Military-Use Software: Challenges and Opportunities

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As the Air Force chief information officer, I focus on improving the management and application of information technology (IT) to improve decision-making in support of all Air Force missions. Increasingly, the effectiveness of our war-fighting capabilities is dependent on software, as most functionality in today's mission and support platforms is enabled by software. In the case of many IT systems, the software is the system. A collective challenge for government and industry is to improve our ability to rapidly develop and acquire robust software that meets today's needs and can evolve to support tomorrow's mission requirements.

Software has become the key element in enabling the military to field warfighting and combat support capabilities, and the importance of software will only increase in the future. The inherent characteristics of software provide three benefits for addressing military requirements: speed, linkage, and adaptability. Well designed and implemented software can be changed in minutes or hours versus the weeks and months required for hardware modification, thus permitting flexibility to address rapidly evolving mission requirements.

In addition, software governs most of the interfaces of today's systems. The flexibility of software enables us to quickly integrate separately developed systems permitting what our Air Force Chief of Staff Gen. John P. Jumper calls horizontal integration of our systems. We will achieve the vision of horizontal integration primarily through effective software application.

Finally, through software adaptability and linkage characteristics, software enables systems to adapt to new environments, new threats, and new concepts of operation. This adaptability is a key enabler to reaping the benefits of rapid technological change and providing the transformational battlefield envisioned by Joint Vision 2020[1]. With software's inherent flexibility come significant challenges that we must actively address if we are to realize the many potential benefits of software.

Unfortunately, many people believe that anyone can write reliable software – it only takes a little creativity. Creativity is important to problem solving when using software; however, building a software system for use in the military environment that is reliable and can be maintained at a reasonable cost requires the application of rigorous engineering discipline. Unfortunately, the software industry has not consistently exhibited this discipline in the design, construction, and testing of systems.

The consequence is that we have many commercial products that are riddled with logic flaws, which decrease the reliability of the target system, and the flaws are increasingly becoming the targets of system attacks using viruses and worms. Moreover, in some instances, we have seen that the inherent flexibility of software coupled with weak understanding of the required engineering disciplines has led to unrealistic expectations of what can be accomplished for software components of weapon systems. Finally, the fact that software can be easily modified has sometimes led to a desire to change requirements in mid-project without assessing architecture impacts and bypassing steps in the software engineering process.

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In short, the inconsistent application of engineering discipline to software development has resulted in a very mixed track record for software-intensive projects and disappointment and distrust on the part of military customers. As one Air Force four-star general recently put it, "I am a strong supporter of the benefits of information technology for improving our war-fighting capabilities, but I worry if the network will be available when we need it."

To overcome these problems of the past, I suggest that our industry partners and we in the military take a fresh look at our software development paradigms and processes. Specifically, I recommend that we focus on three areas that I submit can help improve our software development and support to deliver tomorrow's critical capabilities, bridging the current gap between expectations and delivery. These three areas discussed below are as follows: *integration* of software with other engineering disciplines, establishing a *culture* of software professionalism, and employing an *enterprise* solution focus.

Integration

In the past, software was often viewed as an upstart technology – a black art understood by many and mastered by few. As a result, we tended to create a separate infrastructure for dealing with software issues. We had separate software policies, processes, and organizations. In effect, we created a software stovepipe. In reality, individual software solutions must be integral to and tightly integrated with all components of a system, or in most cases with the *system of systems*. We need to integrate software into our overall systems engineering processes. Software must be an integrated part of our acquisition and engineering policy, processes, training, and metrics.

One promising solution is the Capability Maturity Model® Integration (CMMI®) as a disciplined approach to system development and process improvement. As the model is extended to acquisition activities, we will build on the groundwork and lessons learned from software development to address our management and technical responsibilities.

This integration of software into our overall system engineering processes requires actions by the acquisition, com-

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munications and information, and software communities. We must first ensure that software-knowledgeable personnel understand and apply systems engineering practices. Software must be recognized and managed as an engineering discipline. Likewise, software personnel, both government and contractor, must make the effort to integrate their knowledge and practices into the current acquisition and engineering practices and policies. Software technical jargon, software *geek-speak* if you will, and vague explanations of software issues can hinder progress. While software professionals have a responsibility to educate others on software issues, they also have a responsibility to make terminology, practices, and tools understandable to non-software practitioners: managers, system engineers, and customers.

To help effect this change within the Air Force, we are just beginning to institute the Air Force Software-intensive Systems Improvement Program (AFSSIP). The AFSSIP is predicated on an understanding of software as both a capability enabler and a potential risk area to be identified, and addressed as integral to our overall system engineering processes and disciplines. The success of the AFSSIP requires a new culture with a strong emphasis on training and education.

Culture

Integrating software capability into our existing practices requires a culture change that explicitly recognizes the importance of software and strategic employment of software-knowledgeable people in today's Air Force. No longer can we just say, "Don't worry, we'll fix it in software," and proceed to sign up to unreasonable estimates of software effort, or be surprised when major system problems manifest themselves during software integration and testing. We must move from reactive to proactive in managing software as a capability enabler and a potential system engineering risk area to be identified and managed. As one example, we've established the Air Force Software Steering Group to proactively address software issues at the Headquarters Air Force.

To ensure proper application of software knowledge, we must ensure that software and systems engineering education and training are robust and available to a broad range of our personnel. This renewed emphasis on education and training applies not just to personnel overseeing development of software, but also program managers, system engineers, and even system operators. With a software-knowledgeable work force, we can ask the right questions about software, better understand software impacts, and make decisions that are consistent with the state of the practice. This will result in the fielding of better software intensive systems. To this end, the Center for Systems Engineering at Wright-Patterson Air Force Base has been established to promote education, training, research, and consultation throughout the Department of Defense in the best practices of systems engineering, including software[2]. In the future, we will focus on extending this systems and software engineering emphasis to our program management curricula and senior leader development programs.

We also need government software professionals to be involved in the highest leverage activities in the acquisition of software capability. We must instill in our software professionals knowledge of systems engineering disciplines, including robust architectural design, as well as the expertise necessary for insight into the engineering activities of our contractor partners. We must recognize that software coding, while enjoyable and rewarding, is just one small piece of the larger systems and software engineering discipline. We need software professionals that understand the *entire* process well enough to ensure that the software being developed for military use will be effective and reliable within the environment and enterprise that it must operate.

Enterprise

In today's network-centric battlefield environment, it is clear that no single system or platform provides the full set of capabilities required by a warfighter. As a result, integration among systems becomes a key focus, and seamless connections between systems become a primary requirement. A part of our objective is to leverage machine-to-machine communication – that is, letting computers automatically retrieve, exchanging, and analyze information against established patterns or criteria, thus relieving our operators of this burden.

At the engineering level, these connections require software that is designed and built to facilitate integration into a global enterprise of interconnected systems and information. Our military-use software must be interoperable and highly available using current and emerging technologies such as XML and Web services. Our ability to engineer systems to permit immediate integration with future systems as the environment changes becomes a lynchpin to supporting the battlefield of tomorrow.

In Fred Brooks' seminal essays on software engineering, "The Mythical Man-Month" [1], he described a tenfold difference between making software that works (like what some of us may have written in an entry level programming course) and software that is integrated with all elements of the operating environment and hardened for rigorous use. His point was that robust software takes much more time and energy. Likewise, integration of software solutions into today's complex system-of-systems enterprise environment requires more effort and a focus on the integrated enterprise as the target environment.

Clearly, if the focus is not placed on the enterprise from the beginning of the software design, as with Brooks' example, it may require 10 times the effort later in the life cycle to enable the software to effectively perform in our horizontally integrated, network-centric environment. It is incumbent upon the software professional to understand the bigger target picture for any individual software solution. Clearly, this will become a critical success factor for our software intensive systems.

The use of architecture is fundamental to help in achieving an integrated enterprise vision. Architectures enable us to understand and visualize mission and system relationships and to manage the complexity of developing integrated systems. To realize the benefits of architectural engineering and avoid ineffective, duplicate, and costly systems, we must ensure our software is engineered to satisfy operational architecture requirements and within the context of the appropriate system and technical architectures.

One example of effective enterprise architecting is the Air Force's Global Combat Support System (GCSS-AF) Integrated Framework[3]. The GCSS-AF Integrated Framework architecture provides core enterprise services to all applications, thus reducing the cost of developing and integrating applications while promoting standards for security and interoperability. To date over 60 key logistics applications are accessible through the framework, drawing nearly half a million hits per day.

Conclusion

Software is a critical enabler to achieving today's warfighting and combat support capabilities. As we transform towards tomorrow's net-centric future, proper engineering of software will be increasingly fundamental to achieving our war fighting vision of tomorrow. The future vision for software within the Air Force must focus on integration of software as a part of our system engineering disciplines, changing the culture of our software professionals

and managers, and focus on software components as a part of our larger information enterprise. Focus on these areas will ensure that software, and our software professionals, will be able to deliver advanced military-use capabilities of unmatched quality with accelerated delivery timeframes.◆

Reference

1. Brooks, Frederick P. The Mythical Man-Month: Essays on Software Engineering. 1st ed. New York: Addison-Wesley, 2 Aug. 1995.

Notes

1. Joint Vision 2020 <www.dtic.mil/jointvision>.
2. Center for Systems Engineering <http://cse.afit.edu>.
3. To see the GCSS-AF Integrated Framework in action, Air Force members can access the Air Force Portal at <https://www.my.af.mil>. For additional articles on GCSS-AF, please see the Aug. 2003 edition of CrossTalk.

About the Author

John M. Gilligan is the Air Force chief information officer and the principal advisor to the Air Force leadership on information management, business processes, and information technology standards. He leads the Air Force in creating and enforcing information technology (IT) standards, and promoting and shaping an effective strategic and operational IT planning process. Gilligan also leads the Air Force in acquiring IT systems, ensuring that the conduct of IT processes is timely; cost-effective; follows all applicable statutes, regulations, and policies; and provides the best available capability consistent with requirements and within available budget resources. Prior to joining the staff of the secretary of the Air Force, Gilligan served as the CIO for the Department of Energy where he developed and directed the IT management strategies, policies, and practices for the department. His awards include the Meritorious Civilian Service Medal, the Presidential Meritorious Executive Rank Award, and the Presidential Distinguished Executive Rank Award. He has a bachelor's degree in mathematics from Duquesne University, a Master of Science in computer engineering from Case Western Reserve University, and a Master of Business Administration from Virginia Polytechnic Institute and State University.

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The United States Army

www.army.mil

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The United States Navy

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The United States Marine Corps

www.usmc.mil

This is the U.S. Marine Corps official Web site where you will find quick links to New From the Front, 2003 Concepts and Programs, the Marine Corps Institute, general officer biographies, Marine Band, and more. Information on the site is directed toward the Marines community, U.S. citizens, and the media. News is updated regularly and includes a photo gallery, press releases, and video archive.

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