, and there's a gap there," he says. "We're trying to work the funding process with the air staff in building initiatives for recruiting and retention bonuses and salary adjustments that would make things more in line with the market we are competing in for engineers and scientists." Workforce size and mix involves having a good handle on what the command and Air Force requirements are for engineers and scientists.

### Conclusion

While the AFMC is eleven months into the Year of the Engineer and Scientist, Papa says it is still too early to tell what impact the initiative has had on the problem. "It takes a while to understand whether we've turned anything around. But we're anticipating that by next year we'll be able to have a way to look back and see if anything has improved," he says.

To make sure enough emphasis is placed on the problem and that solutions are reached, Lyles says AFMC's Year of the Engineer and Scientist will continue into 2003. ♦

## About the Interviewees



**Gen. Lester L. Lyles** is commander, Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. The command conducts research, development, test and evaluation, and provides acquisition management services and logistics support necessary to keep Air Force weapons systems ready for war. Previously he served in various assignments, including vice chief of staff at Headquarters U.S. Air Force, director of the Ballistic Missile Defense Organization, commander of the Space and Missile Systems Center at Los Angeles Air Force Base, and commander of Ogden Air Logistics Center, Hill Air Force Base, Utah. Lyles has a master's of science degree in mechanical and nuclear engineering, Air Force Institute of Technology Program, New Mexico State University, Las Cruces; and a bachelor's of science degree in mechanical engineering, Howard University, Washington, D.C. He also graduated from the Defense Systems Management College, Fort Belvoir, Va.; the Armed Forces Staff College, Norfolk, Va.; the National War College, Fort Lesley J. McNair, Washington, D.C.; and the National and International Security Management Course, Harvard University, Cambridge, Mass.



**James A. Papa**, a member of the Senior Executive Service, is the director of Engineering and Technical Management, Headquarters Air Force Materiel Command (AFMC), Wright-Patterson Air Force Base, Ohio. He is directly responsible to the AFMC commander for the effectiveness of systems engineering and manufacturing policies and processes throughout the command. Papa is also responsible for career development programs for members of the AFMC engineering and technical management community. Papa has an extensive background in systems engineering and flight test. He served four years as U.S. Air Force flight test engineer. As a civil servant, he has worked as a project engineer on numerous aircraft and held key test and evaluation management positions. Prior to his current position, he was the executive director for the Air Force Flight Test Center, Edwards Air Force Base, Calif. He is a charter member of the Society of Flight Test Engineers and a member of the International Test and Evaluation Association. Papa has master's of science degrees in aeronautical engineering from the University of Southern California, and in management from the Sloan School of Management, Massachusetts Institute of Technology.

## About the Author



**Tech. Sgt. Carl Norman** is the news service editor for the Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. He provides headquarters and base-level news and newspaper advice to editors at the command's 10 bases across the United States. Previously, he was the non-commissioned officer in charge of public affairs at Arnold Engineering Development Center, Arnold Air Force Base, Tenn. He has also served as editor of the *Tailwind* at Travis Air Force Base, Calif.; the *Airlifter* at Dover Air Force Base, Del.; and the *Tip of the Sword* at Incirlik Air Base, Turkey. Norman is a distinguished graduate of the Noncommissioned Officer Preparatory School and a graduate of the Noncommissioned Officer Academy at Tyndall Air Force Base, Fla. He has attended the Defense Information School's basic journalist, editor, and joint public affairs supervisor courses. He has won several writing and editing awards along with other public affairs-related awards during his career.

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# Air Force Materiel Command Engineers and Scientists

Leif E. Peterson  
Air Force Materiel Command

*Senior leadership within the Air Force Materiel Command (AFMC) as well as the Air Force has emphasized initiatives to recruit, retain, and develop highly skilled and knowledgeable engineers and scientists capable of meeting the challenges of the 21st century. The AFMC, which employs about 70 percent of the total Air Force engineering occupation, is committed to pursuing every avenue available to ensure that it acts on all the appropriate initiatives to take care of this critical part of our workforce.*

One of the Air Force Materiel Command's (AFMC) key objectives is to continue its crucial leadership role in technology. The AFMC is a champion for science and technology, becoming the advocate and ally for leveraging new technologies. Its science and engineering (S&E) workforce is having a tremendous impact on everything it does in the Air Force, both what is currently in the hands of our warfighters and what will be fielded in the future. It is these talented individuals who will enable continuing world-class technology dominance.

Unfortunately, the extensive downsizing the AFMC experienced during the past 11 years has severely weakened the health of the civilian force and challenges its ability to meet future mission challenges. To meet the needs of an increasingly technical aerospace mission, we need to balance the mix of junior, mid-level, and senior civilians in the proper engineering skills. In order to achieve this goal, this command is faced with multiple challenges in recruitment and retention of highly skilled engineers.

Within the AFMC, there are approximately 10,580 S&E positions, which make up about 70 percent of the total Air Force S&E population<sup>1</sup>. The AFMC's S&E workforce is 82 percent civilian and 18 percent military. While its current civilian manning seems to be healthy, it must take a long, hard look at the future.

By 2007, 51 percent of the AFMC's S&E workforce will be eligible for retirement. While not all will retire, historical trends indicate that approximately 20 percent of those eligible to retire will do so the year they become eligible. In addition, the AFMC is competing with the private sector, which entices both potential recruits as well as its existing workforce with financial and quality-of-life incentives. The AFMC is projecting that it will need to hire approximately 3,300 civilian engineers and scientists in the next few years to help fill real and potential gaps.

In an effort to prevent a potential crisis, the AFMC has engaged in a robust recruitment and retention effort. Its initial

approach to the problem will emphasize recruitment and retention bonuses, and explore the possibility of increases in special salary rates for S&Es. Other financial appeals may include paying off student loans and covering the costs for further education. Non-pay issues include a command-wide recruitment program that entails establishing a public Web site that would be a one-stop shopping concept, which would link all of our centers' recruitment efforts to one site. We have also launched a standard entrance and exit survey. These survey tools will capture both the organization's health and shortcomings in its recruiting and retention effectiveness.

In addition, the Air Force is looking to place more emphasis on the civilian workforce through a marketing plan that would create a *total-force* inclusive marketing program. This program would include using a civilian element in the Air Force's marketing efforts aimed at fostering a sense of mission and purpose in all Air Force personnel.

Furthermore, there are several things the AFMC is attempting to put in place to transfer individuals' corporate knowledge prior to them retiring. First, we are aggressively pursuing legislation to introduce *phased retirement* to the workforce. Phased retirement would allow individuals to retire and then come back to work on a part-time schedule to help develop new recruits. Currently, such individuals are penalized since their salary is offset by their annuity. This means it is unattractive for senior executives who may want to work fewer hours to consider returning to the federal government. There is also a provision for gaining a waiver to this requirement. It now requires Office of Personnel Management approval; we are hopeful the waiver approval level will be lowered to the components.

While we are making positive steps toward changes in legislation and policy, these initiatives are currently in the discussion stage and at the present time, no decision has been made to implement any of these ideas. In addition, we are also encouraging our organizations to establish or expand the existing mentoring program to

place new recruits with someone who can foster their knowledge, skills, and abilities.

Senior leaders within the AFMC, as well as the Air Force, have emphasized initiatives to "recruit, retain, and develop highly skilled and knowledgeable technical professionals." Within the AFMC, we are pursuing every avenue available to ensure we are taking on all the appropriate initiatives to take care of this critical part of our workforce. ♦

## Note

1. Demographic data used in this article are drawn from the Headquarters Air Force file and the Air Force Materiel Command, "AFMC's Scientists & Engineers," *Leading Edge* Oct. 2001.

## About the Author



**Leif E. Peterson** is director, Civilian Personnel and Programs Division at Headquarters Air Force Materiel Command Wright-Patterson Air Force Base, Ohio. He previously served as chief of Staffing, Development, and Equal Employment Opportunity Division at the Pentagon in Washington D.C., and as director of Civilian Personnel at Air Combat Command, Langley Air Force Base, Virginia. His awards include two decorations for exceptional civilian service, one meritorious civilian service award, and selection into the Defense Leadership and Management Program. Peterson has a master's degree from Loyola University, Chicago.

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# Army Transformation: Uniformed Army Scientists and Engineers

Lt. Col. Barry L. Shoop and Lt. Col. Kenneth L. Alford  
*U.S. Army*

*The Chief of Staff of the Army General Eric K. Shinseki recently approved in principle the creation of the Uniformed Army Scientist and Engineer (UAS&E) officer functional area. This article discusses the background, implications, and advantages associated with this new officer career path. The UAS&E functional area will provide the Army with a core population of officers who possess specialized expertise to help the Army make informed decisions and integrate technology to improve our ability to defend the nation.*

**“**The nation that will insist on drawing a broad line of demarcation between its fighting man and the thinking man is liable to have its fighting done by fools and its thinking done by cowards.”  
— Sir William Francis Butler

We live in a society immersed in and dependent on technological innovation. The U.S. Army represents a microcosm of this society and has been and continues to be one of the largest users of widely diverse and advanced technology within the armed forces of the United States. The Army is currently undertaking sweeping changes in its force structure, transforming into a more strategically responsive, full-spectrum force that is a lighter, more lethal, and network-centric force that achieves these increased capabilities by leveraging advanced technology innovation.

This Army transformation is heavily invested in technology to lighten the force while increasing the lethality and survivability necessary for full-spectrum dominance. The general categories of technological innovations that are being leveraged include computers, communications, network technologies for the network-centric component, advanced and distributed sensors to provide improved multi-spectral sensing capabilities, composite materials that reduce the overall weight while maintaining or improving the capabilities of the protective armor, electric and hybrid power systems for propulsion and weapons, and many others.

As an institution, the Army needs a cadre of experts in science and technology to fully optimize the capabilities of the force and to understand the potential of future technologies.

The Army's new Officer Personnel Management System (OPMS III, formerly referred to as OPMS XXI) provides the mechanism to allow specialization within career fields. OPMS III has been implemented recently and is in marked

contrast to the way the Army has historically managed officer specialization and career progression. Officers can specialize in Army operations, operational support, information operations, and institutional support. OPMS III provides the mechanism for a viable officer technical career progression.

Gen. Paul Kern, commanding general of the Army Materiel Command, has been instrumental in the creation of a viable career track for uniformed Army engineers and scientists. As he recently

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*“There is a tremendous capability when you have the operational experience of an officer and the technical training that allows a person to see what is in the future.”*

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noted, “There is a tremendous capability when you have the operational experience of an officer and the technical training that allows a person to see what is in the future” [1].

To be successful, the Army transformation requires a corresponding change in the Army officer personnel system that includes a core population of officers who focus on the science and technology that shapes the modern battlefield and the Army force structure. The recently approved in principle, Uniformed Army Scientist and Engineer (UAS&E) functional area will provide a dedicated cadre of experts to support the Army's scientific and engineering needs for the present transformation and future technological evolutions and transformations.

To accomplish the required transformation in the officer corps, the Army has created this new functional area to support a core population of Army engineers and scientists educated in the applied physical sciences. This functional area will include officers with advanced degrees in numerous scientific and engineering disciplines, including but not limited to the following:

- Aeronautical Engineering.
- Applied Mathematics.
- Biochemistry.
- Chemistry.
- Computer Science.
- Electrical Engineering.
- Mechanical Engineering.
- Physics.

This functional area will require approximately 100 officers from the grade of major (O-4) through colonel (O-6) who possess master's of science and doctorate degrees in these and other selected science and engineering disciplines. These officers will provide a core population of officers to serve as engineers and scientists in Army and Department of Defense (DoD) laboratories; the new Research, Development, and Engineering (RDE) Command; the Army staff and joint staff; and in key advisory positions throughout the Army and DoD.

Sample UAS&E duty positions include scientists, engineers, program managers, and advisors within the new RDE Command, Training, and Doctrine Command Battle Labs; Department of the Army and joint staff positions; and program managers at the Defense Advanced Research Projects Agency.

The UAS&E will provide a dedicated cadre of experts to support the Army's scientific and engineering needs. UAS&E officers will possess the field experience necessary to understand the unique environment, operational characteristics, and the technological needs of the Army.

UAS&E officers will possess advanced academic credentials and will

have developed expertise through progressive science and engineering assignments and will be qualified to contribute to science and technology research, advice, and policy development. Functional area designation and career field designation for the UAS&E functional area will be the same as those currently used for the Army Acquisition Corps and Foreign Area Officer functional areas within the Army's operations support career field.

### Historical Background

The idea that the application of the military instrument of power in the conduct of war rests in a body of knowledge that could be studied and mastered by those in the profession of arms is a relatively recent concept.

During the 16th century, the officers who led armies into battle did not receive any special training or education in warfighting. Instead, they received their commissions as a result of aristocracy, heredity, or wealth. At the turn of the

17th century, advances in technology first changed the military's requirements for specialized education. Navigation, artillery, fortifications, and engineering [2] were all subjects first studied by officers in order to become more effective leaders in the military profession.

It can be argued that officer education is, in fact, the cornerstone of the arms profession. It is the responsibility of the military to continually develop and integrate new and improved methods of warfare as a way of achieving superior means to conduct and win wars. To be effective in the process of adapting and adopting new technologies, however, requires military leaders who are imaginative and innovative. Education enables informed and creative leadership.

Officer education has long been a focus of both individuals and study groups. The first-prize papers awarded for contributions to the "Proceedings of the U.S. Naval Institute" in 1879, for example, were on the subject of officer education [3].

In 1996, an Army Science Board study titled "The Science and Engineering Requirements for Military Officers and Civilian Personnel in the High Tech Army of Today and Tomorrow" focused on the need for increased officer technical competency. This study concluded the following:

... the Army's reliance on modern weapon systems and technology has been growing, its cadre of technology-literate line officers and science, math, and engineering (SM&E)-educated officers has been reduced. [4]

Additional background information on this topic [5] is available in the sidebar that accompanies this article.

In the current and future military environment, there exists a changed relationship between officers and technology. Firepower and maneuverability previously defined the realm of officer competencies. The American way of war and the relationship between systems engaged in warfare on the modern battlefield has fundamentally changed as a result of modern technology.

### Scientific Competency

Modern technological marvels provide instant access to work, family, and resources almost anywhere in the world, and have fundamentally changed how people interact. Yet never before have we become so distant from, and at the same time ignorant of, the fundamental science that enables this technology. Technical illiteracy is an epidemic that plagues modern society.

Today, individuals can rely upon engineers and scientists to provide more capable innovations. Within the armed forces, the tactics and doctrines to employ these technologically advanced weapon systems are developed by the military themselves. A lack of understanding of science and technology is an inconvenience for civilians, but it can be fatal on the battlefield.

It is neither practical nor desirable that every officer in the armed forces attempt to understand all of the science and technology that supports our modern military. The UAS&E functional area will provide the Army with a small group of officers who possess the specialized technical skills and understanding necessary to help the armed forces make informed decisions and integrate technology to improve our ability to defend the nation.

Table 1: Typical UAS&E 30-Year Career Progression

Uniformed Army Scientist and Engineer Career Progression	
Years of Service	Duty Assignment
0	<ul style="list-style-type: none"> <li>Commissioned as a second lieutenant.</li> <li>Attends the Infantry Officer Basic Course.</li> </ul>
1-3	<ul style="list-style-type: none"> <li>Promoted to first lieutenant.</li> <li>Serves as a platoon leader.</li> <li>Promoted to captain.</li> </ul>
4	<ul style="list-style-type: none"> <li>Attends the Infantry Captains Career Course.</li> </ul>
4-7	<ul style="list-style-type: none"> <li>Serves as a company commander and possibly in a staff position.</li> </ul>
7	<ul style="list-style-type: none"> <li>Accessed into the Uniformed Army Scientist and Engineer (UAS&amp;E) functional area.</li> </ul>
7-9	<ul style="list-style-type: none"> <li>Attends advanced civil schooling and earns a master's of science degree in mechanical engineering.</li> </ul>
9-10	<ul style="list-style-type: none"> <li>Completes the Command and General Staff Officer Course (either in residence or by correspondence).</li> </ul>
10-13	<ul style="list-style-type: none"> <li>Serves in a UAS&amp;E branch-qualifying duty position (for example, as a research scientist or instructor at the United States Military Academy).</li> <li>Promoted to major.</li> </ul>
13-16	<ul style="list-style-type: none"> <li>Attends advanced civil schooling and earns a doctorate in mechanical engineering.</li> </ul>
16-19	<ul style="list-style-type: none"> <li>Serves in a UAS&amp;E duty position (for example, as a technical advisor in the Mounted Maneuver BattleSpace Lab within the Training and Doctrine Command).</li> <li>Promoted to lieutenant colonel.</li> </ul>
19-22	<ul style="list-style-type: none"> <li>Serves in a UAS&amp;E duty position (for example, as a deputy director in the Research, Development, and Engineering Command).</li> </ul>
22	<ul style="list-style-type: none"> <li>Attends Senior Service College.</li> <li>Promoted to colonel.</li> </ul>
23-30	<ul style="list-style-type: none"> <li>Serves in senior UAS&amp;E duty positions (for example, as a science advisor to the commander, Southcom or as an Army or Defense Science Board member).</li> </ul>



## UAS&E Career Progression

As currently envisioned, the UAS&E functional area will access Army officers into the functional area at about their seventh year of active-duty service. UAS&E officers will be assessed into their functional area at the same time as their non-UAS&E peers.

To better envision the UAS&E functional area career progression, let us consider the career of a hypothetical officer, John Smith, who is commissioned as a second lieutenant in the infantry following the completion of his undergraduate degree in mechanical engineering. Table 1 follows his career from the time he enters active duty as a second lieutenant until he retires as a colonel 30 years later.

The UAS&E career field will provide promotion opportunities through the rank of colonel and will help improve the Army's return on investment from the time and resources dedicated to providing officers with advanced civil schooling.

## Advantages

The Army can achieve the following benefits from creating and supporting the UAS&E functional area:

- By supporting a core group of technically and tactically proficient officers, the Army can better ensure that the maximum advantage is gained from new systems and equipment.
- UAS&E can help the transformed force achieve its full potential through the correct employment of advanced warfighting systems and technologies.
- By providing science advisors to senior-level commanders, UAS&E officers can help reduce resistance to change and help decision-makers understand the benefits of properly applied technologies.
- It provides excellent incentives for recruiting and retaining science and engineering professionals.
- It provides the Army with a set of honest brokers.
- It can help change the Army's general perceptions of technically oriented service.

## Summary

"If you don't like change, you're going to like irrelevance even less" [6].

— Gen. Eric K. Shinseki  
Army Chief of Staff

The Army has recognized the need to develop and support a cadre of uniformed experts in specialized scientific and technological fields in order to help transform itself. The UAS&E functional

## The Quest for Uniformed Army Scientists

The following is a historical outline of the quest for uniformed army scientists:

- **1802** – President Thomas Jefferson signed legislation authorizing the creation of the United States Military Academy at West Point, N.Y. West Point was the first engineering school in the United States.
- **19th Century** – Most large engineering projects completed within the United States (including railroads, bridges, harbors, dams, and roads) benefited from the direct participation of West Point graduates.
- **1925** – The Army sent Jimmy Doolittle to the Massachusetts Institute of Technology to earn a doctorate in aeronautical engineering.
- **World War II** – Numerous scientists in uniform served the nation and the Army. For example, Lt. Goldstine, who held a doctorate in mathematics, encouraged the Ballistic Research Lab to work on a *digital* electronic computing device.
- **1947** – Maj. Gen. Henry S. Aurand, director of Research and Development, general staff at the War Department, tried to create a corps of scientist-officers.
- **1982** – The Army Science Board found that 40 percent of the officers working in research, development, and acquisition positions for the Army had no schooling in science, engineering, or business. They encouraged the creation of the Army's Technology Enhancement Program (TEP).
- **1984** – Lt. Gen. Maxwell Thurman, Army deputy chief of staff for Personnel, directed the initiation of the TEP. Initial entry second lieutenants were sent to earn master's of science degrees. Mid-career majors were sent to earn their doctorates in science and engineering fields.
- **1985** – Brig. Gen. Hines, the deputy commanding general of the Army Personnel Command, created a new officer branch to manage officers in the TEP – the Science & Technology Corps.
- **1990** – Gen. William Tuttle, commanding general of the Army Materiel Command (AMC), offered 140 AMC positions for a Uniformed Army Scientist Program. The Defense Acquisition Workforce Improvement Act was signed into law.
- **1991** – Gen. Gordon Sullivan, Army vice chief of staff, directed a Red Team Analysis of the uniformed army scientist question.
- **1992** – Lt. Gen. Thomas Carney, deputy chief of staff for Personnel, approved the Army Engineer and Scientist (AES) program. The post-Cold War Army drawdown tabled implementation of this program.
- **1998-2001** – Various Army organizations studied the feasibility of creating a Uniformed Army Scientist and Engineer functional area for officers.
- **2001** – Gen. Paul Kern reintroduced the concept of a uniformed Army scientist program.
- **2002** – Gen. Eric K. Shinseki, Army chief of staff, approved in principle a request from Gen. Paul Kern, commanding general of the Army Materiel Command, to create the Uniformed Army Scientist and Engineer (UAS&E) functional area.

area will help meet that need by developing future leaders for Army and DoD research and development organizations who understand soldiers, future technologies, and warfighting.

This small investment in officer personnel within the Army will return large dividends in the future through the effective and efficient application of science and technology to the ever-changing art of war. ♦

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## WEB SITES

### Air Force Institute of Technology

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<http://www.eis.army.mil>

The United States Army Program Executive Office Enterprise Information Systems sponsors a quarterly newsletter called *The Enterprise*. This newsletter contains the latest information direct from project and product managers offices about their successes and forecasts. Their main goal is to provide a venue for communicating essential program information geared mainly for program and project managers. Specialized links for Army, Information Systems, and Infrastructure include the following: the Army Long-Distance Learning Program; Information Management and Telecommunications, which has a current focus on the Pentagon renovation; the Research, Development, Acquisition

and Sustainment Information Activity, which provides information management policy, guidance, custom software applications and services; Defense Communications and Army Transmission Systems; and Defense Communications and Army Switched Systems. These links are all centered on providing troops deployed around the world instantaneous access to sustaining base information.

### National Science Foundation

<http://www.nsf.gov/>

The National Science Foundation is an independent agency of the U.S. government. The foundation consists of the National Science Board of 24 part-time members and a director, each appointed by the president with the advice and consent of the U.S. Senate. Other senior officials include a deputy director who is appointed by the president with the advice and consent of the U.S. Senate and eight assistant directors.

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<http://www.swe.org/>

The Society of Women Engineers (SWE) is a nonprofit educational service organization dedicated to making known the need for women engineers and encouraging young women to consider an engineering education. The SWE stimulates women to achieve full potential in careers as engineers and leaders, expands the image of the engineering profession as a positive force in the quality of life, and demonstrates the value of diversity.

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# A CMMI Case Study: Process Engineering vs. Culture and Leadership

Jeffrey L. Dutton  
Jacobs Sverdrup

*The success of a Capability Maturity Model® Integration<sup>SM</sup> (CMMI<sup>SM</sup>) process improvement effort does not just depend on an understanding of the CMMI, a careful definition of the standard process, innovation in process engineering, a reasoned selection of cost effective engineering technologies, or even a focused and fully responsive training program. Success depends on the core culture of the company, and on the courage and ability of its leaders. The CMMI requires that real people in management, engineering, and infrastructure adopt new behaviors and beliefs. In this environment, two lessons have emerged: Core culture is a principal factor in achieving success, and "change leadership" is as important as "change management."*

The subject organization used in this article<sup>1</sup>, Jacobs Sverdrup's Advanced Systems Group<sup>2</sup>, may be a lot like yours: It employs about 400 people throughout seven states and provides a wide range of engineering services and products to all four military services and to NASA.

Each office has its own field office manager, representing an important operational layer between the senior manager and projects. As a group, services and products are delivered in several technical domains, from office and weapons system software to hardware development and validation of major weapons simulations.

Each of seven major field offices differs from the other in terms of customer culture, and all projects differ in size, complexity, and duration. Forty-person, three-year projects exist alongside two-person, 12-month efforts. Since the Capability Maturity Model® (CMM®) Integration<sup>SM</sup> (CMMI<sup>SM</sup>) adoption effort had to be accomplished with bottom-line dollars (from profit), the pressure to invest resources wisely and carefully was intense from the start.

The improvement effort began by chartering a software engineering process group (SEPG) in February 1999. The decision was made to adopt the CMMI for Software Engineering (CMMI-SW) as the reference model (then published as Version 0.1), as opposed to the CMM. What was the rationale for this decision? Since the organization had yet to adopt any type of process model, it seemed to make little sense to adopt an older model, and then have to upgrade to the newer standard almost immediately.

Because the organization was geographically distributed, the new SEPG went about forming and training distributed Process Action Teams (PAT) to begin the task of adopting the process areas within the CMMI. The idea was that a distributed development of the standard process would make a buy-in much easier.

Each PAT was made up of personnel from at least two of the seven major offices. All of the PATs then met with the SEPG lead as the organizational SEPG on a quarterly basis. It was supported by a Web site that provided workspaces for each PAT, information and references concerning the overall effort, and a viable means of communicating among the PATs.

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*"... we decided to petition the Software Engineering Institute (SEI) to join the CMMI Version 1.0 product development team, primarily to avoid future surprises in the evolution of the CMMI family of models."*

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Unfortunately, the distributed PAT approach was fraught with participation and buy-in issues from the start (see Organizational Culture, page 13). Several solutions to the non-participation problem were tried, including tying individuals' performance evaluations to support for the PATs, positive feedback systems, a newsletter, and intense training for the SEPG and PAT members. By the time CMMI Version 0.2 was published in August 1999, it was clear that the fully distributed approach was not going to work.

Then when it was introduced, the *single process* structure of the CMMI for Systems Engineering and Software Engineering (CMMI-SE/SW) Version 0.2 came as a surprise. We took advantage of this by

making three important decisions. First, due to the nature of the organization's business base, adopting the systems engineering model in conjunction with the software engineering model offered a major advantage because the organization now had the potential to develop a true *single process* for engineering from the start. Second, we decided to reorganize the distributed SEPG into an Engineering Performance Improvement Center (EPIC) with a core team of two people and *field office leads* from each of the seven major offices. Third, we decided to petition the Software Engineering Institute (SEI) to join the CMMI Version 1.0 product development team, primarily to avoid future surprises in the evolution of the CMMI family of models.

With a core team of process engineers and the support of field office leads from all the major offices, EPIC began the task of standard process definition in earnest. The first step EPIC took was to translate the CMMI-SE/SW process areas into core processes that were meaningful to business operations, thus adopting a *core process architecture* (see Figure 1, page 12). This was done for two reasons. First, the CMMI was still evolving in terms of the number and definition of process areas. Second, we wanted to focus on things that were important to the company.

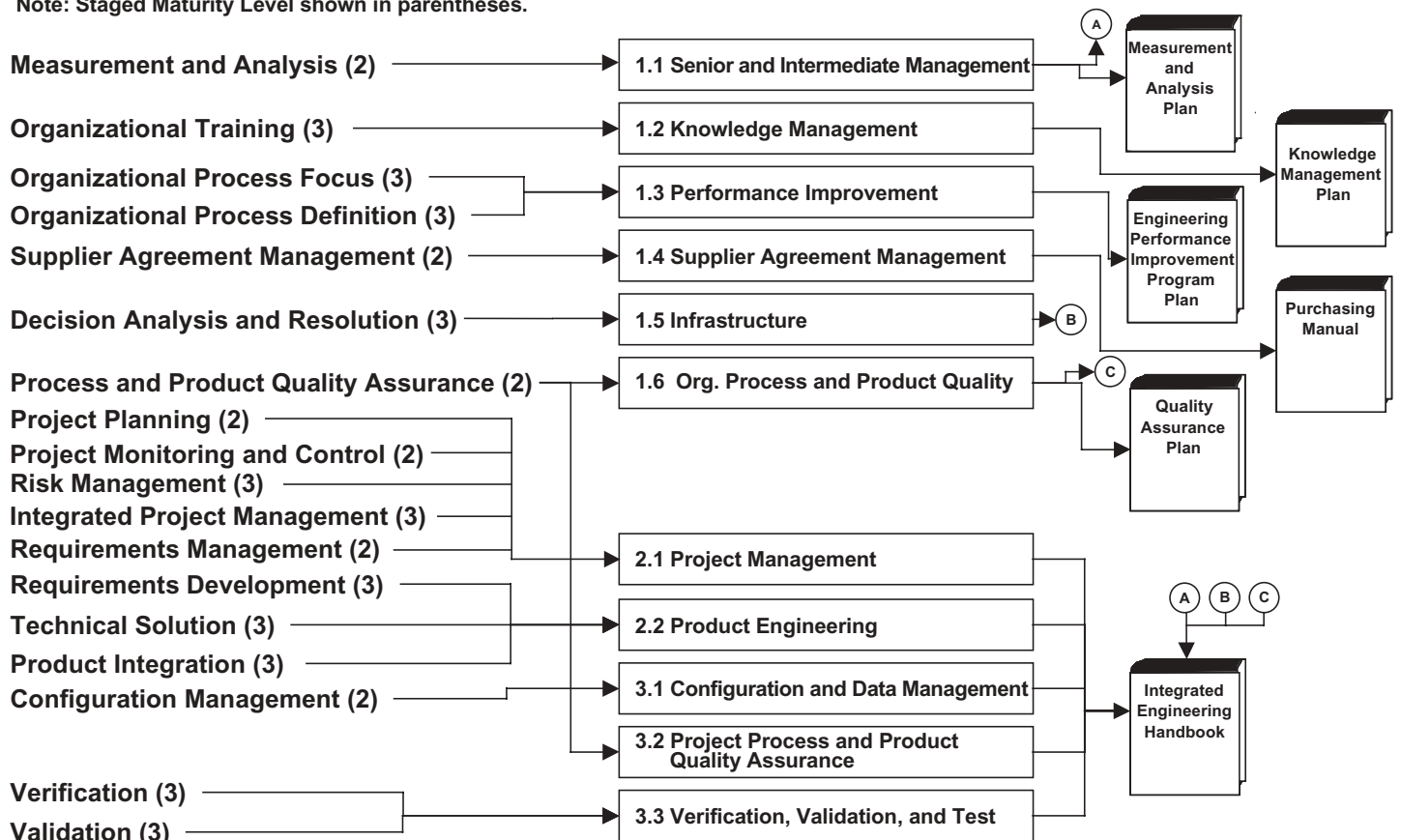
Among other things, we wanted a clear focus on product engineering, which was missing from the CMMI. We included *infrastructure* as a core process, i.e., a recognition that adoption of the CMMI will affect processes and technologies used by business development, human resources, training, information systems, and financial management. We ultimately found a life-cycle framework in ISO/IEC 12207 [1] that served as a starting point for our

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**CMMI-SE/SW L2/L3 PROCESS AREAS**

Note: Staged Maturity Level shown in parentheses.

Figure 1: *Organizational Subsystems*

core process architecture. In addition to focusing our thinking, the core process architecture insulated us from all but the most severe changes to the CMMI-SE/SW as it evolved from Version 0.2.

**Process Engineering****Mechanisms and Innovations**

During the next two years, the organization defined the standard process in six major work products, each with its own primary focus and internal customers. These included the following:

- An integrated engineering handbook for project managers, engineers, and management.
- An engineering performance improvement program plan for the EPIC.
- A process and product quality assurance plan for quality assurance.
- A measurement and analysis plan for the entire organization.
- A purchasing manual for contract managers and project managers.
- A knowledge management plan.

For our purposes, we defined *knowledge management* as containing five specific stages in the learning process: knowledge needs assessment, knowledge assimilation or creation, knowledge codification, knowledge transfer, and assessment of

both assimilation and the knowledge-management process itself. The concept and practice of knowledge management creates alternative training solutions, and allows us to start activities like identification of knowledge domains and development of knowledge base experts.

The organization also adopted several mechanisms and (at least to us) innovations that have proven or are starting to prove their value. Among these are the following:

- A life cycle that is both flexible and recursive, allowing tailoring to support the needs of the project and the customer.
- A repeatable tailoring approach that accommodates services, systems, and hardware and software development for small to large project sizes.
- The use of principal managers and leaders in the organization to teach critical courses.
- The early development of an automated measurement database.
- The development (later than we wanted) of a distributed work environment to support process engineering and information sharing.

Several of these innovations and mechanisms have been the subject of con-

ference panels and the SEI's working group efforts [2, 3, 4].

We understood and have reaffirmed the value of frequent external assessments as a means of refreshing our approach, clarifying issues, and evolving the process culture. We had an external SEI-authorized lead assessor conduct four *profiles*, or low-end assessment requirements for CMMI (ARC) Class B assessments. We have also conducted one ARC Class B assessment that was nearly a full Level 3 Standard CMMI Assessment Method for Process Improvement.

The results of our ARC Class B were that our standard process was nearly complete, but project buy-in and institutionalization was found to be lacking. The assessment caused us to refocus our knowledge management program, and to add activities to gain buy-in at the project and organizational-unit manager level. We also had an *epiphany* as a direct result of the assessment: Our *services* thread in the standard process was not as complete as it needed to be.

In *all* cases, we have found clarifying realizations that catapulted our understanding and insight rapidly forward. The opportunity for organizational delusion (potentially humorous when seen in other

organizations, but not very funny when found in your own) is too great to not rely on frequent outside counsel. We found that frequent *profiles* combined with less frequent full assessments provided the right balance of value vs. cost.

The process engineering team went to great lengths to share all information openly throughout the organization. A continuous and proactive effort was mounted to get buy-in from all levels of the organization, including frequent reviews and decisions made by the EPIC field office leads, intermediate and senior management reviews through an engineering management council, and quality reviews of process documents. Most importantly, the initial version of standard process documentation was completed and refined through the full participation of four pilot projects, which represented small to large software efforts and one systems engineering effort. A significant number of changes and lessons learned from the pilot projects were integrated into the standard process.

During most of the two years, the organization also worked closely with the SEI to better understand the content and intent of the CMMI-SE/SW and associated assessment and evaluation methods. In May 2002, the organization successfully passed the CMMI-SE/SW Level 2 appraisal.

## Organizational Culture

In some aspects, Jacobs Sverdrup's organizational culture was like most in the industry, yet markedly different in other respects to the industry average. There were pockets of well-developed, process-literate software development projects. These offices understood software life-cycle engineering, the value of configuration management, metrics, and quality assurance. They went about project planning in a repeatable, meticulous manner. At the same time, other projects at other locations might have difficulty in understanding the value of clearly specified requirements, or in understanding the difference between requirements analysis and requirements management.

A significant segment of the organization conducted engineering services that did not produce a typical hardware system or software product. Some efforts provided acquisition support services; some provided detailed validation of weapons systems simulations. These *services* projects were staffed with competent to excellent technical personnel and excellent project managers, but they did not reflect elements of a life-cycle engineering culture.

In general, no organization-wide measures were being collected or analyzed on a routine basis, except for customer satisfaction ratings and certain financial performance measures.

There also existed a set of organizational core values that were propagated and institutionalized through leadership example, training, and evaluation of office and personal performance. These core values were assimilated throughout the organization, and provided a foundational starting point for process improvement. These core values were comprised of the following statements: "We are relationship-based," "People are our greatest asset," and "Growth is an imperative."

The values were adhered to and considered in normal operations at each level of the organization. This resulted in a

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*"The underlying message was that commonly held values (processes), if strictly adhered to, offer real potential for organizational and personal success."*

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common culture that exhibited a consistent focus. The underlying message was that commonly held values (processes), if strictly adhered to, offered real potential for organizational and personal success. This core value system, shared by everyone from business and technical leaders to project, intermediate, and senior managers, provided the cultural foundation for process improvement.

Lastly, the organization enjoyed a strong culture of enlightened leadership. Real and consistent effort was routinely invested in defining, evolving, and improving leadership principles and practices among senior, intermediate, and project leaders. Distinctions were commonly made between management and leadership principles and practices.

Strong ethical principles were commonly exercised, illustrated by such practices as commitment to the long-term employment of proven technical personnel, the stewardship of customer resources, and a real dedication to the realization of core values. Managers were required to value the relationship with the

customer over the transactional value of the effort. For example, managers routinely cared for customer resources entrusted to the organization in a way that conserved their use and provided visibility into the way they were expended on behalf of the customer. Why? Customers who are treated this way will ultimately turn over more of their resources to manage. During the time frame under consideration, the concept of operational excellence was added as an ancillary core value.

## Change Leadership

The challenges to organizational leadership proved to be manifold, ranging from developing a trusted relationship with the organizational change agent, EPIC, to supporting the many initiatives needed to obtain buy-in from all levels of the organization.

It is important to consider these challenges carefully. In organizations that are not yet organizationally mature, leaders may attain their positions through CMM Level 1 skills. That is, it is possible to attain leadership positions with *stovepipe* organizational skills. If this is the case in the organization, the prospect for successful adoption of a rigorous and widely scoped model like the CMMI is much less likely. As an organization, we were extremely fortunate that our leadership was dedicated to the underlying principles of improvement.

The challenges to organizational leadership were real, and came from two sources. First, leaders were faced with having to change the way they did business, sometimes in fairly uncomfortable ways. They were asked to alter or even abandon *tried-and-true* concepts, attitudes, and practices that were, for all they knew, the very things that got them where they were. Then, in this changing and somewhat uncomfortable environment, leaders were asked to deal with *push back* (or resistance) from the organization.

Push back comes from all levels of the organization but at different times and for different reasons. It is a natural and expected part of process implementation and institutionalization. The need to respond positively and proactively to objections or criticisms of the evolving standard process is extremely important to buy-in.

Well-meaning engineers and managers sought out our senior leaders to discuss problems and difficulties with the evolving standard process and supporting technologies. This problem was exacerbated by the nature of the CMMI, as the model is intrusive on the processes used by organizational infrastructure, including information

technology. It was important to rely on the leadership's knowledge of the CMMI, of the principles of process improvement, and trust in the seminal abilities of the change manager in dealing with such issues.

The change manager (EPIC technical director) developed a close and continuous relationship with the senior leadership. An early effort was made to understand how the business environment would evolve, that information would be shared across all levels of the organization, and that standard processes would normally have to be followed, even by the leadership. The problem is, these words just did not mean much to an organization that was just starting down its quality path.

So our leadership was pretty much left to discover for itself how real the CMMI is. The discovery process had several layers, each rising into view as the one before was successfully negotiated. Discovery levels included the following:

- The CMMI really does change the way every part of the organization operates.
- The costs associated with adoption of the CMMI are real and cannot be avoided.
- Routine actions have to be conducted in accordance with the standard process, as well as corrective and near-crisis actions.
- A CMMI process improvement effort is not *just another project*, where the work products are the most important output.
- Some of the people you have worked with and trusted for years will resist the improvement effort for various well-intentioned reasons.
- Assessments cannot be used to provide feedback and evaluate the performance of individual elements of the organization.
- The CMMI process improvement effort must be carefully aligned with the goals of the organization to make it worthwhile.
- The management and leadership style that has served to bring leaders this far in the organization now must be negotiated with the unseen authors of a complex model they are just beginning to appreciate.

The business instincts, trust, and core values of the leadership are challenged in this environment, and rightfully so.

## Conclusion

So what combination of elements does it take to succeed in adopting the CMMI? Competent process improvement strata-gems and activities are certainly necessary,

but not sufficient. Innovation may provide considerable additional value to the organization, but not if the process improvement effort is terminated while the process group is busy innovating. Organizational culture and core values have a considerable effect on the probability of success of the CMMI effort. And, because the CMMI intrudes on the infrastructure of an organization, the potential impact of culture on the process improvement effort is magnified.

There will be bumps in the road. Some *heroes* in the organization will probably leave. It will take longer and cost more than anyone wants. Management and leadership will be exposed to a series of *discoveries* that will be somewhat uncomfortable, and even be asked to continuously re-examine the values, beliefs, and management/leadership techniques with which they have succeeded so well in the past. New management techniques will have to be adopted, and the discipline with which engineers conduct business will be made significantly more rigorous. The amount and detail of *continuous information sharing* will increase considerably at all levels of the organization.

The substantive issues that threaten the success of a CMMI process improvement effort stem from a single source: the need for every engineer, manager, and leader in the organization to evolve in a very prescribed manner of conducting business. The professional, hard-working people who make up the organization have to be led to believe that the new way will work. They need to believe it will not threaten their careers, will not ultimately make their jobs more difficult, and will allow them to succeed within a new framework that they are just beginning to understand. This task, while difficult, is critical to success. It requires business leaders who are committed to the fundamental improvement of their organization, who know and trust their people, and who have the skills and character to lead people through change. ♦

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## Note

1. This article is a follow-up to the example in the book by Ahern, Dennis, et. al. CMMI Distilled. Addison-Wesley, 2001: Chapter 2.
2. Jacobs Sverdrup Inc. is a wholly owned subsidiary of Jacobs Engineering.

## About the Author



**Jeffrey L. Dutton** is the technical director of the Engineering Performance Improvement Center (EPIC) at Jacobs Sverdrup. He provides leadership solutions and management of process and technology improvements to the business of conducting and managing engineering programs. EPIC's principal focus is on adoption and institutionalization of the Capability Maturity Model® Integration<sup>SM</sup> for Systems and Software Engineering (CMMI<sup>SM</sup>-SE/SW). Dutton was a member of the Software Engineering Institute's Product Development Team for Version 1.0 of the CMMI-SE/SW. He has led systems engineering and software process improvement efforts for more than six years. Previously, he was an authorized software capability evaluator. He was also assigned to the Office of the Secretary of the Air Force (Research and Development), and Headquarters Air Force Operational Test and Evaluation Center. He has a bachelor's of science degree in aerospace engineering from the University of Arizona and a master's of science degree in operations research from the Air Force Institute of Technology.

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# The AFIT Offers Software Continuing Education at Your Location at No Cost

Maj. Brian G. Hermann  
U.S. Air Force

*All our lives we have heard stories and witnessed examples that show education is the means to improve our abilities and lives in general. Unfortunately, we seem to forget this maxim when we enter the software workforce – instead believing in fads, tools, and long hours. But education truly is the long-term solution to the Department of Defense's software woes, and the Software Professional Development Program is an inexpensive, flexible way to get state-of-the-art software engineering education right away. This article explains the program and reinforces the truth that education is the answer.*

Like most software engineers and managers, you are mired in a never-ending battle to get your project completed to your customer's satisfaction and your boss' schedule and budget. In hopes of improving your fate, you would like to try some of the new techniques you have read or heard about, but first you need more information. There are a number of opportunities, but where will you get your software education?

You could go to a local university or attend a commercial software training class. Most likely, you do not have time to take a leave from work to finish your master's degree, and your local university is too theoretical and cost prohibitive. Commercial software training is frequently expensive and normally requires traveling. So what are your options? You could keep burning the candle at both ends, buy stock in Maalox, and hate your job. Or you could get some practical, state-of-the-art software engineering and management education at your location and at no cost to your unit. That sounds too good to be true – how can we offer that kind of a deal?

In the late 1980s, the Air Force recognized that education was the answer to the software crisis and formed the Software Professional Development Program (SPDP) at the Air Force Institute of Technology (AFIT). This program – once a training requirement for software engineering officers within the communications-computer systems career field – continues to help organizations combat poor quality, late, and over-budget software. As Air Force systems increasingly rely on more complex software, the need for timely software engineering education has increased. SPDP provides this education – free of charge – to all Department of Defense employees. The courses are taught in distance learning, continuing-education format from the AFIT's School of Systems and Logistics at Wright-Patterson Air Force Base in Dayton, Ohio.

## A Custom Curriculum

The SPDP program is flexible to meet your

needs. All distance-learning courses are offered a la carte with no prerequisites. That means you get the knowledge you need, when you need it. Table 1 shows AFIT's current lineup of continuing education software courses. This course lineup represents the largest restructuring of the SPDP curriculum since its inception. In addition, you can tailor a sequence of classes for yourself or you can complete a series to earn one or more of our certificate programs (see Table 2).

The first two courses offer an introduction to the software life cycle and proven techniques to help successfully manage a software development or acquisition project. Specific courses are also offered for each life-cycle phase: requirements, design, implementation, and maintenance. Next, software testing and object-oriented issues are explored. The two final courses offer hands-on opportunities to put your new capabilities into practice.

Our customers told us they wanted shorter courses to fit into schedules filled with deadlines and deployments. Each SPDP course is three to four weeks in

length with twice-weekly lessons. Missing a live class due to a TDY or emergency will not slow you down since we can deliver classes on-demand using Internet video streaming, satellite transmission, videotape, Internet conferencing, or CDs. This gives you the option to come to class as your schedule permits.

While you are taking classes, you will get most of your materials through AFIT's new Web-based learning management system, called Blackboard. This system provides a single, easy-to-navigate location for students to access course materials and lessons. Blackboard also helps to simulate a local classroom environment by providing a place to submit homework, take quizzes, and communicate with fellow students and faculty online. The SPDP program works not because of technology, but because we have been careful to include personal interaction in the mix with practical information. The SPDP faculty deliver the lessons and are available to help you through each course, provide free consulting services for you and your organization, and can even offer on-site workshops if your organiza-

Table 1: SPDP Classes

Course Number	Course Title
CSE 480	Introduction to Software Project Management
CSE 481	Software Systems Engineering
CSE 482	Software Requirements
CSE 483	Software Design
CSE 484	Software Implementation
CSE 485	Software Systems Maintenance
CSE 486	Verification, Validation, and Testing
CSE 487	Fundamentals of Object-Oriented Design
CSE 488	Object-Oriented System Modeling
CSE 489	Advanced Analysis and Design of Object-Oriented Systems
CSE 496	Practicum (In-Residence)

Table 2: SPDP Certificate Programs

Certificate	Required Courses
Software Engineering Management	CSE 480 and 481
Software Life-Cycle Development	CSE 482, 483, 484, and 485
Advanced Software Development	CSE 486, 487, and 488
Technical Software Development	CSE 489 and 496

## COMING EVENTS

**January 27-30**

*Reliability and Maintainability  
Symposium*  
Tampa, FL  
[www.rams.org](http://www.rams.org)

**February 10-13**

*Commercialization of Military and  
Space Electronics Conference*  
Los Angeles, CA  
[www.cti-us.com/ucmsemain.htm](http://www.cti-us.com/ucmsemain.htm)

**February 24-27**

*Software Engineering Process  
Group Conference*



Boston, MA  
[www.sei.cmu.edu/sep/](http://www.sei.cmu.edu/sep/)

**March 24-28**

*International Symposium on  
Integrated Network Management*  
Colorado Springs, CO  
[www.im2003.org](http://www.im2003.org)

**April 8-10**

*FOSE 2003*  
Washington, D.C.  
[www.fose.com](http://www.fose.com)

**April 28-May 1**

*Software Technology Conference 2003*



Salt Lake City, UT  
[www.stc-online.org](http://www.stc-online.org)

**May 3-10**

*International Conference on  
Software Engineering*  
Portland, OR  
[www.icse-conferences.org/2003](http://www.icse-conferences.org/2003)

**May 6-8**

*TechNet 2003*  
Washington, D.C.  
[www.technet2003.org](http://www.technet2003.org)

## Workshop Planning Announcement

The Software Professional Development Program (SPDP) faculty is working to set up the Department of Defense's (DoD) first-ever software engineering education workshop. Goals for this meeting are to develop a listing of educational and training opportunities and to foster working relationships to realize better and more comprehensive educational programs to offer to the DoD's software workforce. If you work in the field of software engineering education and training or represent an organization with a significant demand for software engineering education, please contact the SPDP faculty to add your organization to our list of invitees.

tion has a large education need. As an added bonus, we provide free course textbooks for your professional reference library.

Our only resident course, CSE 496, is offered at least annually at the AFIT's campus and provides students a chance to put all of the SPDP techniques to work in a team-based software development project. Students laud this opportunity as the culmination of the program and a great chance to try new skills in a non-threatening environment while networking with other practitioners.

Your best way out of the software death-march nightmare is to invest some time improving your abilities. Fortunately, you do not have to go far or spend a lot of money. Our faculty is here to help. Most SPDP students see improvement during their current projects. ♦

## Getting Started

Get started today by either filling out an application on our Web site at <<http://ls.afit.edu/spdp>>, e-mailing the faculty at [spdp@afit.edu](mailto:spdp@afit.edu), or contacting Candace Barker at (937) 255-7777 x3319, or DSN 785-7777 x3319.

## About the Author



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## LETTER TO THE EDITOR

Dear CrossTalk Editor,

Hello and thanks for another informative CrossTalk (July 2002) and especially for the Open Forum article "JAD on a Shoestring Budget" by Dr. Mario J. Spina and John A. Rolando.

In my experience facilitating many JAD-like workshops, this approach to requirements elicitation saves time and money and helps clients and technical staff get the right stuff, fast. Best of all, the collaboration that is the hallmark of these sessions sets the stage for solid client-IT relationships so necessary for successful projects.

The authors provided a helpful set of additional reading and Web sites, to which I would like to add my own: <[www.ebgconsulting.com/publications.html#jad](http://www.ebgconsulting.com/publications.html#jad)>.

Please let your readers know that I've also posted numerous articles on my Web site on the JAD topic. There are pages that provide practitioners with checklists, tips, examples, questions and templates that are useful for planning and running workshops.

Ellen Gottesdiener  
EBG Consulting Inc.



# Weather-Impact Decision Aids: Software to Help Plan Optimal Sensor and System Performance

Dr. Richard C. Shirkey  
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*Weather can play a decisive role in military battles, in their planning, and in their execution. Weather-impact decision aids give the commander an edge by allowing both a determination of the optimum selection of weapon systems and a comparison with threat systems under current or forecast weather. This article describes two weather-tactical decision aids: the Integrated Weather Effects Decision Aid and the Target Acquisition Weapons Software.*

Weather is ubiquitous; planning for it is an everyday occurrence, yet it still manages to foul up our plans. Recent military examples abound, such as dust clouds that grounded sorties in Operation Allied Force in Kosovo. To effectively execute missions, the military commander must be aware of the weather and its impact on his/her equipment, personnel, and operations. There are a number of weather-impact decision aids (WIDAs) that determine weather effects on mission-selected equipment and operations. Generally, these WIDAs may be broken into two subsets: rule-based and physics-based.

Rule-based WIDAs, such as the Army's Integrated Weather Effects Decision Aid (IWEDA) [1], are constructed using observed weather impacts that have been collected from field manuals, training centers and schools, and subject matter experts. IWEDA provides information (in the form of stoplight charts) concerning which weapon systems will work best under forecast weather conditions; no information is provided concerning target acquisition range.

Physics-based tactical decision aids (TDAs), such as the Tri-Service Target Acquisition Weapons Software (TAWs) [2], employ physics calculations that have their basis in theory and/or measurements. TAWs determines the probability of detecting a given target at a given range under existing or predicted weather conditions. Thus, physics-based systems produce results in terms of a performance metric that take on a continuum of values rather than the simpler stoplight results from the rule-based systems.

## The IWEDA

IWEDA, a UNIX-based program written in Java, is a collection of rules with associated critical values for aiding the commander in selecting an appropriate platform, system, or sensor under given or forecast weather conditions. It provides qualitative weather impacts for platforms, weapon systems, and operations, including soldier performance.

Each system (Army, Air Force, Navy,

and threat) has its list of relevant rules, which include red-amber-green (unfavorable-marginal-favorable) *critical value thresholds* for one or a combination of the environmental parameters that affect the system. Results are displayed via a matrix of impacts vs. time (see Figures 1 and 2) and

map overlays (see Figure 3, page 18) for the region of interest. Environmental data for the region of interest is supplied primarily via the Army's Battlescale Forecast Model [2], developed for short-range forecasting. The environmental impact rules and critical values for the various systems have been

Figure 1: IWEDA Weather Effect Matrices



Figure 2: IWEDA Full Impacts



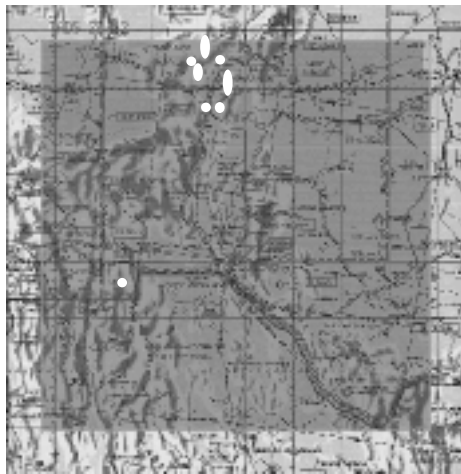


Figure 3: IWEDA Map Overlay for AH-64 TADS TV/DVO

validated through the Training and Doctrine Command's organizations, field manuals and the National Ground and Intelligence Center.

IWEDA is currently being fielded as part of the Army's Command, Control, Communications, Computers and Intelligence (C4I) tactical weather system, the Integrated Meteorological System. As a C4I tool, IWEDA does not dictate a course of action, but only informs the commander that there will be weather impacts on the force (friendly or threat).

IWEDA rules, which interact with the weather database to determine impacts on the selected system(s), are determined from system concepts and are embodied in a computer database that has been tied to *critical values*. The critical values are defined, in a meteorological sense, as those values of weather factors that can significantly reduce the effectiveness of, or prevent execution of, tactical operations and/or weapon systems.

An example of such a rule would be "usage of TOW2 is not recommended for visibilities less than three kilometers." In this example rule, a visibility of three kilometers (the critical value) has been coupled with a system (TOW2) resulting in a rule. We can further define this critical value, or range of values, as the point where the occurrence of a meteorological element

causes a significant (moderate or severe) impact on a military operation, system, subsystem, or personnel.

In general, the rules are determined by operational usage (as embodied in the field manuals, etc.), whereas the critical values are determined by doctrine, safety, or engineering factors (people, modeling, or testing). Currently IWEDA stores information on 102 systems, 86 of which are friendly, 16 of which are threat-rated.

### IWEDA Operational Usage

IWEDA is arranged in a fashion that presents systems, subsystems and components in a hierarchal fashion. A group of systems is called a mission; a system often contains one or more subsystems; the subsystems often have one or more components. The user has the option to define which systems belong to a mission and to delete optional subsystems and components from a system thereby allowing a determination of weather impacts from operations or missions at the highest level down to systems, subsystems, and components at the lowest level.

For missions, systems, subsystems, and components, the impacts over the forecast period are shown on weather effects matrices (WEMs, see Figure 1). The WEM is color-coded; for use with non-color printers, cells are annotated with R (red), A (amber), or G (green). Red areas indicate that operations are severely impacted: There is either a total or severe degradation or the operational limits or safety criteria have been exceeded. Amber indicates that operations are marginal and the operational capability is degraded, or there is a marginal degradation. Green indicates that there are no operational restrictions.

Based on requirements, users may query and view various levels of information: text impact statements or spatial distributions of impacts on a map overlay.

### IWEDA Example

In the following example, a user-defined mission is created by selecting three friendly and two threat systems. Once the mission has been configured, the database is queried to determine the weather impacts on the

systems, their subsystems, and components. Results are presented as a function of time and location.

To construct the example mission, the A-10, AH-64, personnel, SA-14, and SA-16 systems were selected from IWEDA's *friendly* and *threat* graphical user interfaces (GUI). Once these systems have been selected, IWEDA determines the weather impacts on the mission; results are presented to the user in the form of a WEM, as shown in Figure 1.

Initially, the lower half of the WEM is blank with the upper half showing the weather impacts as a function of system(s) and time. By performing a *right* click on any of the colored cells, such as the AH-64 for 22/12 (day/time), condensed impacts are shown in a scrollable window in the lower half of the WEM (impacts for the configured AH-64 system have been reproduced in Table 1). The WEM shows impacts on the AH-64 system as a function of time and general environmental conditions, but we do not know the full (detailed) impact or where the impact is occurring within the forecast area.

To determine the full impact statement and the location, a *left* mouse click is performed on the AH-64 cell for the selected day of the month and time, i.e., 22/12. This brings up the next screen (see Figure 2) that presents all of the selected AH-64 subsystems and components and their color-coded impacts.

As in the WEM GUI, initially only the top half of Figure 2 is presented to the user. To obtain further information, the user clicks on one of the colored blocks; in the example presented, the TV/direct view sight component of the Target Acquisition Designation Sight (TADS) has been interrogated. This results in a color-coded map overlay (Figure 3) showing where the TV/D is affected by the weather. The full impact statement, along with its source, can now be obtained by moving the cursor (shown as a white circle) and clicking upon a white area on the map (upper left of center).

The associated full impact statement then appears in the lower half of Figure 2, which in this case is "Any occurrence of fog or visibility <1.9 mi (3100m) significantly reduces the target and background contrast making target acquisition difficult." Contrast this with the condensed impact statement of "Fog and Low Visibility" shown in the WEM.

In summary, the colored cells in the WEM display the *worst-case* condition for the selected mission, during the *selected time*, for the *entire forecast region*. If the user wishes to know why a particular cell is red or amber,

Table 1: Impacts for the AH-64 System for 22/12

System AH-64 has marginal impact: High Pressure Altitude
Subsystem 30 MM MACHINE GUN has marginal impact: Low Visibility
Component THERMAL SIGHT has marginal impact: Reduced Visibility
Component TV/DIRECT VIEW SIGHT has marginal impact: Reduced Visibility
Component TV/DIRECT VIEW SIGHT has unfavorable impact: Fog and Low Visibility
Component Laser R/D has marginal impact: Reduced Visibility
Component Laser R/D has unfavorable impact: Low Visibility
Subsystem HELLFIRE has marginal impact: Icing Aloft
Subsystem GENERATOR has marginal impact: High Altitude
Component NIGHT VISION GOGGLES has unfavorable impact: Reduced Illumination

further information is available in impact statements, which explain why a particular cell exists. Detailed analysis for the impacted system or sensor can be obtained from the color-coded map.

## The TAWS

TAWS [3], a GUI-based program running under the Windows operating system, is a Tri-Service program that includes Air Force, Army, and Navy sensors and targets. TAWS supports systems in three regions of the spectrum: visible (0.4 - 0.9 microns), laser (1.06 microns), and infrared (IR) (3-5 microns; 8-12 microns). It accepts current or forecast weather data to determine target detection range for selected sensors and targets. The commander uses this information for mission-planning purposes or to ascertain which sensors can see the furthest under the given weather conditions.

TAWS performs both illumination and performance prediction calculations (PPC). The PPC can be done for single or multiple locations during a mission. The illumination analysis involves the computation of solar and lunar ephemeris information for a specified location. A mission planner, for example, might be interested in an illumination analysis to determine the time of sunset for a particular mission date and location. For a single location, the PPC could be used to predict detection range for a particularly important target as a function of time, while a PPC for multiple locations along a mission route would be useful to a mission planner predicting detection ranges for a series of key locations as a function of time.

To determine the acquisition range to a given target a number of quantities need to be known: the target-to-background contrast, the atmospheric conditions, solar or lunar luminance, and sensor characteristics, all of which vary with spectral region. We discuss each of these in the following sections and provide an illustrative example at the end.

### Target-to-Background Contrast

Contrast is defined as the ability of an observer to distinguish an object from its background; it degrades as the atmospheric path length increases. At visible wavelengths, where radiation scattering from atmospheric particulates is important, the mathematical formulation of the contrast is different than in the infrared (IR), where emission is the dominant process. Since TAWS computes contrast in both of these spectral regions, we present the following formulations.

**Visual Contrast Model:** The inherent, or zero range (usually defined as the target's

position), contrast at visible wavelengths,  $C(0)$ , is the difference between the target,  $I_t$ , and background,  $I_b$  radiances, divided by the background radiance,

$$C(0) = [I_t(0) - I_b(0)]/I_b(0). \quad (1)$$

We may express the apparent contrast at range  $r$  as

$$C(r) = \frac{C(0)}{1 + [I_p(r)/I_b(0)][1/T(r)]}, \quad (2)$$

where  $T(r)$  is the atmospheric transmission, and  $I_p$  is radiation scattered from atmospheric aerosols and gases into the line-of-sight.  $I_p$  is called the path radiance and may be thought of as atmospheric noise scattered into the sensor's field of view; it is not dependent upon the target.

In TAWS at visible wavelengths, the target and background radiances are determined using Hering and Johnson's Fast Atmospheric SCATtering model (FASCAT) [4], which calculates upwelling and downwelling radiance terms at specified heights in the atmosphere.

For designated sensor and target altitudes, the apparent contrast is calculated for slant paths, which may include an optional cloud layer. Objects in sunlight or shadow may be viewed against sky, cloud, or terrain backgrounds. The path radiance  $I_p$  and the background radiance  $I_b$  are determined by a multiple scattering calculation using the delta-Eddington approximation [5] in conjunction with the atmospheric model. The contrast is subsequently determined using equation (2).

For visible/near-IR scenarios, the target may be on the ground or elevated. An elevated target may be viewed with an upward or downward line-of-sight (LOS). Sky and cloud backgrounds are supported for the upward LOS; distant earth and low-lying cloud backgrounds are supported for the downward LOS.

**Thermal Contrast Model:** The inherent contrast at thermal wavelengths is defined as the target temperature minus the background temperature,

$$C(0) = [I_t(0) - I_b(0)] = \Delta T, \quad (3)$$

where  $\Delta T$  is the temperature difference between the target and background. Note that as the temperature increases, so will the inherent radiance,  $I(0)$ . Thus, the contrast in the IR is,

$$C(r) = C(0) T(r) = \Delta T T(r). \quad (4)$$

In TAWS,  $C(0)$  is determined indirectly

by the Multi-Service Electro-optic Signature model (MuSES) [6], which calculates the equilibrium background and target temperatures using antecedent illumination and weather data.

MuSES has two primary components: a thermal analyzer module and a signature model. Thermal analysis is the computation of physical temperature and heat rates that are obtained through energy balance on a node or isothermal element using a finite-difference numerical solution of the differential equations. The main output of a thermal model is physical temperatures and net heat rates that compare to empirical measurements of contact sensors.

The signature analysis is the computation of apparent temperature or radiance, which is composed of an emitted component that is a function of physical temperature and emissivity and a reflected component that is a function of irradiance from its surroundings and its reflectivity. In other words, the signature is what a sensor views and measures the radiance of a target, which is only partially dependent on its physical temperature. Thus, the signature model provides a link between the output of the thermal model and the desired output in signature analyses.

The basic heat source components considered by MuSES include longwave radiation, solar absorption, engine heating, engine compartment air, exhaust gas, track and wheel heating, and convection. Inter-reflections between diffuse surfaces are also taken into consideration. These various temperatures and effects are used to calculate  $\Delta T$ .

**Laser Contrast Model:** The laser model does not compute contrast.

### Atmospheric Information

To determine the loss of energy as radiation passes through the atmosphere requires knowledge of the atmospheric constituents (gases and aerosols) and its state (pressure, temperature, relative humidity, etc.). This loss of energy is expressed in the form of atmospheric transmission, which ranges in value from zero to one and is highly dependent upon the aerosol type present. This loss of energy can be represented by Beer's law for atmospheric transmission,

$$T(r) = e^{-(k_a + k_p + k_m) r}, \quad (5)$$

where  $k_a$ ,  $k_p$ , and  $k_m$  are the aerosol, precipitation, and molecular extinction coefficients, respectively. The molecular extinction coefficients are determined in TAWS by using a scaled down version of the low transmission atmospheric propagation code

Aerosol	Properties
Rural	Boundary layer background aerosol found in continental air masses.
Urban	Rural aerosol plus an added component representing soot-like aerosols that include particles produced in urban and industrial complexes.
Maritime	Characterizes aerosols that include sea-salt particles; the target area is more than a few kilometers inland.
Tropospheric	Characterizes aerosols found in very clean air masses and in the free atmosphere above the boundary layer.
Desert	Characterizes aerosols found in the boundary layer of desert, arid, or semi-arid climatic regions.
Navy Maritime	Describes aerosols found in the boundary layer of oceanic environments; includes wind speed dependence.
Advection Fog	Characterizes wet aerosols found in dense fogs, where visibility is less than 1 km.
Radiative Fog	Describes aerosol properties in less dense fogs, where visibility is 1 km or greater.
Camouflage Smokes	Characterizes white phosphorus, fog oil, and hexachloroethane smoke.
Battlefield Induced Contaminants (BIC)	A persistent pall of smoke and dust that sometimes covers areas where intense combat has occurred.

Table 2: TAWS Aerosol Models

LOWTRAN [7]. The aerosol extinction coefficients [8, 9] are read from pre-calculated internal tables.

TAWS contains 10 aerosol and two precipitation models that are used in various combinations by the IR, television/night vision goggles, and laser models to determine the appropriate aerosol and/or precipitation extinction coefficients. The aerosols describe the primary particulates of the air mass close to the surface at the location of interest. The naturally occurring aerosols include rural, urban, maritime, tropospheric, desert, advective fog, radiative fog, and Navy maritime. There are three types of camouflage smokes: white phosphorus, fog oil, and hexachloroethane. A 10th aerosol, in the form of battlefield induced contaminants, is available for situations where there is a persistent pall of smoke and dust raised by combat. Properties of the aerosol models are presented in Table 2. TAWS also contains rain and snow precipitation models.

TAWS allows a wide range of meteorological conditions, all of which may be selected by the user and some of which may be automatically input via the Air Force Weather Agency (AFWA) or the Navy Tactical Environmental Data Server (TEDS). These meteorological parameters include the following (those values noted with an asterisk may be downloaded from AFWA or TEDS): atmospheric dewpoint temperature\*; sea surface temperature\*; wind velocity/direction\*; visibility\*; precip-

itation type/rate; surface aerosol type; battlefield induced contaminants; high-, mid-, and low-level clouds\*; and the boundary layer height.

#### Solar/Lunar Illumination

Illumination analysis in TAWS involves the computation of solar and lunar ephemeris data for a specified location and a series of dates or times. Solar/lunar ephemeris input information is derived from user-input time of day/time of year and latitude/longitude, in conjunction with the Solar-Lunar Almanac Code [10].

The solar/lunar ephemeris information is also computed and used for target acquisition analysis. In this case, in conjunction with variable cloud cover, the solar/lunar position is used to calculate target/background heating for the IR model and inherent target/background radiance for the visible model. The laser model does not use ephemeris information.

#### Sensor Information

Sensors are user-selected once the spectral region has been chosen. The relevant sensor curve is automatically retrieved from the sensor database.

Within TAWS, target detection range for Silicon TeleVision (TV), night vision goggles (NVG), and IR sensors is determined by using the Acquire sensor performance model [11]. Acquire predicts target detection and discrimination range performance for systems that image in the vis-

ible and infrared spectral bands. Ranges and probabilities predicted by the model represent the expected performance of an ensemble of trained military observers with respect to an average target having a specified signature and size. TAWS currently only supports detection ranges; other acquisition ranges are scheduled to be added in the near term.

TAWS supports two different classes of systems that employ laser designators operating at 1.06 microns: laser ranging and laser lock-on systems. Each of these has designator and receiver components. The airborne laser ranging systems measure the distance from the ranger system to the target by measuring the travel time of the laser pulse from the designator to the target and from the target to the receiver. The designator and receiver are physically collocated in the same hardware package for all ranging systems. For the laser lock-on weapons, the designator illuminates the target and the receiver receives the reflected beam. TAWS predicts the maximum effective range for either the designator or lock-on receiver.

#### Example

We present here a winter scenario using a T-80 Soviet main battle tank in exercised and off modes, against a snow background at IR wavelengths. The sensor and tank were aligned such that the sensor always had a frontal view of the tank; the sensor height was 10 feet. The date and location were fixed at 21 December, latitude 37° 32' N, longitude 127° 00' E (Seoul, S. Korea), respectively. The weather conditions were overcast and snowing with visibilities of three miles (light snow) and one mile (heavy snow) with a light breeze (~3m/s) from the west. The relative humidity and temperature, taken from a climatological database [12], as a function of local time are presented in Table 3.

The results of the model run are shown in Figure 4. The two vertical lines, determined using the illumination analysis capability of TAWS, indicate the sunrise and sunset times. As expected, the detection range is considerably larger when the visibility is higher; for given weather conditions the exercised tank is easier to detect relative to the tank in the off state.

Thermal crossover, defined as the time during the day when the thermal contrast is at a minimum and the polarity of the contrast reverses, generally occurs at mid-morning and late afternoon. For example, in early morning the background temperature may be greater than the target temperature. After thermal crossover, the target temperature may be greater than the background temperature. In the example, ther-

Table 3: Input Relative Humidity (RH) (%) and Temperature (°C) as a Function of Time (HRS)

Time	1800	2100	0000	0300	0600	0900	1200	1500	1800	2100	0000
Temp	1	-3	-3	-5	-5	0	0	1	1	-3	-3
RH	69	74	74	86	86	80	80	69	69	74	74

mal crossover occurs at approximately 0900 and 1700, accounting for the low detection range at those times. The commander/user can now optimize assets by choosing a time when detection range is maximized and by avoiding those times such as when thermal crossover occurs, when detection ranges are at a minimum.

Using this information in conjunction with weather forecast information (as opposed to static information used in this example) provides additional relevant information. For example, let us examine the "tank on" curves in Figure 4. If the weather conditions were predicted to change from heavy to light snow at 1200 local, the detection range would increase from approximately one and one-half kilometers to approximately four and one-half kilometers, providing the commander with an opportunity for increased detection. Such scenarios may also be used for friendly/threat comparisons to determine the delta in range due to differing systems.

## Conclusions

IWEDA provides the commander with an easy-to-use and interpret tactical application that allows for near real-time evaluation of sensor employment options. Automating the environmental parameter retrieval by using a prognostic data set further enhances the application and allows for realistic planning based on evolving weather.

TAWS aids the warfighter in determining what sensor/weapon system will work best against a user-selected target under adverse weather conditions. TAWS accomplishes this by using accepted sensor performance and aerosol models coupled with proven techniques for determining atmospheric transmission and contrast. In addition to determination of acquisition ranges, TAWS may be used for mission planning and for determination of *deltas* between friendly and threat systems.

Taken together, these TDAs provide the commander a significant advantage for system selection under adverse weather conditions. ♦

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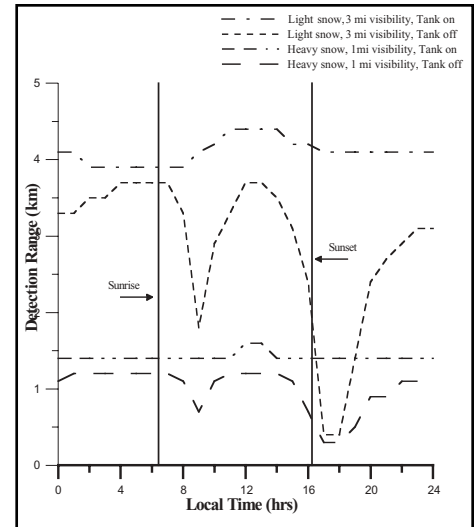


Figure 4: *Detection Range vs. Time*

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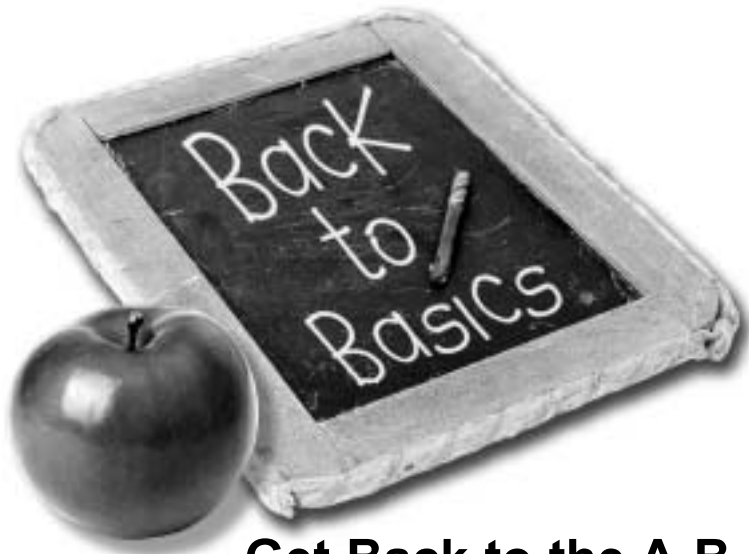
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## Get Back to the A-B-Cs of Software Management with the 2003 STSC Seminar Series

For the third year, the Air Force's Software Technology Support Center (STSC) is offering a series of informative software-related seminars in a workshop environment. This year's series will focus on some of the fundamentals of software management in acquisition and development programs – a Back to Basics.

The 2003 STSC seminar series will include these topics:

January 14-16	Life-Cycle Software Project Management	Hill AFB Vicinity
February 18-20	Life-Cycle Software Project Management	Hanscom AFB Vicinity
March 11-13	The Requirement for Good Requirements	Hill AFB Vicinity
April 22-24	The Requirement for Good Requirements	Hanscom AFB Vicinity
May 13-15	Software Schedule and Cost Estimation	Hill AFB Vicinity
June 17-19	Introduction to CMMI	Hanscom AFB Vicinity
July 15-17	Introduction to CMMI	Hill AFB Vicinity
August 19-21	The Risks of Not Being Risk Conscious: Software Risk Management Basics	Hill AFB Vicinity
September 16-18	Software Quality Assurance	Hill AFB Vicinity
October 14-16	Why Is Buying Software So Difficult?	Hill AFB Vicinity
November 18-19	Bringing It All Together for the Software Manager (Software Best Practices: An Executive's Perspective)	Hill AFB Vicinity

Senior managers, project managers, project leads, and projects team members would all benefit from these seminars that are FREE to U.S. government employees; however, seating is limited. So act quickly.

### Seminar Highlights

#### Life-Cycle Software Project Management

"We will be able to put some type of standardization and consistency in place."

You hear it all the time: another software development effort is over cost and the due date long since past. Unfortunately, this has become the norm rather than the exception. But why? Is it because we don't know how to manage software projects properly? Or is it because we don't properly implement what we know?

Good Project Management is the key to a successful project. Project Management for software projects begins when a system is initially being considered and continues until the last operating system is shut down. During this life cycle, several areas must be addressed.

The purpose of the *Life-Cycle Software Project Management* seminar is to provide project management instruction to those who don't know how to manage software projects, and to provide encouragement to implement proper software project management techniques to those who do know how to manage software projects. This seminar addresses project initiation, the many

aspects of project planning, project monitoring and control through project closeout and lessons learned.

#### The Requirement for Good Requirements

It is a widely accepted premise that requirements are the foundation upon which entire systems are developed. It is also widely accepted that the various requirements activities are often not accomplished in an attempt to get systems completed faster. This often results in hours of rework, correction, and ultimately having to settle for a system that lacks the required functionality.

The seminar, *The Requirement For Good Requirements*, covers the fundamentals of requirements engineering, analysis, elicitation, documentation, and verification and validation. This seminar will focus on getting requirements right the first time. The seminar will include training in theory and applicability of all requirements activities. It will also include planned exercises to help participants solidify the concepts taught. Additional reading materials will be provided to highlight key topics that correspond to seminar materials.

For additional information about these seminars, visit our Web site at [www.stsc.hill.af.mil](http://www.stsc.hill.af.mil).

**SPACE IS LIMITED.** To reserve your place at any of these seminars, contact Debra Ascuena at 801-775-5778 (DSN 775-5778) or [debra.ascuena@hill.af.mil](mailto:debra.ascuena@hill.af.mil).

## Software Schedule and Cost Estimation

One of the most dominant and serious complaints arising from the "software crisis" is the inability to estimate with acceptable accuracy the cost, resources, and schedule required for software development. Traditional intuitive estimation methods have consistently produced optimistic results that contribute to the too familiar cost overrun and schedule slippage.

The rapidly increasing cost of software has led customers for these products to become less willing to tolerate the uncertainty and losses associated with inaccurate cost and schedule estimates unless the developer is willing to accept a significant portion of that risk. This customer pressure emphasizes the need to use an estimation method that can be applied early in the software development where trade-off studies and investment decisions are made. The estimation method must be able to consider the characteristics of the development organization and the environmental effects imposed by the development task, as well as the application size and complexity, in order to support reasonable estimates.

The seminar, *Software Schedule and Cost Estimation*, addresses the fundamental concepts of estimating and controlling software developments, schedule, and costs. Means of early recognition of potential problems will be discussed. Exposure will be given to various estimation methods and approaches. Data collection and validation techniques to improve the estimation process will be presented and experience estimating the size and complexity of a software development task will be provided.

### Introduction to CMMI

This seminar is the *Introduction to CMMI* course that was developed by the Software Engineering Institute (SEI). This course is centered on the Capability Maturity Model (CMM®) Integration<sup>SM</sup> (a service mark of SEI). The model is intended to provide guidance for improving your organization's processes and your ability to manage the development, acquisition, and maintenance of products and services. CMMI places proven practices into a structure that helps your organization assess its organizational maturity and process area capability, establish priorities for improvement, and guide the implementation of these improvements.

This seminar will provide attendees with the following:

- CMMI overview.
- Engineering process maturity: CMMI principles.
- Capability levels and process areas of the CMMI Model Continuous Representation.
- Linking the process areas together.
- Interpreting CMMI.
- Application of CMMI.

## The Risks of Not Being Risk Conscious:

### Software Risk Management Basics

A recent insurance industry television advertisement portrays individuals parachuting, bungee jumping, and participating in other seemingly dangerous activities. The participants are then asked to drive on U.S. highways without insurance coverage. When presented with this situation, the individuals flee in fear. The risk associated with driving without insurance is considered too great.

We consistently see software programs/projects that blindly venture forward with little or no consideration for the risks that may be encountered along the way. Some of these projects face risks similar in magnitude to that portrayed in the insurance example. This lack of proper software risk management places numerous software projects at risk of failure.

The purpose of *The Risks of Not Being Risk Conscious: Software Risk Management Basics* seminar is to provide risk management instruction to those responsible for software projects. This seminar will educate attendees of the value and rationale for performing risk management. Participants will gain both theoretical and practical knowledge to assist them in properly identifying, analyzing, and mitigating program/project risks.

## Software Quality Assurance

We hear a lot today about quality with regard to products and services. Organizations undertake quality initiatives with the intent to improve customer satisfaction and thus increase revenues. It has been said that quality is that illusive characteristic that is hard to define, impossible to measure, yet easy to recognize.

The IEEE Handbook of Software Quality Assurance defines software quality assurance as the set of systematic activities providing evidence of the ability of the software process to produce a software product that is fit for use. A more fitting definition may be simply keeping the customer happy.

The seminar, *Software Quality Assurance*, addresses the fundamental concepts of quality assurance relative to software projects. This seminar defines software quality assurance and explores methods and means of assuring quality in the software development and acquisition processes.

## Why Is Buying Software So Difficult?

We buy things every day: gasoline, newspapers, shoes, and even something as common as canned beans. Acquiring products and services from others is a routine part of our daily lives. So why is buying software so much more difficult?

The seminar, *Why Is Buying Software So Difficult?*, addresses the fundamentals of software acquisition. During this seminar, we will point out the major differences between purchasing common, everyday items, and purchasing made-to-order software. We will discuss common pitfalls of software acquisition and actions that should be taken to avoid them. We will compare and contrast software acquisition with hardware acquisition. Additionally, we will discuss how acquisition reform has benefited (as well as in some cases hindered) the software acquisition process. Particular attention will be paid to recent changes in the Department of Defense 5000 series of regulations as they apply to software acquisition.

## Bringing It All Together for the Software Manager (Software Best Practices: An Executive's Perspective)

Numerous studies have been conducted documenting the value to organizations of embracing best practices. Without exception, these studies highlight the critical nature of executive or management support to the success of any software development effort.

This seminar was developed to educate executive level personnel as to their role in the successful execution of software engineering activities using industry best practices. Executives will be educated in best practices from a systems-thinking perspective, examining each life-cycle activity, critical success factors and measurements, the role of senior management, what to look for, and what to ask for to ensure the success of the organization and the program. Emphasis will be placed in key areas where management leadership, direction, and support are essential to success. An opportunity to collaborate with other executives facing the challenges associated with systems engineering will be provided. Additional reading materials will also be provided to highlight key topics that correspond to industry best practices.

"Excellent class — One of the best government-sponsored classes I have taken."

"Overall outstanding!"

"Very good course — more professional than any I've attended in the past few years."



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These seminars are being offered by the Air Force's Software Technology Support Center (STSC) and are being sponsored by the Air Force's Computer Resources Support Improvement Program (CRSIP). For information about these organizations and their services, please visit the STSC Web site at [www.stsc.hill.af.mil](http://www.stsc.hill.af.mil).



# The Privilege and Responsibility of Software Development

Grady Booch

Rational Software Corporation

*As professionals, it is a tremendous privilege to be part of an industry that delivers software that makes a fundamental difference to our organizations, our country, and our civilization. At the same time, however, we must realize that creating quality software that matters is intrinsically hard. As such, as professionals, we have a deep responsibility to do our work with purpose, courage, and a sense of moral purpose.*

No one really wants software. End users typically hate software for many reasons. It is that thing that gets in the way of their work (by driving unnatural work processes). It wastes time (when their machines go down), distracts them (by offering up a deluge of useless or misleading information), and generally annoys them (when the bones of the underlying implementation show through). Users simply want to accomplish their mission, and insofar as any underlying software makes its presence known, it is counter to getting the job done.

Program managers often hate software as well. It is that thing that eats up budgets with an insatiable appetite for growth. It is terribly slippery to get ones hands around, and even if you do, it has a tendency to slip out of your control at a moment's notice leaving an ugly, smelly mess on the floor.

Bad software – and there is far too much of it in the world – not only wastes time and budgets, distracts, and annoys, it can also put lives, businesses, and whole economies at risk [1]. Even at its best, a software-intensive system can amplify human intelligence, but it cannot replace human judgment; a software-intensive system can fuse, coordinate, classify, and analyze information, but it cannot create knowledge.

Still, we bring software into our lives and into our systems for some very basic reasons. There are some things that we can do in software that we cannot do otherwise:

- Control an aerodynamically unstable aircraft.
- Fuse and analyze information from a multitude of sensors so as to form a unique view of the world.
- Create virtual worlds wherein experiments that would otherwise be too dangerous to conduct can be carried out.
- Search through terabytes of information in the beat of a heart.

Furthermore, software offers greater flexibility than can be offered in hardware, which is why the mix of software to hardware within many systems is growing in

favor of software. Finally, for the most part, investment in software has an undeniable economic return: Across the spectrum, from embedded systems to command and control systems to enterprise information systems, the presence of software adds essential value, far more than the investment necessary to create that software.

As I look back over the history of software development, it strikes me that ours is an industry that has largely grown out of demand from users who want more from their systems for less. All of our systems are constrained by the laws of physics and by a

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*“... a software-intensive system can amplify human intelligence, but it cannot replace human judgment ...”*

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few laws of software [1]. But for the most part, it is our ability as an industry to develop better software faster, software that meets the needs of its end users, that is the primary constraint upon meeting our vision for what software can do in the world. Insofar as a given software development team can execute well, they enable the mission for which they labor; insofar as they execute inefficiently or not at all, they fail the organization that commissioned them.

In that sense, software development is – or certainly should be – considered an engineering discipline. From the perspective of a software-intensive project, there exists the competing forces of cost, schedule, functionality, compatibility, performance, capacity, scalability, reliability, availability, security, fault tolerance, and resilience, all in the presence of technology and business churn. Balancing these forces is very much an engineering activity. There is no such thing as a *perfect* design or a *perfect* system; indeed, the very presence of any new system changes the way its stakehold-

ers view the world and thus alters their vision for what that new system should have done in the first place.

We as developers are the ones who do the heavy lifting, creating, and rearranging the components that make up our software worlds to form systems that balance these forces.

As developers, we have all had our share of bad days: days that our operating systems, networks, workstations, and co-workers conspire against us to suck all productivity out of the air; days that our bosses or their bosses or our customers hammer us for errors done or for functions left undone; or days that turn into nights and back into days again as we chase some elusive gnome from our system.

These are the days of living as a net-slave [2], a microserf [3]. After abiding such days during which we labor to build artifacts that live in the realm of nanoseconds, sometimes we long for a life with “no unit of time shorter than a season” [4].

Still, most of us come to the profession of software development deliberately, typically because we like to create things from pure thought, things that give life to our machines and that matter to our organizations, perhaps even to the world. For others, software creeps up behind us and grabs us by the neck; although we may secure an uneasy truce with it even though we may not be code warriors, we still require some degree of development skills so that we can wrestle that software to the ground and direct it to carry out our will. Either way, as an intentional or as an accidental developer, we build things that the rest of the world needs and uses and yet are often invisible to them.

For this reason, it is both a privilege as well as a deep responsibility to be a software developer.

It is a privilege because – in spite of some inevitable dark days – we collectively are given the opportunity to create things that matter: to individuals, to teams, to organizations, to countries, to our civilization. We have the honor of delivering the



stuff of pure intellectual effort that can protect, defend, heal, serve, entertain, connect, and liberate, freeing the human spirit to pursue those activities that are purely and uniquely human.

Paul Levy, Rational's chairman, once noted the following:

Ultimately, building software [is] the world's most important industry. Software today allows a brother in San Jose to call a sister in St. Petersburg. Software today speeds the process of drug discovery, potentially curing Alzheimer's. Software today drives the imaging systems that allow the early detection of breast cancer and other maladies. Software controls the passive restraint systems and anti-lock breaking systems that save children's lives in automobiles every day. Software powers our communications and transportation technologies. Software allows us to peer deep within ourselves and study the human genome. Software allows us to explore and understand our universe. And, make no mistake about it, we are just getting started. [5]

Simultaneously, we have a deep responsibility. Because individuals and organizations depend on the artifacts we create, we have an obligation to deliver quality systems using scarce human and computing resources intentionally and wisely. This is why we hurt when our projects fail, not only because each failure represents our inability to deliver real value, but also because life is too short to spend precious time on constructing bad software that no one wants, needs, or will ever use.

As professionals, we also have a moral responsibility: Do we choose to labor on a system that we know will fail or that might steal from another person their time, their liberty, or their life? Questions like this have no technical answers, but rather are ones that must be consciously weighed by our individual belief system as we deploy technology to the world.

At the very least, the consequences of our failure may be as simple as the delivery of annoying software, which behaves in unexpected ways or is so fragile that it drives the user rather than letting the user drive it. Such software wastes our time and gets in the way of accomplishing real work. At the other extreme, the consequences may be life threatening: The software fails, and people die.

Across this entire spectrum of bad software, it is partly a failure of the team in the

sense that the *organization* failed to deliver a useful system that worked. However, it is ultimately a failure of the *individual*. Denying all responsibility by hiding inside an organization is no excuse for this kind of failure.

Personal responsibility can manifest itself in a variety of ways: arguing against unrealistic schedules, working out of the box where it might yield a solution that sidesteps the current barriers to progress, expecting quality, and demanding the best from your colleagues. To do otherwise permits an environment in which a succession of lies is permitted to flourish, with the inevitable delivery of bad software.

Thus, software development is ultimately a human activity, not only because it emanates from the human intellect, but also because it requires the cooperative activity of others to make it real.

As professionals, we therefore constantly seek better ways to deliver quality software that matters, because the task is too complex to squander our time and our energy. This is why we analyze *why* projects were successful and similarly look at failed projects to learn from their mistakes. We then codify all these lessons learned in the best practices and processes that constitute our industry's tribal memory, such as found in the Rational Unified Process and in emerging ideas from eXtreme Programming. For the same reason, we agree upon common notations such as the Unified Modeling Language that help us communicate and reason about our systems.

Still, the demand for software continues to rise at a staggering rate. The ever-growing capabilities of hardware combined with increasing social awareness and economic value of the utility of computers create tremendous pressure to automate systems of even greater complexity. Thus, our privilege to carry out our skills continues, as well as does our responsibilities.

Indeed, as Levy said, "We are just getting started." Software is perhaps the most splendid material to build things: We create software from pure thought and shape it at will to form new worlds limited only by our imagination. As professionals, we labor to build quality systems that are useful and that work. As software engineers, we face the task of creating complex systems with elegance in the presence of scarce computing and human resources. Inescapably, economic realities demand that we build such systems purposefully and efficiently. Developing quality software that matters is fundamentally hard; ultimately, however, our rewards are great, for what we do as an industry changes the world.

And that is why I am – as we all should

be – both proud and humbled to be called a software developer. ♦

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## Note

1. See "ACM Forum on Risks to the Public in Computers and Related Systems." Peter Neumann moderator. <<http://catless.ncl.ac.uk/Risks>>.

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**Grady Booch**, is chief scientist at Rational Software Corporation and has been since its inception in 1980. He is recognized internationally

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# Job Satisfaction and Performance Viewed From a Two Dimensional Model

David B. Putman

Avionic Software Development Branch (U.S. Air Force)

*Traditional theory suggests that job performance is affected by job satisfaction; increase job satisfaction and you will increase job performance. However, engineering staffs within the government are prime examples of cases in which reality does not match the theory. While these engineering staffs continue to remain highly competitive and turn out high quality products, the government struggles to get a handle on the pay disparity between the private and public sectors. I contend that job performance is much more complex than the traditional theory. After getting no satisfaction from existing research, I am proposing another way to look at job satisfaction and job performance. I have developed a model that does not strongly contradict earlier research, while at the same time addresses some of the challenges to the earlier work. Hopefully, this model will become an additional tool that you can use when you are dealing with job performance issues.*

While working on my master's degree in business administration (MBA) in the early 1990s, I wrote a research paper on job satisfaction vs. job performance based upon the publicized work of others. The prevailing theory was/is that increased job satisfaction results in increased performance. Intuitively this theory makes sense. While countless hours of research and money have been invested in this theory, there still seems to be a problem with encouraging high performance.

From the research I performed in the early '90s, I could not come up with a convincing argument to back this theory. I concluded that the two attributes, job satisfaction and job performance, are too closely linked to one another, and that they affect each other. Here are cases in point: If a person is highly satisfied with his/her job, this would lead the person to want to do a good job and to perform well. On the other side is the person's ability level. If the person is struggling with performing the job, it may give the appearance that the person is a poor performer even though he/she may be exhausting a great deal of effort in trying to perform the job. This person's frustration then in turn leads to poor job satisfaction.

Some researchers have expressed similar ideas, such as *performance affects satisfaction* [1], while one researcher went so far as to say that there is no relation [2]. Intuitively we feel that there must be a relationship. After all, it makes sense in our minds, researchers continue their efforts to explore the concept, and many are hungry for the latest information on the subject.

Since 1994, the federal government has allowed the engineering pay scale to erode. In an organization stymied by a great bureaucracy already burdened by financial cuts, it is extremely difficult to find the funds necessary to cover an increase in

engineering salaries. Today, electronic engineers within the federal government perceive that they are making much less than their counterparts in the private industry. It is not surprising that recruiting is extremely difficult and that those leaving to take other jobs (e.g. attrition excluding death and retirement) are greater than the other job series on a military base, and morale has been better.

## New Measure of Performance

So what kind of effects has this had on job performance? Thankfully our performance is not as bad as one would predict. We continue to deliver high quality products (I am unaware of any customer complaints of bad quality). This observation stirred an interest in me to go back to the books and review the latest research on job performance. My results were the same as before: The two attributes, job satisfaction and performance, are too closely linked to one another. I was once again left with the feeling that they affected each other. Because of this observation, I started trying to find another way to look at job performance.

To begin, I looked at job satisfaction as a combination of three elements: task satisfaction, employment satisfaction, and market satisfaction.

Task satisfaction comes from performing the tasks required of the job. Increasing a person's salary may make an undesirable task more bearable, but it doesn't necessarily make it more enjoyable.

Employment satisfaction consists of elements such as personnel policies, benefits, career opportunities, work environment, style of management, fit in the organization, etc. Many of these elements are within the company's control; others are not. For example, there may be very little that a company can do for an employee who does not get along with his/her peers. The employer can try to assure that

all individuals are treated professionally, but the company cannot make the co-workers become close friends.

Market satisfaction is comprised of forces external to the company that affect the individual's job. Political situations and public laws can easily affect job dissatisfaction. An individual may be unhappy with having to conform to an OSHA law but the company cannot waive the requirement to improve an individual's job satisfaction. In most cases, market satisfaction will be consistent across the job market; the same external forces will be present even if the employee changes employers. However there are differences in the external forces affecting jobs within the government and those within the private sector.

The diagram in Figure 1 illustrates the assumed correlation between job satisfaction and job performance. The theory is that the employee's performance is in direct correlation to their satisfaction; improve their satisfaction and you will improve their performance.

In looking for a new way to look at performance vs. satisfaction, I started with a very basic view: comparing the satisfaction and performance of a specific task. I will refer to these as task satisfaction and task performance. Task satisfaction is strongly influenced by a person's aptitude; it is the satisfaction received by the employee for performing that specific task. *Task satisfaction excludes any outside influences on the individual's total job satisfaction.*

In developing this model, I considered the research of those who have performed a great deal of work in the field of management, including Peter Drucker, Herzberg, and Maslow (see Additional Reading). The test of this model was 1) it should not strongly contradict the work previously performed, and 2) it should help answer the challenges of the earlier work.

In Figure 2, I have broken the relationship of performance and satisfaction into four quadrants to further explore and explain the complexity of the relationship. This figure helps to understand the complexity while trying to keep the concept manageable. There are varying degrees of satisfaction and performance so it is difficult to state exactly where one would draw the line between high performance and low performance and between high satisfaction and low satisfaction. Each person is somewhere along those two lines. We can only try to understand what will happen as the employees move along those lines.

Figure 2 creates four quadrants. Two of the quadrants are the ones referenced by traditional theory:

- High Task Satisfaction and High Task Performance.
- Low Task Satisfaction and Low Task Performance.

The other two quadrants are:

- High Task Satisfaction and Low Task Performance.
- Low Task Satisfaction and High Task Performance.

My initial discussion using the two-dimensional model will look at the two axes from a positive viewpoint, i.e., the person wants to perform well.

**High Task Satisfaction and High Task Performance.** This individual loves his/her job. He/she has the aptitude, the skill, and resources necessary to perform the assigned task, and he/she performs the task quite well. A person in this quadrant may become so caught up in his/her task that the person does not realize that he/she has worked past quitting time.

**Low Task Satisfaction and Low Task Performance.** The manager should consider whether or not something is missing. Does the employee lack the aptitude, the skills, or the resources necessary to perform the task well? Being in this quadrant does not mean that the employee is not trying! From the employee's perception, the employee may be expending a great deal of effort in trying to complete the task. The employee may feel that he/she is doing everything humanly possible and he/she does not understand why management is unhappy with his/her performance. This person may experience very low task satisfaction because he/she finds it difficult or unfavorable to perform the task. This person may be a clock-watcher, never arriving early or staying late without being mandated and compensated.

**Low Task Satisfaction and High Task Performance.** Is a person in this

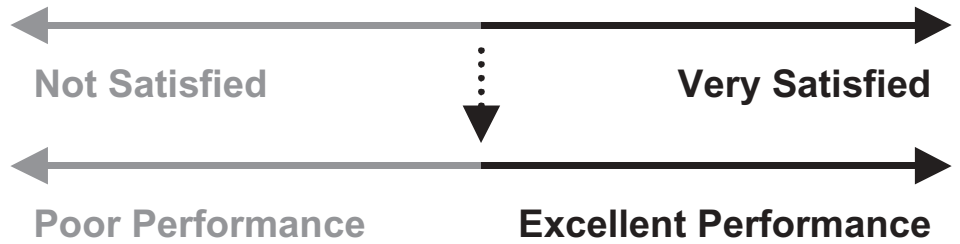


Figure 1: *Traditional Satisfaction vs. Performance Model*

quadrant really that rare? This person is indicating that they would rather be doing another job, but at the same time their personal values are such that they are giving this task their best effort. I suggest that this is a person that you want to keep. It may well be worth your effort to look at developing a graceful transition plan that would allow this individual to move to another position while minimizing the impact to your present operations.

**High Task Satisfaction and Low Task Performance.** From a positive viewpoint, a person in this quadrant loves his/her work but he/she is not performing as expected. The employee may find it hard to quit working on a task knowing that he/she can always make it better (i.e., a perfectionist that never finishes his task). Or, the person may enjoy what he/she is doing but lacks the aptitude, skill, or other resources necessary to do the task quickly.

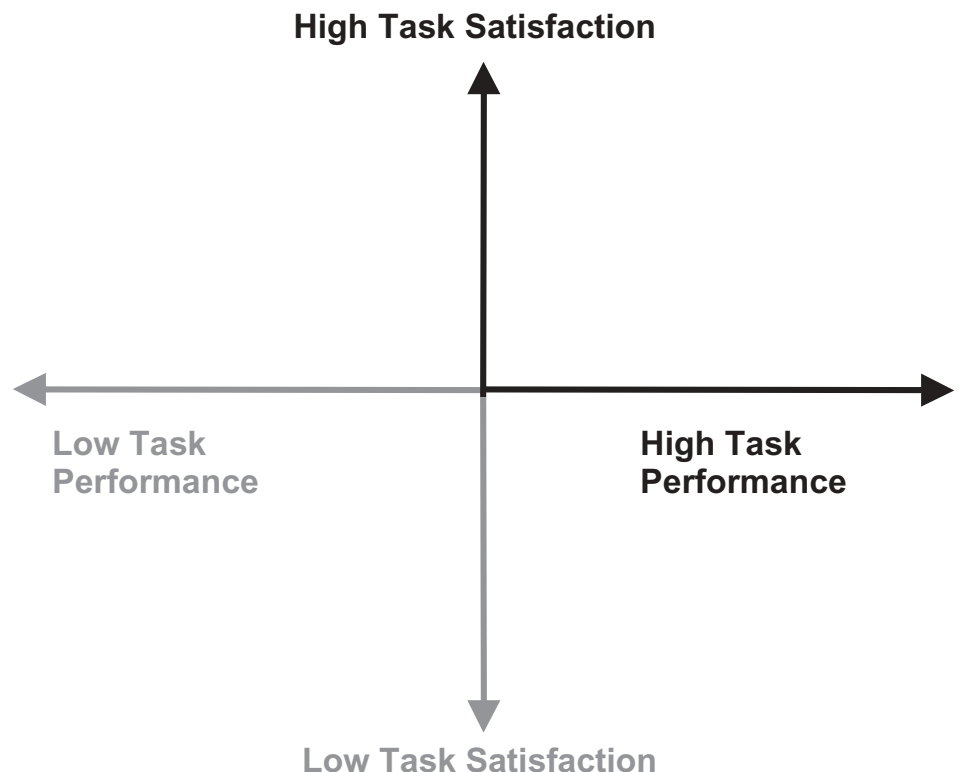
The discussion so far has been from a positive viewpoint. If the person's aptitude is such that they enjoy the tasks and they have the skills to perform the tasks,

then they have the potential of being in the high satisfaction and high performance quadrant. If the basic needs are not met, then increasing the person's salary is not going to improve performance. If a person *should* be in the high task satisfaction and high task performance quadrant and they are not performing as expected then the question is one of choice, "Why did the employee conscientiously or unconscientiously chose to move towards the left (decreased performance) in Figure 2?" Factors influencing the person's conscious or unconscious movements along the performance line include those related to employment satisfaction and market satisfaction.

While working on my MBA, I was fortunate to have the opportunity to take a course on business ethics [3] in which we explored moral reasoning. The four levels of moral reasoning are as follows:

1. Reasoning based upon "me." The kind of reasoning that is seen in children and criminals such as, "I want it therefore I'll take it."

Figure 2: *Two Dimensional View of Task Satisfaction vs. Task Performance*



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2. Reasoning based upon outside influence like public law or religious teachings such as, "It's against the law to speed, so I don't speed," or "It's a sin to steal, so I don't steal."

3. Reasoning based upon your personal value system such as, "I believe that by helping others I help to make the world a better place, therefore I volunteer to help others."

4. Reasoning based upon the greatest good for the greatest number. Political leaders are often faced with basing decisions on this type of rational.

The lowest level of moral reasoning is level 1; the highest level is to recognize the various levels and understand what level of reasoning you are using. For example, a person may have to base a decision using the greatest good for the greatest number even though that decision may contradict the person's own personal value system. Recognizing the different levels of reasoning will help the person understand why they are anguishing over a decision. Some decisions are made conscientiously whereas others are made unconsciously such as reactions.

What I am suggesting is that each person is consciously or unconsciously moving along the line from low performance to high performance based upon their own personal value system and their moral reasoning. This is why two individuals with similar skills, knowledge, and capabilities appear to be at different ends of the performance spectrum. Both employees may feel as though the company does not value them, but the first employee's value system is based upon the thinking, "Two wrongs don't make a right, and I'm still going to do my best." Whereas the other employee's value system may be based upon, "You get what you pay for. You pay me half of what I feel that I am worth, therefore I'll produce half of what I'm capable of producing."

We will never be able to pinpoint an exact correlation between job satisfaction and performance that will work in every situation. Doing a job well may improve job satisfaction, being satisfied may encourage a person to try harder, and each person's personal value system will have an effect on how he/she reacts to motivators and impediments. The best you can do is try to understand that performance is a complex issue, and recognize where you have control to address issues affecting an individual's performance. ♦

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## About the Author



**David B. Putman** is branch chief of the Avionic Software Development Branch at Hill Air Force Base, Utah. He has more than

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you and yours the very best  
this holiday season and the happiest of New Years.  
May it bring peace to an uncertain world.



## Beware the Engineer

I need to begin this column by saying that everybody has a few obsessions. What's mine? I am extremely punctual. My watch is set weekly (via WWV, the National Institute of Standards and Technology short-wave radio station). In fact, a few of my friends might call me obsessive-compulsive about time.

Shortly after I married my beautiful wife Marcia, my wristwatch broke. She truly showed she understood my needs by buying me a very nice and very accurate replacement – it gained just two seconds a week.

About three years ago, the battery in the watch died. I went to the jewelry store in the mall to get a new battery. A young person who couldn't have completed high school opened my watch, replaced the battery, and reassembled it. Later that evening, I noticed that the face of the watch (the round sheet with the numerals on it) had slipped a few degrees, so that the numerals no longer lined up correctly with the hands. I disregarded my wife's advice to take it back to the jeweler the next day. Instead, I made the following three observations: 1) I am a well-trained engineer, 2) I have a set of miniature tools, and 3) if the young person not-out-of-high-school could do it, so could I!

Let's cut to the end of the story. The watch manufacturer eventually sent the watch back to me with a note saying it would be cheaper to just buy a new one. Moral of the story: Engineers can't fix everything they think they can. (Moral No. 2: Never try to fix anything your spouse gave you).

Unfortunately, you now need to ignore the moral of this story (I know I already have) because you are an engineer. Would a heart surgeon decide to do brain surgery? No way. Would a licensed plumber offer to wire your house for you? Probably not. Would a person who has built databases offer to help design a real-time radar system? Sure! As a matter of fact, as engineers we are expected to be adaptable.

Look at an employer's rationale: "Nobody has ever done exactly what we're doing, so we are willing to take people who are just plain ol' good engineers." As a matter of fact, as engineers you are expected to be flexible to a degree unheard of in other professions. Let's face it – we are EXPECTED to think that whatever it is, we can do it!

I'm not saying this is a good thing, but in today's job market (where there is still a severe shortage of trained and qualified engineers), we are willing to take warm bodies and not look at their qualifications too closely. We're trained early to be geeks and to think that we can fix almost anything (with incomplete or poor requirements, poor management ... don't get me started!).

Last May, I wrote a BackTalk called "Week of the Geek." In it, I suggested several indicators that you might have geek-like tendencies. I asked for additional suggestions and received quite a few. It made me feel good to know two things: 1) people do read this column, and 2) ... I thought I was a geek?

As promised, here are some of the better geek indicators I received. If you read any of these indicators and think, "Gee, I do that!" well, it's not just me who thinks you're a geek, too!

- For entertainment, you read a book on mathematics or engineering.
- You have an integrated PDA/cell phone/mobile Web device. Extra geek points if you wear it around your neck.
- You own two or more computers, but only one of them is functional at any given time because you're working on upgrades to all the rest. Extra points if you have enough parts left over from previous computer upgrades to build a whole new computer.
- Choosing to buy flowers for your girlfriend vs. upgrading your RAM is a moral dilemma.
- In college you thought the phrase spring break meant mental fatigue failure (come on, think about it).
- The sales people at the local computer store can't answer your questions.
- You sit backwards on Disneyland rides to see how they do the special effects.
- You've tried to repair a \$5 radio.
- You look forward to Christmas so you can put the kids' toys together.
- You think that people yawning around you are sleep deprived.
- Your laptop computer costs more than your car.
- A real geek knows that "resistance is futile" is what the Borg says in Star Trek, but "resistance is useless" is what the Vogon say in "The Hitchhikers Guide to the Galaxy."
- Your watch does not automatically

synchronize itself, but you do have a bookmark on your browser pointing to the atomic clock.

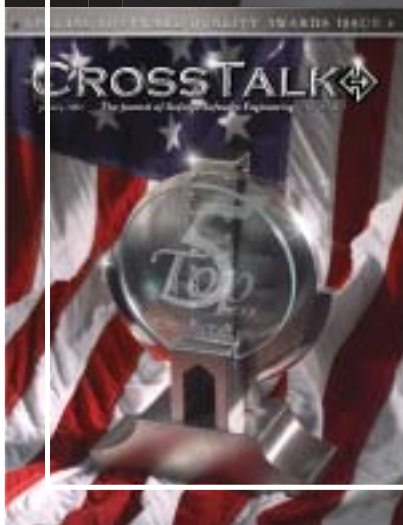
- You find yourself interrupting computer store salesmen to correct something they say.
- You've accidentally dialed an IP address.
- Your friends use you as tech support.
- You've named a computer.
- You have your local computer store on speed dial.
- You can't carry on a conversation without talking about computers.
- Co-workers have to e-mail you about the fire alarm to get you out of the building.
- You've found "stray" diskettes when doing laundry.
- Your computer has its own phone line – but your teenager doesn't.
- You check the national weather service Web page for current weather conditions (rather than look out the window).
- Your pet has a Web page.
- You get really excited when Yahoo adds your link.
- You've tried to use your Palm IR port to re-program Furbies.
- You're definitely an old or retired geek if you talk about the "good old days" where you could program your Timex/Sinclair with 64 KILOBYTES. Extra points if you know CP/M. Double extra points if you know PICK OS.
- You're an old or retired geek if you own both a pocket protector and a slide rule, and you know how to use them both without referring to the instruction manuals.
- You're an old or retired geek if you've ever mounted a magnetic tape reel.
- You have a license plate with a programming language on it (or are at least, thinking "Wow – That's cool! I wish I had one!").
- You wanted to know if my original list was posted to a list server.

Thanks to Dawn Jaeger, Lynn Knight, Christopher Smith, Robert Smith, James Meyers, Chuck Calhoun, Claire Jones, Ray Rangel, Clark Duplichie, Bob Mathis and Joe Urda, among many others.

— David A. Cook, Geek in Residence  
Software Technology Support Center



You have  
one last  
chance . . .



**2002 U.S. Government's Top 5 Quality Software Projects**

The Department of Defense and CROSSTALK are currently accepting nominations for the 2002 U.S. Government's Top 5 Quality Software Projects. Outstanding performance of software teams will be recognized and best practices promoted.

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The deadline for the 2002 nominations is December 13, 2002. You can review the nomination and selection process, scoring criteria, and nomination criteria by visiting our Web site. Then, using the nomination form, submit your project for consideration for this prominent award.

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