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Distributed – The Next Step in T&E

Bernard "Chip" Ferguson
Deputy Director, Interoperability and Cyber Test Capability, Test Resource Management Center (TRMC)

Neyer Torrico
Joint Mission Environment Test Capability (JMETC) Engineer, Scientific Research Corporation

Discovering problems when building complex products and systems is a normal part of any development process. The complexity and expense of today's military systems, and the current budget realities, clearly demonstrate the need for a rigorous Test and Evaluation (T&E) process. According to the 2012 T&E Management Guide from the Defense Acquisition University (DAU), "Correcting defects later in the system development life cycle has been estimated to add from 10 percent to 30 percent to the cost of each item. Such costly redesign and modification efforts can be reduced if carefully planned and executed T&E helps to detect and fix system deficiencies early in the acquisition process. Fixes instituted during early work efforts cost significantly less than those implemented later, when most key design decisions have already been made."[1]


Bernard "Chip" Ferguson

Early and frequent testing of a system's capability to operate in its intended environment will allow designers and system engineers to identify and correct fundamental issues with performance before they become operational specifications. Also, as the transition to net-centric warfare is accelerated, the requirement to successfully demonstrate interoperability between new and legacy systems will only increase the need for testing.

Distributed Testing is a methodology that allows testing early and often throughout the development and fielding process. Distributed Testing is not a new process, but it has only recently come to be an accepted T&E practice. As distributed methodologies become more ingrained into T&E planning and execution, Distributed Testing will prove to be an invaluable tool in reducing the cost and time necessary for fielding new warfighting capabilities and systems. The intent of this article is to provide a background of Distributed Testing and to discuss its potential within the T&E community. But first, a review of basic T&E concepts is in order, including the definitions of T&E terms, types of T&E events, and various modeling and simulation (M&S) tools that can be used to increase T&E effectiveness and cost performance.

Definitions of T&E Terms

A **test** is a program or procedure designed to obtain, verify, or provide data for the evaluation of any of the following: progress in accomplishing developmental objectives; the performance, operational capability, and suitability of systems, subsystems, components, and equipment items; and the vulnerability and lethality of systems, subsystems, components, and equipment items.[2] The output of a test is **raw data** that can be used to measure specific or individual performance factors. A test can be very resource intensive, in that it can require a large amount of manpower and equipment to obtain adequate and credible data.

In contrast, an **evaluation** is a process whereby raw data obtained during a test is logically assembled, analyzed, and compared to expected performance to aid in systematic decision-making.[3] The output of an evaluation is **analyzed information**, derived from the review and analysis of qualitative or quantitative data obtained from design reviews, hardware inspections, M&S, hardware and software testing, metrics review, and/or operational usage of equipment. An evaluation can be intellectually intensive, in that the evaluators must draw conclusions by determining how data from tests, models, and simulations relate and interact.

TEST
An event that obtains raw data to be used to measure specific or individual performance factors.

EVALUATION
The process whereby raw data obtained during a test is logically assembled, analyzed, and compared to expected performance to aid in systematic decision-making.

When test and evaluation are combined, the result is a process by which a system or components are exercised and the results analyzed to provide performance-related information. **Test and Evaluation (T&E)** is used at a variety of levels, including for basic technology, for components and subsystems, for a complete system or product, and even for several systems working together. The information produced by T&E has many uses to include design decisions, production decisions, risk identification, risk mitigation, and gathering of empirical data to validate models and simulations.[4] T&E is a process that ensures a product or system meets its designed capability by enabling an assessment of technical performance, specifications, and system maturity. This allows the developer to determine whether the product or system performs correctly and is appropriate for use by the customer.

Types of T&E Events

The Department of Defense (DoD) performs T&E on its acquisition systems and has in place a well-defined process to plan, conduct, and report for T&E. There are three distinct types of T&E defined by the DoD: **Developmental Test and Evaluation (DT&E or DT), Operational Test and Evaluation (OT&E or OT)**, and **Live Fire Test and Evaluation (LFT&E)**. DT&E addresses whether the product or system performs correctly ("Is the thing designed and built right?"); while OT&E addresses whether the product or system is appropriate for use by the customer ("Is the thing suitable and effective?"). LFT&E is a testing process that provides an assessment of the survivability and/or lethality of a conventional weapon or weapon system, and for now is outside the scope of our discussion on Distributed Testing methodologies.

The Defense Acquisition Guide, Chapter 9 (T&E), published by the DAU describes **Integrated T&E** as the collaborative planning and collaborative execution of test phases and events to provide shared data in support of independent analysis, evaluation, and reporting by all stakeholders, particularly the development and operational test and evaluation communities. But Integrated T&E includes more than just concurrent or combined DT&E and OT&E and it serves as a concept for test design, not a new type of T&E. Integrated testing focuses the entire test program on designing, developing, and producing a comprehensive plan that coordinates all test activities to support evaluation results for decision makers at required decision reviews.[5] Integrated T&E will be addressed below as a key advantage of Distributed Testing.

Chapter 9 of the Defense Acquisition Guide also identifies and discusses other T&E topics, to include: **Modeling and Simulation in T&E, Net Centric Operations T&E, Testing in a Joint Operational Environment, Information Assurance Testing, Interoperability Testing, Software T&E**, and **System-of-Systems T&E**. However, there is no significant coverage in any of the DAU products defining or discussing Distributed Testing. So for the purposes of examining Distributed Testing, it would be good to first offer a brief discussion of some of the elements that make up Distributed Testing. A key element in Distributed Testing is the use of Modeling and Simulation in T&E.

Modeling and Simulation Tools for T&E

Paragraph 9.7.2 of the Defense Acquisition Guide discusses M&S in T&E and states that "For T&E, the appropriate application of M&S is an essential tool in achieving both an effective and efficient T&E program." While M&S in T&E can be used to great effect, it is just a tool meant to compliment other T&E resources. M&S can be used to augment—not replace—live testing on a land, sea, or air range (commonly referred to as "open air testing"). M&S can be used in planning to identify high-payoff areas in which to apply scarce test resources. Rehearsals using M&S can help identify cost effective test scenarios and reduce risk of failure. During the execution of test events, M&S can be used to provide a surrogate capability when it is too impractical or too costly to use real-world assets. This impracticality is particularly likely for capability testing or testing a system that is part of a system-of-systems (SoS).[6] So where appropriate, a program's T&E strategy should leverage the advantages of M&S.

All M&S used in T&E must be accredited by the intended user, generally the system's Program Manager or the agency responsible for the Operational Test. Accreditation can only be achieved through a rigorous Verification, Validation & Accreditation (VV&A) process as well as an acknowledged willingness by the user to accept the subject M&S for their application requirements. Therefore, the intended use of M&S should be identified early so resources can be made available to support development and VV&A.[7] The program should involve the relevant OT agency in planning the use of M&S, to ensure support for both DT&E and OT&E objectives. This involvement should begin early in the program's planning stages.[8] More detailed information on the applications of M&S in T&E, to include VV&A, is available in the Defense Acquisition Guide as well as in Service and other DoD Component guidelines.

In order to explore how M&S can be used for T&E, it is necessary to understand some basic concepts of modeling and simulation.

A **model** is simply a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.[9] A model can be a representation of an actual or conceptual system that can be used to predict how the system might perform under various conditions or in a range of real-world environments.

A **simulation** is an implementation of a model over time.[10] That is, it is a way to examine how a model behaves over time. Or more precisely, it is the process of conducting events with a model for understanding the behavior of the system modeled under selected conditions. Simulations may include the use of computer inputs, laboratory models, or mock-ups of actual products. Simulations are often programmed for use on a computer.

There are three basic types of simulations: **live, virtual, and constructive**. These are often combined and referred to as LVC Simulations.[11] The use of LVC Simulations forms the core capability of Distributed Testing.

> **Live simulations** are simulations in which real people operate real systems. For instance, military training events using actual equipment are considered simulations because they are not conducted against a live enemy.[12] For T&E purposes, live simulations may use equipment that is representative of an actual product, rather than the actual product itself. In addition, live simulations can be connected with virtual and/or constructive simulations.

> **Virtual simulations** are simulations in which real people operate simulated systems. Virtual simulations sometimes replicate or use actual equipment in a central role by exercising motor control skills, decision skills, or human-generated command and control. In many virtual simulations, the operators are immersed in a virtual environment that looks, feels, and behaves like the real thing. Virtual simulations can enable the testing of dangerous tasks at no risk to the operator and little risk to the equipment.[13] An example of a virtual simulation is an actual pilot operating in a cockpit replicated in a laboratory, but contributing operationally realistic inputs to an event.

> **Constructive simulations** are simulations in which simulated people operate simulated systems. Real people stimulate, or make inputs, to such simulations, but are not involved in determining the outcomes. Constructive simulations cover the range from a simple single system simulation to complex multi-simulation interactive configurations.[14] An example of a constructive simulation is a computer-generated aircraft run by a computer program that, while perhaps limited in capability, still injects operationally realistic inputs into a test event.

Some specialized types of simulations integrate actual hardware with other LVC models.

Hardware-in-the-Loop (HWIL, or sometimes called HITL) is one such type of simulation. It usually consists of the actual hardware, software, and external stimuli/drivers used to test the system's or sub-system's capability to operate in an environment simulating actual conditions. For the purposes of this article, HWIL simulations in T&E should be considered a methodology to integrate actual system or sub-system hardware in conjunction with other LVC models, and not be limited to defining a specific laboratory or system. HWIL simulations place prototype or actual products and working components in the simulation to demonstrate the capability to operate within a selected environment that closely replicates real-world operating conditions. This may be just a single small sub-system, or it could be very large and complicated, like a cockpit simulator of a fighter aircraft. The HWIL provides a system, or even SoS, environment in which the sub-system hardware can operate. The Guided Weapons Evaluation Facility (GWEF), located at Eglin AFB in Florida, is a good example of a HWIL. The GWEF provides test support for developing and evaluating precision-guided weapons in simulated "real-world" environments. An actual weapon's seeker and guidance components are tied into various computer-generated capabilities to provide operationally realistic environments and test conditions. Other examples of a HWIL could be using current/operational radio components for testing an upgraded command and control system, or using legacy radar receiver equipment to test a developmental shipboard fire control computer.

It is much easier to control a HWIL system environment than a live system in an open air test event. Individual parameters can be controlled in the laboratory. The hardware performs the normal role that it would have operating in a real environment. Runs can be repeated, parameters can be changed as required, and the hardware is never destroyed in the test.

Using HWILs, one can begin to understand system performance early in the development process, even before the product is completely developed. The degree of realism provided is dependent on the test requirements and based on the product maturity level discussed in the previous lesson. A HWIL can be used to include a real-world environment and components into early maturity testing. *That is why testing is done — to determine whether components work individually and also together as a system or even a SoS.* A HWIL can inject a realistic, simulated representation of the intended operating environment into the test, giving the product developers and test planners early insight into how the components will work together as a system or a SoS in a realistic setting. This early insight is especially important in allowing the developer to correct problems and faults before the product design is finalized.

Systems Integration Laboratory (SIL) is a relatively new innovation in simulations. One can think of a SIL as a HWIL on steroids. It provides a test capability that is a cross between a pure simulation and the final system. A SIL is a risk-reduction facility where the complete unit or system, including software and hardware, can be integrated and tested prior to building the first production prototype. The SIL will often start out with constructive models that are replaced by HWIL and actual subsystem hardware as the system matures over time. The SIL uses as many actual operating subsystems (e.g., hydraulic sub-system, engine and power train, flight controls, and computer resources) as is technically and economically feasible.

The SIL enables the system to be tested around the clock, through a range of normal and extreme operating conditions, in a very cost-effective manner. The 46 Test Squadron at Eglin AFB, FL, operates a SIL that replicates a functioning Air Operation Center. This operationally representative facility is used to conduct testing (mostly DT&E) on new and legacy Command and Control systems. Individual work stations can be manned by combat qualified mission controllers and operators who can receive and inject various operationally realistic inputs to a test environment.

So What is Distributed Testing?

All types of live, virtual, and constructive models and simulations can be connected or linked. In many cases, this is done with systems and capabilities (such as a HWIL or a SIL) that are not co-located. In fact, a distributed environment is a crucial element in using LVC M&S to support T&E. By sharing information through a Wide-Area Network (WAN) infrastructure, LVC capabilities can be linked around a base, around a city, or around the world to form a distributed environment. When this is done to support T&E, it is referred to as Distributed Testing.

No DoD-wide accepted definition of Distributed Testing exists as of the writing of this article. However, for the purposes of this article, Distributed Testing can be considered a process for linking various geographically separated LVC sites and capabilities together in a distributed environment, for use across the acquisition life cycle, to support and conduct the T&E of a subsystem, system, or SoS in a Joint or cyberspace environment.

DISTRIBUTED TESTING

A process for linking various geographically separated live, virtual, and constructive sites and capabilities together in a distributed environment, for use across a product's acquisition life cycle, to support and conduct the T&E of a sub-system, system, or system-of-systems in a Joint or cyberspace environment.

Distributed Testing can be used to integrate systems and subsystems that are still under development as well as mature systems that already exist, but are located at geographically separated facilities. It can also be used to compliment or in some cases, in lieu of, large-scale open air tests using actual, live, operational hardware for the systems involved. Conducting distributed LVC testing compliments live-only testing and provides the means for rapid integration of components and systems early in a product's developmental life cycle. It also provides an efficient means of adding realism to T&E by providing systems and capabilities not otherwise available, or by including separate but interrelated systems and subsystems. Conducting T&E by integrating components and capabilities early in a product's developmental life cycle will reduce the technical risk of components not working together. Complementing the risk reduction inherent in early Distributed Testing, is the cost savings of correcting technical deficiencies before they become part of the operational design.

While Distributed Testing is particularly suited for most T&E, such as assessing a data exchange between components, sub-systems, systems, or within a SoS, distributed methodologies are certainly not appropriate for all T&E. For example, Distributed Testing would not be appropriate for system performance testing, reliability testing, and other tests that do not include other systems or systems-of-systems. However, Acquisition Program Managers should strongly consider Distributed Testing in situations where necessary systems, components, or capabilities are not co-located in a central test site. That is, when testers do not have all the system's components in the same test location, they can connect the needed capabilities without the expense and difficulties of bringing them to a central test location. Also, Distributed Testing methodologies should be strongly considered when a system is required to demonstrate interoperability, which is the capability to work effectively with other systems. More specifically, when testers must show that the system under test works with other systems, Distributed Testing will prove to be a cost effective method for providing an operationally realistic environment for the system to operate in…even very early in its developmental life cycle. Lastly, while cyber security testing is out of the scope of discussion for this article, Program Managers tasked with conducting cyber T&E should consider the benefits of distributed testing methodologies which provide the needed infrastructure and capabilities.

Distributed testing methodologies have already demonstrated efficiencies across the developmental and T&E process to include significant savings in cost and time, improved risk reduction, and new and/or increased systems capabilities. The advantages realized by Distributed Testing include but are not limited to:

- **Integrated T&E** - As introduced above, Integrated T&E allows test events to share a single test point or mission that can provide data to satisfy multiple objectives, without compromising the test objectives of either the DT&E or OT&E. Early identification of systems and mission elements enables the development and execution of an efficient and effective DT/OT integration in the T&E strategy. This will allow an early "operational influence" into the developmental cycle. If done correctly, the enhanced operational realism in DT&E provides greater opportunity for early identification of system design improvements, and may even change the course of system development. While Integrated T&E does not replace or eliminate the need for dedicated Initial Operational Test and Evaluation (as required by section 2399 of title 10 USC, "Operational Test and Evaluation of Defense Acquisition Programs"), the goal is to conduct a seamless test program that produces credible data to all evaluators that addresses developmental, operational, and sustainment issues early in the acquisition process--when the issues are easier and cheaper to correct.
- **A near real-time Test-Fix-Test capability** - That is, as a test event uncovers flaws in a system, the designers can make a correction and then immediately conduct a re-test to ensure the flaw has been fixed. This is especially true of software and information exchanges used in Command and Control systems.
- **The ability of T&E Programs to "move data—not people"** - The distributed nature of the event means that large teams of data collectors and analysts need not be deployed locally for the test event. Data collection and most analysis can be conducted from the home station with near real time access to the needed test data.
- **A collaborative, virtual workplace** - Enables a connective relationship between geographically dispersed Subject Matter Experts (SMEs) and entities in the system-of-systems environment that they wouldn't have otherwise. This relationship can foster communication and feedback that can provide significant improvements to the systems under evaluation and across the spectrum of the mission area.

Distributed Testing can support all phases of the acquisition life cycle, specifically DT and OT, and clearly facilitates rapid acquisition. Yet, despite offering some significant advantages over traditional testing, Distributed Testing has been slow to gain acceptance in the DoD T&E community, in part because it requires testers to think about T&E in a new way. In recent years, the DoD has stood up a capability to provide a Department-wide capability that makes Distributed Testing more accessible. The Joint Mission Environment Test Capability has paved the way for more widespread and even routine use of Distributed Testing by providing the required network infrastructure, technical expertise, and several test tools that are readily available and cost effective to the entire DoD T&E community.

Joint Mission Environment Test Capability

The Joint Mission Environment Test Capability (JMETC) program, executed under the Under Secretary of Defense (Acquisition, Technology, and Logistics – AT&L) was established in 2006, with responsibility for execution assigned to the Director of the Test Resource Management Center (TRMC). JMETC is the DoD's corporate solution that provides a persistent and secure infrastructure by establishing network connectivity using the Secret Defense Research Engineering Network (SDREN) for linking distributed LVC T&E facilities, enabling the test and acquisition community customers to evaluate new and legacy systems and capabilities in a net-centric and Joint mission environment. JMETC supports testing across the full spectrum of the acquisition process for the distributed integration of live systems and simulations to support DT and OT, Interoperability Certification, Net-Ready Key Performance Parameter compliance and even cyber security testing.

JMETC has grown to over 75 functional sites, with 15 new sites planned, and 7 connection points to other networks. Although a great number of sites are military, academia and industry technology leaders are also part of the infrastructure. In addition, JMETC also provides a number of services to ensure that the components needed for Distributed Testing are available and functioning for the customer's test event. JMETC services include:

- Readily-available, persistent connectivity with standing network security agreements
- Common integration software for linking assets
- Distributed test planning, execution, and analysis tools
- Support to Acquisition Programs with the expertise to integrate distributed test facilities

JMETC does not conduct test events. Rather, JMETC support allows the T&E customer to minimize the technical risk associated with planning and executing a Distributed Test event by providing a persistent LVC infrastructure and the associated technical expertise and support needed to plan for and execute distributed events. This distributed capability enables a more robust T&E capability throughout the life cycle of a system. The support JMETC provides includes:

- Experienced and highly skilled distributed T&E experts who are deployed for distributed planning and operations
- A robust, secure, and reliable network
- Data exchange methodologies and solutions that have already been tested, proven, and put into practice

JMETC actively captures customers' needs and requirements. On a continuous basis, the JMETC Program Office steers test capabilities modernization efforts to improve distributed test capabilities. JMETC is the distributed T&E community's enterprise-level focal point for collecting and maintaining lessons learned about Distributed Testing, facilitating reuse of resources and improving the DoD distributed test capability.

JMETC supports customers from across the DoD focusing on defense acquisition programs. Current JMETC customers include the USAF Joint Space Operations Center Mission System and Three-Dimensional Expeditionary Long-Range Radar, Navy P-8A Poseidon Multi-Mission Maritime Aircraft (Increment 3), the Army Integrated Air and Missile Defense (Increment 2), Joint Tactical Networking Center, and the Apache Block III. JMETC also provides direct support to Service Operational Test Agencies and the Joint Interoperability Test Command (JITC). JITC evaluates the interoperability of defense acquisition programs in the most operationally realistic environment possible and determines if the system conforms to a Net Ready Key Performance Parameter (NR-KPP) or other applicable interoperability standards. The NR-KPP defines net-ready attributes required for both the technical exchange of information and the end-to-end operational effectiveness of that exchange. A JITC Interoperability Certification follows operationally realistic, end-to-end testing and is required of a system prior to fielding.[16] JMETC routinely supports JITC testing of major defense acquisition programs from all the Services, supplying the network infrastructure, technical expertise, and test tools needed for system-level interoperability evaluations. These systems include: the B-2B, Patriot Missile System, E-3 Airborne Warning and Control System, E/A-18G, Aegis and Aegis Ballistic Missile Defense System, Ship Self Defense System, Joint Tactical Ground Station, Forward Area Defense Command and Control, and the Littoral Combat Ship.

A good example of past successes for JMETC T&E customers is the Battlefield Airborne Communication Node (BACN) Joint Urgent Operational Need. Completed in August and September of 2010, the BACN program involved the integration of the BACN payload onto multiple platforms as a solution to an urgent in-theater need for beyond line-of-sight communications. The BACN payload is used to relay, bridge, and range extension for combat ground forces and supporting aircraft for Close Air Support and other battlefield interdiction missions. The Distributed Testing in the Fall of 2010 included live-fly assets, as well as Constructive and Virtual Simulations conducting Developmental Testing, and an integrated Operational Utility Evaluation. This JMETC supported distributed event demonstrated the efficient and successful integration of DT and OT despite many of the required test assets not being available on-site at the test location. The test agency reported that on this event they saved over $1.2M, which was directly attributable to using JMETC and Distributed Testing methodologies. However, the real impact was that this urgently needed combat capability was fielded—quickly!

Why use JMETC vs other network solutions?

JMETC is more than just a provider of the network infrastructure. JMETC has structured itself to provide both on-site and remote customer support. JMETC's distributed test expertise and continual customer support during event planning, preparation, execution, and post-execution analysis will ensure the ease of use and successful application of the JMETC infrastructure and tools. Services routinely provided by the JMETC Technical Team include:

- Assistance with planning distributed test events
- Standard interface definitions and software algorithms
- Local infrastructure network configuration support
- On-site engineering support during event
- Distributed test planning, execution and analysis tools as well as associated training
- Collaboration tools (e.g., VoIP, CHAT, VTC, virtual whiteboards, desktop sharing, etc.)
- Information Assurance tools and services
- Network performance analysis before, during, and/or after event execution
- Dedicated help desk

The JMETC Systems Control (SYSCON), located at Patuxent River Naval Air Station, monitors and assesses the end-to-end network infrastructure to ensure it will meet key distributed test parameters such as throughput, packet loss and latency. SYSCON personnel proactively troubleshoot the network through continuous analysis of the network performance characterization data to first identify potential anomalies and then work with local infrastructure and the WAN service provider to isolate, identify and resolve issues. In addition to providing network performance management, utilization monitoring and analysis, the JMETC SYSCON also serves as a helpdesk, both online and via direct phone support, for JMETC sites, users, and events.

The JMETC Reuse Repository, located at www.jmetc.org, is an online collaborative environment with relevant JMETC and Distributed Testing information. The Reuse Repository is structured to give the user community easy access to general program information, frequently asked questions, lessons learned, fact sheets, opportunities for distributed test event collaboration, and insight into the JMETC capabilities. It also includes links to the JMETC Help Desk, an anthology of sites on the JMETC infrastructure, information on past events, the latest middleware, software, documentation, test event lessons learned, and web-enabled collaboration services.

JMETC is continuously reviewing customer requirements to ensure the infrastructure is addressing the distributed testing community's needs. Also, JMETC is aggressively addressing cyber security testing requirements *(See the December 2013 issue of the ITEA Journal)*. With the addition of the National Cyber Range and other cyber security initiatives, JMETC is investing in capabilities that will be needed for building cyber T&E infrastructure, methodology, workforce, and tools. Further descriptions of cyber security T&E at the National Cyber Range, will be presented in future articles in this Journal.

In short, JMETC concentrates on the infrastructure so the T&E customer can focus on their test. JMETC reduces the cost and time to plan and prepare for Distributed Testing in a Joint environment, largely due to the persistency and robustness of the environment, availability of subject matter experts to support customers, common integration software for linking assets, and tools specifically designed to support distributed testing. JMETC's unique total package support allows the T&E customer to minimize the technical risk associated with planning for and providing the Distributed Test infrastructure so that they can truly focus on their test requirements, planning, and execution. For more information concerning JMETC products or capability, contact the JMETC team at www.jmetc.org.

Distributed Testing: The Next Step in T&E

Distributed Testing will enable a rapid transformation of T&E. What does that mean? As depicted in Fig. 1, **Distributed Testing will enable agile, streamlined, affordable and continuous T&E**. That is transformational! Program Managers and Test Directors can employ Distributed Testing through the use of the JMETC infrastructure and services to take advantage of more frequent, smaller events, and even one-on-one systems interoperability tests as well as large-scale scenario-based testing. Distributed Testing can be a mix of various combinations of LVC assets and capabilities. Having the persistent infrastructure capability that JMETC provides will allow program managers to identify problems early in the system's developmental cycle – when they are significantly cheaper and easier to fix. The use of smaller scale and frequent distributed T&E events will allow T&E programs to test earlier and test more often in a program's life cycle. Operational testers will be able to leverage appropriate developmental test data and provide an early operational influence to a systems development. This integration of T&E across the developmental life cycle will enable efficient testing with legacy systems and allow for interoperability testing with new systems. Distributed Testing will also support distributed data collection and data analysis. JMETC is currently supporting a major acquisition program that is interested in using distributed methodologies planning to save $4 million in travel costs for data collectors and test engineers alone.

The concept of transforming T&E is not new. The Office of the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation (DASD[DT&E]) and Director, Test Resource Management Center, has embarked on an effort to deploy improved capability to the DoD in an effective and timely manner. This effort requires "that programs get the development right and verify it through rigorous DT&E before a system or program is committed to production. In other words, we must Shift Left!"[17] The Shift Left initiative fundamentally is about improving DT&E to set the conditions for successful production and deployment. Shift Left achieves this goal through earlier identification and correction of failure modes, thereby avoiding the high costs of late cycle repair and reducing the impact of fielding capabilities that do not satisfy requirements.

There are three key elements of Shift Left: *earlier testing for interoperability, earlier testing of cybersecurity, and conducting DT&E in a mission context.* While shifting tests of interoperability and cybersecurity earlier in the life cycle forms a more comprehensive set of pre-production developmental test activities and gains test efficiencies, mission context is essential to adequately evaluate (and expose potential failure modes in) the four critical developmental issue areas: performance, reliability, interoperability, and cybersecurity. Bringing mission context into DT&E does not mean program managers have to rehearse the initial Operational Test and Evaluation, but getting the system out of the lab to see how it will actually be used always should be an important part of DT&E. Interoperability has proven to be a persistent challenge, especially throughout the past decade of combat operations, which suggests that testers are not finding interoperability issues early enough in DT to fix them before operational urgency demands the system go to the field.[18]

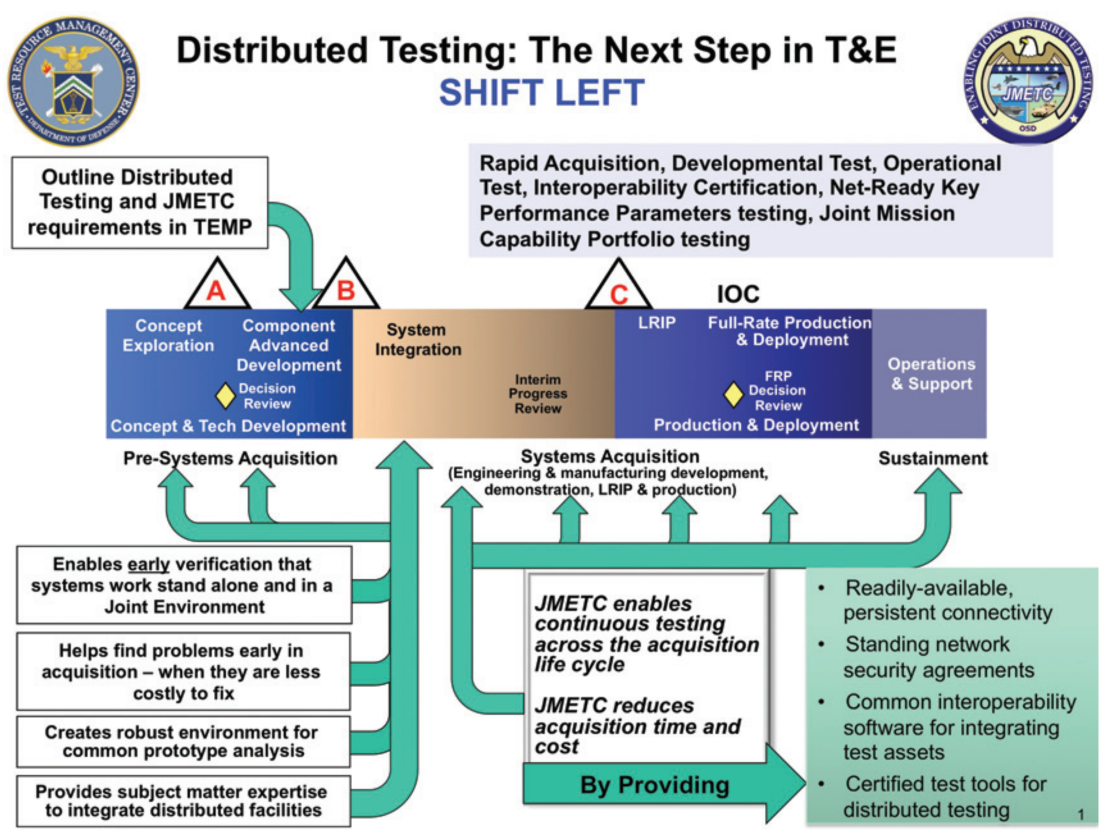

Figure 1: The next step in T&E will focus on a program's early integration with operational systems. Injecting Joint Mission Threads into the test process as early as possible will enable Acquisition Programs and DT&E test designers to make dramatic improvements in SoS and systems interoperability. This rapid transformation already enables near real-time performance analysis and problem resolution: Test-Fix-Test. It also allows efficiencies and capability improvements across the entire acquisition and program life cycle. This in turn will accelerate acquisition programs and allow them to put out better products, more inexpensively. JMETC enables acquisition programs to set the conditions for improved production readiness and reduces the likelihood that major deficiencies get to the field—that is, to "Shift Left!"

Conclusion

Distributed Testing is a cost-effective way for programs across the life cycle of an acquisition system to integrate individual systems or system-of-systems in a realistic Joint environment to assess integration and interoperability within a Joint mission context. Distributed Testing provides access to other Service/Component capabilities, threats, and targets that would be very difficult, if not cost-prohibitive, to assemble in a single test location.

Distributed Testing IS the next step in T&E. It enables agile and persistent T&E across the life cycle of a system. The distinctive advantage of Distributed Testing is to provide a near real-time test-fix-test capability for a system or system-of-systems. Distributed Testing enables early verification that systems work standalone and in a Joint SoS Environment. That in turn helps find problems early in acquisition— when they are less costly to fix—and therefore enables a *better product while reducing acquisition time and cost*. This is the essence of transforming T&E—the needed "Shift Left!" ❑

MR. BERNARD "CHIP" FERGUSON is the Deputy Director, Interoperability and Cyber Test Capability, Test Resource Management Center (TRMC). In that position he is the Program Manager for TRMC's Joint Mission Environment Test Capability (JMETC) Program, and also the Director of the National Cyber Range (NCR). Since joining the Army in 1965, Mr. Ferguson has held leadership positions in combat units, varied level staffs, the Army's Operational Test and Evaluation Command, and Office of the Director, Test and Evaluation, Office of the Secretary of Defense. Upon retirement from active duty, Mr. Ferguson became a Division Manager and Operations Manager with SAIC supporting test and evaluation in DoD. With his vast experience in distributed testing and evaluation, Mr. Ferguson was selected for his current position in 2006.

MR. NEYER TORRICO received his Bachelor of Science in Electrical Engineering, with emphasis on Communications from George Mason University in May 2012. His capstone project, Foot Surface Temperature Monitoring System, was sponsored by a private company and resulted in a successful prototype with a patent pending. Immediately after graduating from college, he worked for a small company designing physical and intrusion detection security systems. He is currently employed by Scientific Research Corporation (SRC) and in April 2013, joined the Test Resource Management Center (TRMC) as an Engineer supporting the Joint Mission Environment Test Capability (JMETC) Program. His is responsible for maintaining and managing the JMETC reuse repository at www.jmetc.org. He is currently pursuing a master's degree in Systems Engineering.

Endnotes

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2 Defense Acquisition University Glossary of Defense Acquisition Acronyms and Terms, Dec 2012, 15th Edition

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