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"Distributed Testing"

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TECHNICAL PAPER ABSTRACTS:

Experience with Distributed Testing

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Distributed testing has been in development in U.S. Army test and evaluation for more than 10 years. The impetus comes from the requirement to test systems-of-systems, particularly the Future Combat Systems, but any network-centric program will produce the same requirement. The technology to realize distributed testing arises from the modeling and simulation program known as the Virtual Proving Ground. Beginning with constructive simulations, non-real-time systems and dial-up communications, the capability has evolved to a fully networked collection of test centers, simulations, laboratories, live platforms, protocols, processes and personnel that can provide the operationally realistic environment for evaluating test articles. The natural extension to a joint mission environment test capability is demonstrated, and results are presented to delineate lessons learned, current needs and a path forward.

Distributed Testing: Helping the U.S. Army Develop a Network-Centric Warfare Capability

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The Army Developmental Test Command identified test requirements for network-centric warfare systems and initiated a planning process for identifying solutions. Advent of the Future Combat Systems moved the process from planning to technology development, with a primary result being the current distributed test capability. Further requirements for testing joint weapon systems, joint interoperability and the net-centric key performance parameter reinforce distributed testing as an essential test capability. This paper briefly sketches the history of distributed testing and describes some recent Army experience. The transition from platform to network focus is discussed, with implications cited for future testing.

continued…

Air Force-Integrated Collaborative Environment (AF-ICE) Development Philosophy

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Capabilities-based development planning and assessment challenges the existing analytic processes and modeling and simulation infrastructure available for conducting analysis for supporting the requirements development and acquisition processes. New tools, infrastructure and processes are needed to handle the complexities introduced by the networked systems-of-systems approaches to providing capabilities that are now common within the Department of Defense. The Air Force-Integrated Collaborative Environment is intended to provide a persistent, composable, flexible infrastructure along with a series of tools, standards, processes and policies for using the environment to conduct the continuous analysis required to support capabilities-based planning processes.

DISA Transforms Test and Evaluation to Support Net-Centric Operations

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The Defense Information Systems Agency (DISA) recently completed fielding the $800 million Global Information Grid-Bandwidth Expansion to provide 10-gigabit-per-second, secure, Internet Protocol-based transport services to the combatant commanders, Services and agencies. Now that the "information superhighway" has been built, DISA is pursuing ways to provide net-centric services, at Internet speed, to the warfighter. Initiatives such as Net-Centric Enterprise Services and Joint Command and Control lead the way in meeting this goal. DISA's Test and Evaluation Directorate is transforming to support these initiatives.

DEVS/RMI—An Auto-Adaptive and Reconfigurable Distributed Simulation Environment for Engineering Studies

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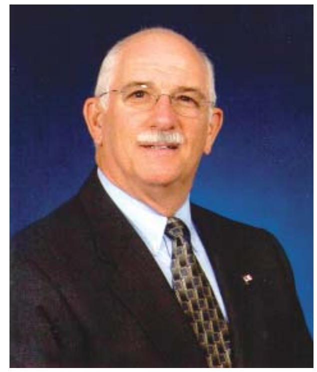
With the increased demand for distributed simulation and testing environments to support large-scale modeling and simulation applications, much research has focused on developing a software environment to support simulation across a heterogeneous computing network. This paper presents a new implementation of the Discrete Event System Specification (DEVS) formalism, called DEVS/Remote Method Invocation (RMI), a natively distributed simulation system based on standard implementation of DEVS. The objective is to distribute simulation entities across network nodes seamlessly without any of the commonly used middleware. The DEVS/RMI system also is built to support auto-adaptive and reconfiguration of simulations during run-time. Because Java RMI supports the synchronization of local objects with remote ones, no additional simulation time management needs to be added when distributing the simulators to remote nodes.

Spring is upon us, and new growth will soon remind us all of new possibilities that lie ahead. Your Association leadership has not been standing idly by, but working hard to prepare for a new era for ITEA. Our foremost efforts have been focused on the search for a new ITEA Executive Director to relieve retiring R. Alan Plishker. The search process has gone well, with the goal of having a selection presented to the ITEA Board of Directors by the end of March. When the new Executive Director is in place, ITEA will begin the development of an ITEA Strategic Implementation Plan based on the current 2003 Strategic Plan. This plan will focus the Association's efforts over the next five years to ensure two critical goals: that belonging to ITEA continues to fully support individual and corporate membership expectations; and that we work to sustain ITEA's place as the premier International T&E Association. Stay tuned.

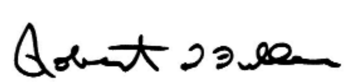
Alan Plishker, ITEA's Executive Director since 1989, has, as he's always done in all aspects of his job since the beginning, been working diligently to make this transition go as smoothly as possible. His tireless, steadfast leadership over these past many years has enabled our Association to grow and prosper, not only from a membership and financial standpoint, but also from the perspective of creating for ITEA a status as the leading International T&E Association. Alan's outstanding contributions to our Association have been innumerable; we applaud his efforts in developing ITEA during its formative years; and the Association will continue to reap the benefits of his knowledge and stewardship for years to come.

This time of year is also when we are regaled by the entertainment industry's numerous award shows. It is easy to make light of these festive and highly promoted events, but we have to give credit to an industry's ability to bring attention to those individuals in their profession that have performed at a level to be recognized as the best of breed. No profession should fail to recognize its own for superior achievement and life-long accomplishment. ITEA will again recognize individuals who have also demonstrated superior achievement and life-long accomplishment in the field of T&E at this year's Annual ITEA International Symposium in Orlando, Florida, October 30-November 2, 2006. Now is the time for you to make a commitment to submit an award nomination to recognize a colleague, a subordinate or even a superior who deserves recognition for his or her accomplishments in T&E or related fields over the past year. Please see Association News, beginning on page 61 of this edition of the *ITEA Journal,* for more information.



Robert T. Fuller

Finally, on a separate note, on June 7, 2005, then-Acting Deputy Secretary of Defense Gordon England authorized a sweeping and integrated assessment to consider "every aspect" of acquisition, giving rise to the Defense Acquisition Performance Assessment Project, which has come to be known as the Kadish Committee Report, accessible on the Web at *http://www.defenselink.mil/pubs/pdfs/DAPA%2012-22%20WEB%20Exec%20Summary.pdf* for those who have not seen it. The report "recommends reducing government-induced instability through an integrated transformation of the major elements of the larger Acquisition System that can reduce cost, enhance acquisition performance and accelerate by years the delivery of key capabilities." The report goes on to say that, "The current Operational Test and Evaluation process is creating program instability by introducing new requirements through the testing process. Instability of requirements is also introduced by policy mandates and changes to the acquisition rules." Further, "There is an inclination for the test community to drive increased requirements that are not otherwise identified in program baselines or by the Combatant Commanders." This report is a good read in my view and one I recommend to all. You may not agree with its statements and conclusions, but as T&E professionals, it is clearly worthy of your time and contemplation. ❑



"Plug and Test": The Goal of Distributed T&E

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Just over two years ago, I took on the challenge of leading the development of a Roadmap to help steer the Department of Defense (DoD) toward effectively conducting testing in a joint environment. DoD had figured out that military systems, even so-called "simple" Service-centric systems, were eventually going to operate in a much larger joint *and coalition* environment. The Global War on Terror has forced a change in DoD, with a realization that we needed to figure out how systems play together and their contribution to mission outcome. To win the Global War on Terror, the consensus within DoD is to be joint—in warfighting, training and acquisition. This means that we must "conceive joint" capabilities, develop "born joint" material solutions and "test as we fight" in a realistic environment. The "Testing in a Joint Environment Roadmap" was approved by the Deputy Secretary of Defense in November 2004, and set DoD on a course for joint experimentation, acquisition, training and testing. As a formal program of record, the Joint Mission Environment Test Capability (JMETC) is a net-centric enabler for conducting joint systems demonstrations across the experimentation, engineering, testing and training domains.

Michael D. Crisp

The Roadmap

The Testing in a Joint Environment Roadmap proposed changes that will enable the test and evaluation (T&E) community to "test like we fight." The Roadmap promotes:

■ *Institutionalizing* the need to test in realistic joint operational environments. The Roadmap requires changes to DoD policy and enforcement by leadership.

■ *Defining* capabilities in common, measurable warfighting terms—an essential element in establishing an evaluation continuum over the lifecycle of systems.

■ *Establishing* persistent connectivity between battle labs, hardware-in-the-loop simulations, developmental test facilities and live force instrumentation. This is necessary to achieve net-centricity and interoperability.

■ *Using* this persistent connectivity to achieve robust live-virtual-constructive (LVC) joint mission environments for joint experimentation, development, test and training. Persistent connectivity, with standardized processes, protocols and interfaces, is needed to make comparable the results of these communities.

As a step forward to conducting realistic and adequate joint testing, the Roadmap also recommended that DoD should:

■ *Share* test and Joint National Training Capability venues and resources.

■ *Allow* for increased use of the Guard and Reserve forces, where appropriate.

■ *Revitalize* modeling and simulation to achieve the DoD vision of a decade ago.

Taken as a whole, the Roadmap is an important enabler for acquiring capabilities that are "born joint," and testing legacy equipment and systems that are "made joint." The Secretary's guidance established new DoD policy *to be institutionalized*, that we *will conduct testing in a joint environment* where applicable, and directs that we *provide the resources required*. The stage has been set, and the process for joint testing has begun.

Understanding distributed T&E

Distributed T&E and its place within testing in a joint environment means different things to different people, depending on the type of technology at play. Distributed T&E provides the ability to demonstrate system performance capabilities by remotely interfacing other system elements, *their stimuli*, and users by forming stable, repeatable, dynamic and realistic joint mission environments. The system elements can be LVC or any combination thereof. Distributed T&E can be applied throughout the development cycle from requirements generation, through design, engineering, product acceptance and in-Service support. It is not a new environment, requirement, phase or method of testing, but rather, a more efficient and effective way of doing what we have always done. Instead of bringing in all interfacing elements to the test range, we merely "plug and test" into the T&E "net," so to speak. The idea is not new, as the commercial telecommunications industry long ago figured out that distributed operations naturally demanded distributed performance monitoring. It makes little programmatic sense, much less a sound business case, to separately fund program-specific test networks that are highly duplicative. A common, distributed test capability, as represented by JMETC, will provide the necessary joint context for DoD and industry.

Application to T&E

Distributed engineering has made significant strides in the DoD, but its use in T&E is only now just being realized. The Navy had great success using its distributed engineering capability to solve vexing combat system problems experienced at sea, but did not really apply it to new programs under development. The Air Force more efficiently trained pilots and analyzed platform contribution to mission outcome through distributed air combat simulations, but used such capability only in unique cases for T&E of weapons. For more than 15 years, the Army used its distributed engineering infrastructure to develop requirements for future systems, but never much for actual program engineering and testing.

It is only in the last few years that these capabilities have become integral aspects of the system development itself. Our systems have become so complex, with systems integration such a driving element of acquisition, that I can safely say that today, ***all*** of our most complex systems under development have been forced to build distributed engineering and test capabilities…unfortunately, true to past paradigms, most solely for their own use. Programs confidently assert that they can now "plug and test," but for the most part, they can do so only within their own mission arena under specific program applications. Unfortunately, we continue to be very adept at ensuring that every garage in the neighborhood has its own proprietary approach toward distributed systems testing. The problem is that we just cannot afford to do business this way.

Why now?

For the most part, the T&E infrastructure that continues to serve the best military in the world was built to assess functionality within and between elements of that system, primarily on a program-by-program basis. As system functionality grew, programs had to bear the cost of adding more test elements to their infrastructure. For critical capabilities, we even went so far as to build parallel systems for the primary purpose of testing. We were comfortable in our own little controlled T&E worlds as we watched our tool boxes grow.

Times have changed and, in some ways, our infrastructure was, and to some degree still is, slow to respond. The concept of net-centricity introduced government and industry to system interdependency so that each system element capitalized on each other's contribution to produce much greater overall effect. Systems no longer had real control over who they interfaced with. Their job was to push information up, without necessarily seeing what was going to be done with it. Small programs could now impact big systems in big ways. We accepted this "net-centricity" as a characteristic delivered to the user, but winced when applying it to engineering, much less testing. Why did the premise of distributed testing upset our paradigm of T&E so much that it became acceptable for each program to build, use and ultimately tear down a T&E capability, rather than trust entities outside of their immediate control?

A new vector

The Roadmap set a clear vector for DoD, attempting to mimic what private industry already knows. Keep it lean, and capitalize on what others have done or own to lower the cost of bringing goods and services to market. Fiscal realities, system complexity and interdependency of today's systems tell us that there must be a better way than having programs build their own engineering and T&E infrastructure only to see it dismantled at the end of development. Neither does DoD need another new "compliance" site to verify some abstract degree of "jointness" or another new formal test phase at the back end of development. The Roadmap lays out a coherent path to lash together the robust capabilities that already exist within and outside of DoD for the primary use of ***developers, testers and trainers***. Systems are both users and contributors to the network. The Roadmap is not just some new centrally controlled capability, but rather, a federation of capabilities under the Services' control for use by *everyone! JMETC is a corporate solution—it serves the users by bringing standardized business rules, processes, protocols and procedures that are fungible across DoD and industry*. This is truly a different paradigm. This is not about ownership, but of collaborative participation. We can no more centrally own or control the vast T&E infrastructure resident within DoD, the Services, industry and academia than we can own or control the Internet. We have to focus on better ways to plug and play across community boundaries.

Seeing the potential

Lashing together such a capability is not merely academic; it makes good business sense and could very well be the key to freeing us from oppressively long development cycles. Making it easier to borrow your neighbor's saw for awhile is certainly more cost effective than buying your own. Imagine the potential savings for a missile developer where engineers from the seeker division merely plug brassboard elements into the net and choose from a menu of simulated and constructed stimuli from other divisions (or government archives) across the country or around the globe. Imagine, instead of distributed events between divisions in one company, we have a dynamic plug and test capability between industry, government and academia. Users act as customers, selecting the elements of their test environment based on defining and understanding requirements, cost, pedigree and availability.

Small programs, which would otherwise defer testing with major integrating elements, have the chance to play early in their development at a much lower cost than if they pursued it on their own. Imagine a robust backbone of T&E capability similar to our interstate highway system, serving not only those myriad customers on short, point-to-point trips (for example, short-duration engineering efforts between two contractors solving a mutual interface problem), but at the same time those on more dedicated long-haul efforts (such as participating in a major orchestrated joint Service demonstration). Imagine being able to tap into live sensors in far away theaters of conflict and feed them into centers where warriors are assessing combat systems still under development. This is reality today, but it has to be done at the corporate level—in a persistent, efficient and cost-conscious manner. As system capability requirements and interdependency grow, so too will the environment in which system performance and contribution have to be demonstrated. A robust, distributed "plug and test" capability can realistically get us there.

21st-century solutions

Distributed engineering, T&E and training solutions are already a reality, but they are not focused at the corporate level. The question is whether we can achieve consensus and a common business approach to move the T&E community toward open partnerships and collaboration across the joint domain. Today, there are more than 40 distributed engineering and test networks just within DoD. Program managers are rarely rewarded for diverting scarce resources for investing in what might be a noble effort for the common good, because delivering on-time and within budget are top priorities. The reality today is that the investments to make this happen are already being made and multiplied many times over—*no new real investment is necessary*. Most programs are in a constant state of development, spiraling out products on a periodic basis while providing lifecycle support for fielded systems. For all intents and purposes, some degree of system emulation, be it digital or actual hardware-in-the-loop, is always up and running. When this is multiplied by almost a thousand systems in existence, one can see the lost opportunities to reduce excess T&E capabilities and program costs. JMETC is a first step in creating the joint mission environment, enabling joint solutions for the warfighter.

There are myriad process, facilities, policy and proprietary issues that we are working to overcome, but these are merely sidebars of a capability that is already here and expanding every day. We as a community have to embrace the potential of distributed T&E, just as the commercial sector has done, and set aside fears of losing control and discipline. Plug and test is here, and it works. ❑

MICHAEL D. CRISP serves as the deputy director, Air Warfare, Operational Test and Evaluation (OT&E), Office of the Secretary of Defense (OSD), Washington, D.C., where he is directly responsible for the adequacy of OT&E for air systems within the Department of Defense (DoD). His responsibilities include oversight for the conduct of major weapons systems assessments that are reported to the Secretary of Defense and Congress, and to support the participation of the Director, OT&E, on the Defense Acquisition Board and in the Defense Acquisition Executive Summary process. He also serves as program director for the Joint Test and Evaluation program, which funds joint Service projects to develop joint tactics, techniques and procedures to better support joint operations. He also oversees efforts to develop and implement the DoD Joint Testing in Transformation Roadmap, which calls for the creation of a joint test, training and experimentation infrastructure capable of supporting the conduct of each in a joint mission environment. A career Navy officer, Crisp concluded his 23-year naval career as senior military assistant to the DOT&E/OSD from June 1998 to June 2001, where he was the principal military advisor to the director, and where he coordinated efforts to work with the Service Operational Test Agencies and Congress on testing policies and procedures. While in the private sector, he was involved in program management for the Defense Information Systems Agency/Joint Interoperability Test Command Joint Distributed Engineering Plant program in the National Capital Region, and was responsible for program development and coordination with OSD, Joint Forces Command and the Services in developing a collaborative, distributed engineering, test and experimentation infrastructure for system-of-systems interoperability and integration testing. He holds a master of science degree in national security and strategic studies from the National War College; a bachelor of science degree from the U.S. Naval Academy; and memberships in ITEA and the National Defense Industrial Association.

The Evolution of Recorders for Test and Evaluation

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Recorders have always played a key role in the world of test and evaluation (T&E). In many T&E applications, data are passed in real time from a platform to a central control facility. Because datalinks can experience outages, the data are stored onboard the platform to ensure data integrity. In many cases, the datalink is not capable of passing all the data. When this occurs, only time-critical data are transmitted (while all the data are stored for post-mission retrieval and processing). This trend is graphically illustrated in *Figure 1*.

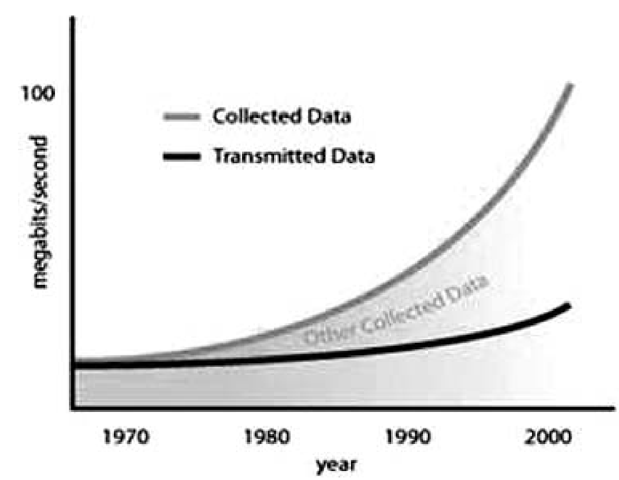

Figure 1. Graph illustrates transmission of time-critical data

Next-generation tactical aircraft will be tested using recorders that record in excess of 200 megabits per second (mbps) of data while only transmitting 5 mbps. Onboard recorders have evolved over time to meet the ever-increasing requirements of smaller volumes, operating in harsher environments, and storing larger quantities of data. Figure 1 graphically illustrates the amount of data being recorded onboard test articles, as well as the gap between transmitted and recorded data. This evolution has, for some time, leveraged commercial products typical in the commercial market. More recently, however, the T&E community has embarked on new technology to keep pace with the exponentially increasing demands for more data capacity.

In the early 1990s, small-volume recorders were made using solid-state, non-removable volatile memory with data capacity on the order of 2 Megabytes (Mbytes). These "state-of-the-art" devices required a lithium battery to maintain memory and an external computer to download the data via an umbilical cord; these two constraints greatly limited their utility. In the late 1990s, the storage media became commonly available in 220-Mbyte removable Personal Computer Memory Card International Association (PCMCIA) cards. These recording devices required no battery and were compatible with standard laptop PCMCIA ports. With the advent of high-capacity commercial products, including Smart Media, Universal Serial Bus (USB) drives and Compact Flash (CF), the test community is again turning to commercial technology to keep pace with T&E's high-capacity demands.

All of these technologies offer a significant advantage over PCMCIA cards, but CF (that is, the same devices used in digital cameras) has additional advantages, including high density, laptop compatibility and an association-controlled form factor. Current state-of-the-art CF storage is 4 Gigabytes (Gbytes) (such as that shown in *Figure 2*), but 10-Gbyte cards are just around the corner. The Test Resource Management Center (TRMC)-funded EnRAP program will employ 10-Gbyte CF cards.

Figure 2. Four-Gigabyte Compact Flash card

Although these devices have remarkable performance, T&E data storage requirements continue to increase. In the not-too-distant future, one envisions the need to recode Terabytes of data to meet the challenge of higher sampling rates and the availability of more data types, including high-resolution video. This will pose capacity and density challenges, as well as the need for faster data read and write times. To meet these needs, TRMC is investing in a new technology, referred to as the holographic memory cube (HMC).

Holographic data storage uses lasers to store information as two-dimensional (2D) "pages" of electronic patterns within the volume of special optical materials such as a photorefractive (PR) crystal. Holographic data are generated by recording the light interference pattern formed by an object laser beam carrying a page of optically modulated data (binary bits) and a reference laser beam in a cubic photorefractive crystal. Because these holographically recorded data are recorded in three dimensions and uniformly spread out throughout the entire PR crystal volume, massive redundancy is built into the holograms. The stored data will not suffer from imperfections in the media or point defects.

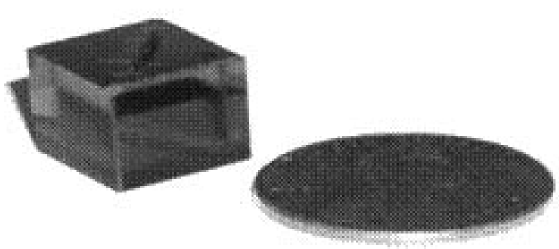

Figure 3. A photorefractive crystal cube smaller than a penny, capable of holding more than 10 Terabytes of data

Because several millions of data bits are placed on each page, and millions of pages can be stored in material the size of a sugar cube (see *Figure 3* for a size comparison), holographic systems offer the possibility of:

- Compact storage of many trillions of bytes (tens of Tbytes) of data;
- Transfer rates of billions or more of bits per second (tens of Gbits/s);
- Random access memory with single element data selection in 100 microseconds or less; and
- No moving parts.

To date, no other memory technology that offers all four of these advantages is close to commercialization.

A challenge of using these next-generation devices is that HMC technology requires a complex laser-based hologram recording and readout system. Today, this HMC input/output system is quite large, on the order of 40 cubic inches. TRMC is working with the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Lab to test and advance the utility of these devices. A brassboard HMC system has been integrated, laboratory tested and field-demonstrated for holographic memory data recording and retrieval. The system consists of state-of-the-art optoelectronic devices and components. Initial test results are quite good, but much more work is required before HMC will be used in military platforms, and then in digital cameras and iPods and, well, the list is endless… ❑

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).***