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"Networked Systems T&E"

25th Anniversary

FEATURED CAPABILITY

The Cyber Warfare Integrated Network (CWIN), Northrop Grumman Corporation Integrated Systems Sector, El Segundo, California

SPECIAL ANNIVERSARY FEATURE

ITEA's Silver Anniversary: 25 Years Dedicated to Test & Evaluation

With contributions from ITEA's Past Presidents

TECHNICAL PAPER ABSTRACTS:

Framework for M&S-Based System Development and Testing in a Net-Centric Environment

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Department of Defense (DoD) acquisition policy requires testing throughout the systems development process to ensure not only technical certification but also mission effectiveness. Complexity within each new system, as well as composition into families-of-systems and systems-of-systems, combines with the extensive use of simulation in the design phase to multiply the challenges over traditional interoperability testing methodologies and processes. This paper presents a new methodology and process that integrates system development and testing intended to address the new challenges. The approach goes beyond current software development paradigms in that it rests upon and exploits dynamic systems theory, a modeling and simulation (M&S) framework, and model-continuity development concepts. The process can be applied to development of systems from scratch or in a form of reverse engineering in which requirements have already been developed in an informal manner. This paper illustrates the latter possibility, with an example drawn from a current effort to support automated test generation for an important tactical command and control standard. It also discusses how the new process represents an important addition to current methodologies in that enables simulation-based model continuity in developing and testing specifications that stem from the DoD Architectural Framework (DoDAF). Finally, the paper addresses the development of M&S and allied software development infrastructure that can offer web-accessible services for DoD's emerging Net-Centric Enterprise Services on the Global Information Grid.

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Net Ready Key Performance Parameter (NR-KPP) Test and Evaluation Strategy

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Joint Vision 2020 will be achieved with the introduction of a wide range of new technologies that will support network-centric warfare, from the Joint Tactical Radio System to unmanned ground vehicles. The Net Ready Key Performance Parameter (NR-KPP) has been established in part to ensure that these new systems will seamlessly integrate into a net-centric environment. The challenge to the test and evaluation (T&E) community is to first understand the NR-KPP and then to develop strategies to evaluate it. This challenge is made somewhat more difficult in that some key components of the NR-KPP are continually evolving. This paper presents an overview of the NR-KPP and suggests some strategies for evaluating it.

Distributed Net-Centric Interoperability Certification Testing

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For decades, the Joint Interoperability Test Command (JITC), as one of the key organizational elements of the Defense Information Systems Agency (DISA) Testing Directorate, has directly contributed to Department of Defense (DoD) combat operations success by providing interoperability test and evaluation services and technical support for emerging and legacy information systems through distributed testing. JITC continues to execute complex distributed test events and on-demand warfighter support efforts for legacy and new systems, as well as emerging technologies. Two examples of how distributed test networks allow the accomplishment of complex tests include the annual DoD Interoperability Communications Exercise (DICE) exercise, supported by Joint Forces Command and the Joint Staff, and conducted by JITC. Because JITC is DoD's interoperability certification authority, DICE is the sole DoD exercise whose primary purpose is to generate joint interoperability certifications. The second example is Internet Protocol version 6 (IPv6), an emerging replacement for the aging IPv4, which is not yet widely implemented in North America. IPv6 is an improved version of IPv4 that will coexist with, and eventually replace IPv4, in most networks. Because DoD runs the world's largest IP network, JITC is using distributed testing to assist the IPv6 Transition Office in assessing the maturity and capability of vendor IPv6 products being marketed to DoD.

Reengineering Telemetry: The iNET Systems Approach

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The type and complexity of weapon systems being tested on Department of Defense (DoD) ranges has changed drastically in the last several decades. However, the basic underlying architecture of telemetry that supports this testing has remained relatively unchanged. This paper examines an effort to reengineer telemetry to meet the challenge of testing the next generation of weapon systems.

continued…

Test and Evaluation in the World of Network-Centric Warfare

Ross Douglas
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Successful testing in the network-centric battle management environment still follows accepted practices established long ago. Detailed system requirements lead to a realistic requirement traceability matrix that allows detailed planning. What is new today, however, is the openness, early communication and vastly expanded coordination required by all participants in the system-of-systems architecture. The new watch phase could be "coordinate early and coordinate often."

WORKSHOP PAPER SERIES

Linking Force-on-Force Modeling for System-of-Systems Evaluation and Analysis

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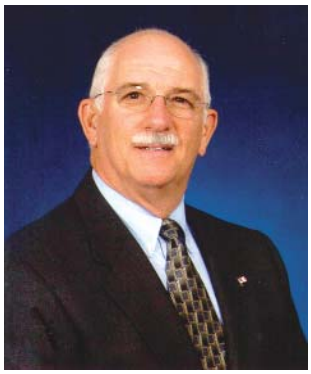
"The 'E' in Test and Evaluation" Workshop, hosted by the ITEA Francis Scott Key Chapter from October 5-7, 2004, in Baltimore, Maryland, covered various topics relating to improving evaluation efforts. This paper will address many of those ideas presented and discussed during the workshop, focusing mainly on the "Linking Force-on-Force Modeling for System-of-Systems Evaluation and Analysis" session, co-chaired by Geoff Robinson, Training and Doctrine Command (TRADOC) Analysis Center (TRAC), and Roe Mirabelle, Army Evaluation Center (AEC). Participants included Senior Analyst Mark Burrough, AEC, and Junior Analyst Jamie L. Mullen, AEC. Papers presented during this session were "Utilizing Force-on-Force Modeling for System-of-Systems Evaluation and Analysis," by Mark Burrough, and "Confidence-Based Approach to Force-on-Force Prediction. Part II Simulation-Based Prediction," by Dr. Larry J. Levy and Barry L. Mitchell, The Johns Hopkins University Applied Physics Laboratory (JHU APL, which also helped host the event).

Celebrating ITEA's 25th "Silver" Anniversary: 1980 - 2005

This year, ITEA is 25 years old, and we will formally celebrate this milestone during our **2005 Annual ITEA International Symposium**, which is being held in Albuquerque, New Mexico, September 26-29, at the Albuquerque Convention Center. Detailed information about all that will take place at the symposium is available on the ITEA web site, **www.itea.org**, and in the brochures mailed to each of you. I hope that ***all of you***—whether you are early, long-time members who helped create and shape our Association, or whether you are one of our many new contributors who will carry the torch in the decades ahead—will make every effort to attend. Along with an outstanding program centered on the theme **"Transformational Test and Evaluation—Programs, Methodologies and Lessons Learned for T&E in the Joint Force and Coalition Battlespace,"** we will recognize and express our appreciation to our Past Presidents, many of whom will be in attendance. You will note, starting on page 61 of this edition of the *ITEA Journal*, essays by each of these Past Presidents, who have honored us by sharing personal memories of the issues, events and relationships that shaped their time in office.

While preparing for our **Silver Anniversary Celebration**, I looked back on an article that appeared in our 1990 10th Anniversary *ITEA Journal*. It was a "Personal Remembrance" by ITEA Founder Dr. Allen R. Matthews—the man for whom our highest ITEA award is named. His comments were very interesting in light of our circumstances today and the latest efforts on acquisition reform. I hope as you read some excerpts that I have provided below, you will see how his thoughts truly remain relevant to this day:

■ ***"Need for Improved T&E:*** *In the 1970s, it became clear that an enhanced T&E process was needed within the Department of Defense. Basic flaws included inadequate T&E, off-the-record T&E, general use of outdated surplus operational equipment, lack of an R&D budget for T&E use, omission from industry of Independent Research and Development (IR&D) programs, weak interdisciplinary capabilities, limited professional staffing, inadequate T&E coordination, inconsistent financial costs, antique technology, component hardware instead of system testing, nonrepeatable tests, competition among test centers, inadequate scope of test reports, and so forth."*



Robert T. Fuller

■ ***"Founding ITEA:*** *During the late 1970s… the T&E community needed the cohesion that would be provided by a separate organization oriented to the technology/management of the unique T&E profession, which spanned not only government, industry and academia, but also the broad and separate organizational lines of the three armed services and the Department of Defense Headquarters."*

In our most recent issue of the *ITEA Journal* (June/July 2005), we announced the forthcoming retirement of our Executive Director, R. Alan Plishker. Alan has been critical to the growth and success of ITEA since assuming the role of Chief Administrator and Executive Officer in 1989. More importantly his guidance and leadership have sustained and expanded our programs, events and professional courses, thus gaining for ITEA the reputation of a top T&E professional educational association. He will depart when a new Executive Director is identified, but no later than March 31, 2006. **Michael A. Schall** is the chair of the search committee. His contact information is **mschall@itea.org**; telephone **(703) 354-0700**. **See page 20** in this issue of the *ITEA Journal* for a description of the Executive Director's position. Please pass the word to those you think may be interested in applying for this position, and ask them to contact Mike.

In concert with Alan's announced retirement in March 2006, the ITEA Board of Directors and the ITEA Committee Chairs are in the process of reviewing ITEA's current mode of operations. Along with the Board Members and Committee Chairs, I would like to encourage members to provide comments, concerns and recommendations on what changes should be considered. Please contact myself or any member of the Board of Directors/Committee Chairs, at **itea@itea.org**.

See you in Albuquerque. ❑

Wanted: A New Test Approach for Military Net-Centric Operations

David J. Carstairs

Electronic Systems Center, Air Force Materiel Command,
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Joint Vision 2020, the plan for military superiority by the Department of Defense (DoD), calls for the U.S. Armed Forces to be faster, more lethal and more precise than they are today.

David J. Carstairs

Achieving a decisive military advantage is the idea behind net-centric operations, which enable U.S. military forces to share all the relevant information about a situation. Achieving net-centric operations will allow U.S. forces to operate with greater initiative and situational awareness, allowing increased speed of command.

The idea is that everybody will receive all the information they need, when they need it. Any level of net-centric operations depends on a supporting environment called the Global Information Grid (GIG). The GIG provides the end-to-end set of capabilities, processes and personnel to manage and provide information on demand to warfighters, policy makers and supporting personnel. But providing information is only part of achieving military superiority. We also need rapid, agile test and evaluation (T&E) of command and control (C^2) enterprise capabilities to ensure system interoperability and operational security.

We are now fighting an enemy that changes tactics practically daily. We are fighting wars in Afghanistan and Iraq while keeping our eye on hotspots such as Syria, Korea and Iran. Yet, while hostilities throughout the world have increased during the past several years, U.S. force structure has been reduced. Military personnel are being reduced in number through personnel drawdown; facilities are being lost through Base Realignment and Closure activities; and weapon programs are experiencing budget cuts. We do not have the luxury of taking six months to react to new military crises.

Speed of command

In the former Cold War environment, combat capability was increased by adding more platforms, such as the U.S. Air Force's F-15 Eagle, Airborne Warning and Control Systems (AWACS) and others. But to offset the trend of using fewer platforms in today's world, DoD is using net-centric operations to generate battlespace awareness and to increase its speed of command. Improving speed of command puts decision makers more in sync with shooters and transforms warfare from discretely escalating steps to a continuous process.

Warfighters will be able to create new offensive and defensive capabilities by quickly reconfiguring their systems to accept and transmit data from sensors, as well as information about threats and targets. However, current T&E processes could be an impediment if net-centric capabilities need to be fielded faster than our adversaries apply new threat technologies. It is difficult to predict what new capabilities will be required, so our T&E infrastructure must be flexible enough to accommodate rapid evolution for a timely response.

One of the major problems facing DoD is providing sufficient interoperability throughout the C^2 enterprise. If we consider the generic enterprise as three increasingly complex levels, we can see how T&E becomes increasingly problematic. At the lowest level, optimizing individual programs or systems is straightforward. The second level increases T&E complexity because systems are combined into a system-of-systems in which interoperability is critical. The third level, the enterprise, is the most complex and the level at which joint and coalition operations are conducted. Current T&E concepts do not scale to this level because they do not address the many possible interdependencies among the complex systems in a C^2 enterprise.

Another problem in testing complex systems involves addressing all relevant mission threads. A mission thread is an end-to-end, ordered sequence of activities that provide a capability (for example, to attack and

destroy a target). To completely test a capability would involve testing all of its threads. Any new enterprise T&E effort should focus on evaluating overall mission capabilities and using mission threads for sample testing. In other words, if net-centric operations provides a capability, and that capability can reconfigure processes for many mission threads, we want to evaluate the envelope of enterprise capability, not just a set of constituent threads.

New paradigm is needed

As DoD continues developing its net-centric operational capabilities, a new T&E paradigm must be developed to keep pace with DoD's changing capabilities and the ability of our adversaries to throw new threats at us *(see Figure 1)*. Recognizing that testing all C² mission thread possibilities is impossible, the paradigm then has two parts. First is a network infrastructure for T&E that is always in place. This avoids the expense of building a network for every new capability and mission and then tearing it down after testing. Second is the ability to quickly test new technologies and capabilities.

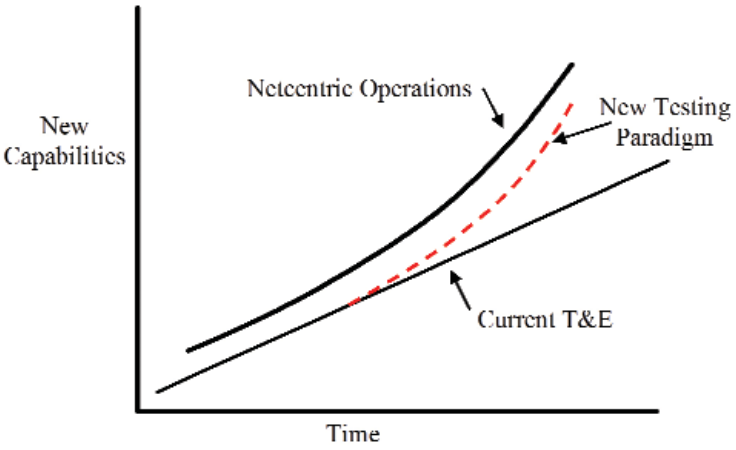


Figure 1. Network operations are changing so quickly that current T&E processes cannot keep pace. A new testing paradigm (dashed red line) needs to be developed to close the gap.

One solution is to create an infrastructure independent of the GIG. For now, call it a Collaborative Test Environment, or CTE. "Collaborative" is the operative word, both in planning a CTE and in using it. By necessity, a CTE will be a distributed environment—a federation of new and existing facilities from commercial, military and not-for profit organizations. Every military service should own a piece of it. Facilities run by not-for-profit companies such as the MITRE Corporation and the Massachusetts Institute of Technology's Lincoln Laboratory could also participate.

Linking facilities

Almost every organization that might be interested has one or more of the pieces that could contribute to a CTE: laboratories, test facilities, simulators and so forth. For example, the military services have facilities such as the:

- Joint Systems Integrated C² Center
- Air Force C² Enterprise Integration Facility (CEIF)
- Air Force Combined Air Operations Center-Experimental (CAOC-X)
- Joint Interoperability Test Command (JITC) Defense Information Testbed
- Army Digital Integrated Laboratory (DIL)
- Naval Center for Tactical Systems Interoperability (NCTSI)
- Contractor facilities

(Note: These facilities have not endorsed the strawman CTE concept, but are mentioned as examples of a potential CTE infrastructure.)

Save time, reduce GIG vulnerabilities

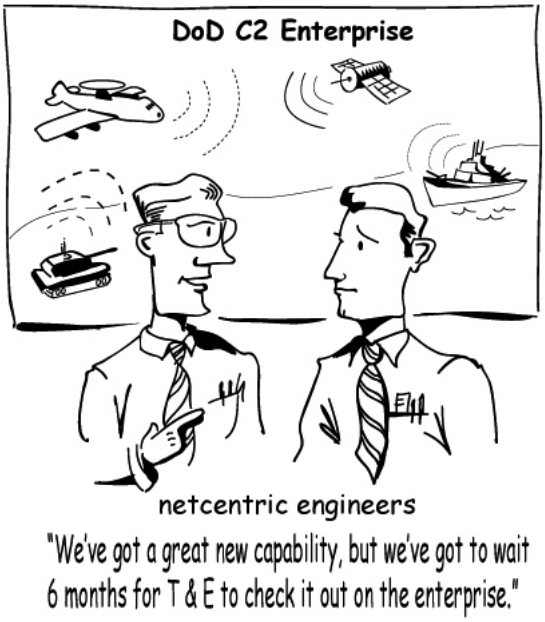
A CTE would allow DoD and U.S. allies and coalition partners to simulate parts of the network that may not yet exist, facilitating modeling evaluation of new capabilities in ways that have not been possible before. Such capability modeling/simulation would evolve to reveal potential responses to postulated and real threats. Those modeled capabilities and observed responses could then be verified in a CTE network environment to determine their operational benefits and to support rapid deployment. If a CTE could tap into the evolving C² enterprise network, it would eliminate the impractical need for replication of a large operational network time after time.

To develop the best net-centric operations capabilities, a range of CTE users should participate. As the Joint Distributed Engineering Plant (JDEP) has proposed, a collaboration of warfighters, testers and developers is critical. However, a CTE must be devoted to the evaluation of net-centric operations in

a realistic C2 enterprise. Early involvement in development activities by the operators and testers will make them more familiar with new T&E concepts for the C2 enterprise, making testing more efficient. The operators and testers can then help define and refine test procedures to make them more effective in achieving test objectives. Early collaboration also can establish confidence in test results and address difficult-to-test situations, especially those that require long durations in realistic operational environments. Early involvement would also facilitate designs of experiments to test the boundaries of the capability envelope, providing greater confidence in the robustness of new capabilities.

Vulnerability testing

A CTE would be useful in testing applications vulnerabilities, as well as their interoperability, so that the GIG is not disrupted and remains secure. An internal team of "good guy" hackers could poke at a CTE to discover any vulnerability. Security control would be a DoD responsibility. The goal of making data available to everyone anytime makes testing communications extremely important, both for vulnerability and operations. Currently, DoD communications connectivity exhibits tremendous heterogeneity with a wide variety of bandwidths, costs, security levels and contention. For example, an F-15 may not have the ability to receive data within the same bandwidth as the Army ground station that sends the data.



From a C2 enterprise perspective, the key is to begin pulling together disparate systems with vested interests in collaborative frameworks to address operational issues with minimal recurring communications infrastructure costs. Critical to this initiative is the ability to understand the limitations inherent in sending data from one platform to another or from one network architecture to another.

Physical infrastructure

Although connecting facilities takes time and funding (for example, to lease communications lines), these issues are typically not show-stoppers. Often, communications "pipes" that have been sized for simultaneous-use or stressing applications have underutilized capacity that could be shared by a CTE, resulting in cost savings. More flexible connectivity arrangements with constant low-level operational use is highly desirable for C2 enterprise applications and can accommodate brief on-demand bandwidth-spiking. Flexibility and adaptability are the keys.

Conclusion

A CTE would address an existing void in net-centric T&E capabilities for DoD's C2 enterprise. A CTE could provide rapid T&E of new C2 technologies and changing missions for DoD. With a readily available infrastructure, existing test networks could be flexibly linked together as needed, thus saving valuable resources. Given these challenges and the promise of enhancing our warfighting capability, is it possible that stakeholder organizations can collaboratively develop a new T&E paradigm for the C2 enterprise? ❑

***DAVID J. CARSTAIRS**, a member of the Senior Executive Service, is director, Network Centric Operations/Integration Wing, Electronic Systems Center, Air Force Materiel Command, Hanscom Air Force Base (AFB), Massachusetts. As director, he is responsible for a portfolio valued at more than $20 billion in three critical mission groups: Global Information Grid Systems, Enterprise Integration and Global Air Traffic Systems. Prior to his current assignment, he was director of Defense Information Infrastructure-Air Force Systems Program Office, Hanscom AFB. Previously, he was the system program director for the Strategic and Nuclear Deterrence Command and Control Systems Program Office, Peterson AFB, Colorado. Carstairs has held management positions in various Air Force communications programs and in acquisition support and development.*

What Effect Will Galileo Have on the MRTFB Infrastructure?

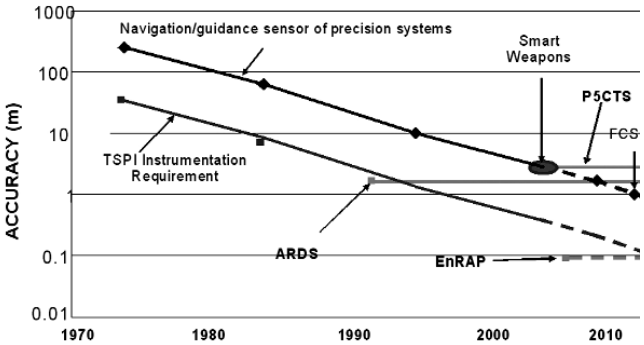
By G. Derrick Hinton

Since making its debut in the early 1990s, the Global Positioning System (GPS) has proven to be a cost-effective source for worldwide navigation, surveillance and tracking. GPS provides a source for computing highly accurate three-dimensional position, velocity and universal time. As such, GPS is widely employed on Department of Defense (DoD) smart weapons for navigation and guidance.

It is universally accepted that test equipment must provide a "factor of 10" better Time, Space, Position Information (TSPI) performance than the system under test. Until now, the test and evaluation (T&E) community has achieved the required level of performance by employing "differential" and, more recently, "kinematic" positioning, which requires a network of ground-based reference receivers. To date, warplanners have not proposed deploying such a network in an operational context, but this may change. The graph *(top right)* shows the trend in weapon system accuracy and the attendant performance of TSPI instrumentation.

The European Union (EU) is currently developing its own satellite navigation system, called Galileo. In 2004, the United States and the EU signed a cooperative agreement to "harmonize" GPS and Galileo. Galileo will comprise a constellation of 30 satellites in three orbital planes at an altitude of ~23,600 km. Galileo will broadcast 10 navigation signals in the L-band on three carrier frequencies with six of the navigation signals available to the civilian community. The Galileo signal parameters are very similar to the Modernized GPS satellites, which are organized in six orbital planes at an altitude of ~24,000 km. Modernized GPS will broadcast eight navigation signals in the L-band on three carrier frequencies, with four navigation signals available to the civilian community. Galileo does employ several key design features that offer performance advantages over GPS. These include the use of a hydrogen maser clock (versus rubidium) to enhance on-orbit accuracy and the coherent transmission of four signals with an effective bandwidth of 90 MHz (versus 20 MHz for GPS). 90 MHz has the potential to provided millimeter-level position accuracy.

The planned development of Galileo alongside GPS and its various augmentation services extends the number of satellite-based position and timing services. It is expected that both Modernized GPS (Block IIR and Block IIF with IOC 2010) and Galileo (IOC 2010) will be appropriately exploited by warfighters to achieve greater navigation and guidance accuracy while having better anti-jam performance. The T&E community must, in turn, enhance today's instrumentation to meet the test requirements of these higher-accuracy weapons. It is envisioned that an integrated GPS/Galileo instrumentation set must be developed as a baseline to achieve the TSPI accuracy required for future T&E. In addition, it is imperative for the T&E community to actively participate in the next-generation GPS III (FOC ~2030) constellation design/development phases, to support future T&E needs and performance requirements.



The Galileo spectrum was carefully chosen to facilitate system compatibility (non-interference when the two systems operate separately) while ensuring system interoperability (the combined use of the two systems). Compatibility/interoperability will allow the development of an integrated, low-cost GPS/Galileo-based TSPI set, which will significantly enhance the capabilities of a GPS-only TSPI set.

The integrated set would have access to more than 50 satellites. This added number of satellites would provide greater signal coverage and availability in urban and GPS-denied environments. More importantly, the added number of satellites would also enhance the achievable TSPI accuracy when both GPS and Galileo signals are available in the following way: The highest level of GPS-based positioning accuracy is provided by using the phase of the carrier signal (as opposed to the code signal). This carrier-based phase method, used in kinematic positioning, has been shown to provide cm-level accuracy. However, this method must first determine "carrier phase ambiguities." This process is very sensitive to environmental error sources and the number of simultaneous signals that are available for processing. An integrated GPS/Galileo set would increase TSPI performance by increasing the efficiency and reliability of the ambiguity resolution process. Because, for the reason stated above, a tactical weapon could not practically employ kinematic positioning; the resultant accuracy of the integrated set potentially can provide the "factor-of-10" accuracy advantage required for the GPS/Galileo-equipped tactical weapon.

But will it? Time will tell… Galileo is still under development, and GPS has not finished its system enhancements. But one thing is certain: The T&E community must explore integrated GPS/Galileo technology and be ready to exploit the increased accuracies offered by these systems, both in combination and standing alone. ❑

G. Derrick Hinton *is program manager, Central Test and Evaluation Investment Program, for the Joint Investment Programs and Policy deputate under the Defense Test Resource Management Center. He is also chairman of the ITEA Technology Committee* ***(itea@itea.org, Attn: G. Derrick Hinton, Chairman).***