THE TEST AND TRAINING ENABLING ARCHITECTURE, TENA, AN IMPORTANT COMPONENT IN JOINT MISSION ENVIRONMENT TEST CAPABILITY (JMETC) SUCCESSES

By

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ABSTRACT

The Joint Mission Environment Test Capability (JMETC) is a distributed live, virtual, and constructive (LVC) testing capability developed to support the acquisition community and to demonstrate Net-Ready Key Performance Parameters (KPP) requirements in a customer-specific Joint Mission Environment (JME). JMETC provides connectivity to the Services' distributed test capabilities and simulations, as well as industry test resources. JMETC uses the Test and Training Enabling Architecture, TENA, which is well-designed for supporting JMETC events. TENA provides the architecture and software capabilities necessary to enable interoperability among range instrumentation systems, facilities, and simulations. TENA, used in major field exercises and numerous distributed test events, provides JMETC with a technology already being deployed in DoD.

Keywords: Interoperability, 3CE, IO Range, Auto-code Generation, LROM Test Tool

INTRODUCTION

Warfighters test and train mostly on the geographically dispersed Department of Defense (DoD) land, sea, and air test and training ranges that are scattered across the United States from border to border and ocean to ocean. Today's military test and training events range from individual systems under test to small-unit maneuvering to large-scale Joint Services exercises, such as the United States Joint Forces Command (USJFCOM) Joint National Training Capability (JNTC) events where simulated and constructive and live-fire events are blended to enact representative scenarios spread across ranges scattered among several states. Data collected during these events provides military unit and weapon systems evaluation and validation, and perhaps more importantly, can quickly and definitively illuminate any necessary improvements to ensure effective and safe weapon system operation and training. This data also invariably affects almost every aspect of range operation and management, including budget definition and approval.

Ensuring the Joint Forces are the best trained and equipped requires a corporate Joint Force Testing Capability that reflects the realization that "if we fight jointly, we must train and test jointly." Being successful in the development of that Joint testing capability requires a supporting and guiding corporate activity, and in December 2005, the JMETC program element was formed. JMETC is a distributed live, virtual, and constructive (LVC) testing capability developed to support the acquisition community during program development, developmental testing, operational testing, interoperability certification, and including demonstration of Net Ready Key Performance Parameters (KPP) requirements in a customer-specific Joint Mission Environment (JME). JMETC provides readily available connectivity to the Services' distributed test capabilities and simulations, as well as industry test resources. JMETC, although a testing capability, is aligned with the Joint National Training Capability (JNTC) integration solutions to foster test, training, and experimental collaboration.

The JMETC program has used the Test and Training Enabling Architecture, TENA, to prototype new testing support infrastructure. TENA, the live range instrumentation architecture for JNTC and field-proven in major field exercises as well as numerous distributed test events, provides JMETC a technology already being deployed in DoD. TENA provides the middleware and software components while the JMETC Virtual Private Network (VPN) provides the hardware connectivity through utilization of the existing Secure Defense Research and Engineering Network (SDREN) and Defense Research and Engineering Network (DREN). Testing of the VPN is currently underway and will continue through FY08. Together, the TENA and JMETC complement enables and enhances distributed testing and training.

While JMETC is a relatively new presence for the test and training community, TENA has become a range community mainstay, evolving since the late 1990s when it was brought into play to solve an old problem that restricted range effectiveness. Many of the early range data collection and analysis systems were part of a vertical "stovepipe" growth of the instrumentation and instrumentation suites, and not able to utilize the advantages found in the concepts of range interoperability and range resource reuse, concepts that allow for taking easy advantage of the growth in modeling and simulation and its revolutionary application to training, concepts that were being forwarded in the late 1990s by the Foundation Initiative 2010 (FI 2010) project, which was sponsored by the Office of the Secretary of Defense (OSD) Central Test and Evaluation Investment Program (CTEIP).

Utilizing TENA, JMETC has successfully enabled several initial prototype demonstrations: 1) an Air Combat example (a Data Link Messages Test Environment) which used the TENA-enabled Interoperability Test & Evaluation Capability (InterTEC) project and demonstrated distributed interoperability testing using a LVC environment, 2) a Technical Alignment with JNTC events (test and training cooperation) which demonstrated collaboration on integration of tactical training range instrumentation for the Weapons & Tactics Instructor (WTI) and Red Flag Alaska exercises, 3) a Land Combat example (Future Combat System (FCS) test environment) with JMETC support of the Army Cross-Command Collaborative Environment (3CE) and demonstration of interoperable laboratories and ranges with common modeling and simulation and data environments supporting distributed LVC tests, and 4) an Information Operations example (IO Range integration) which showed collaboration on Information Operations Use Cases and demonstrated network connectivity for large-scale, multiple security level events and distributing video data at multiple sites. Let us examine two of the prototype demonstrations.

For the Land Combat example, JMETC supported the 2006 US Army 3CE Simulation Environment Characterization Assessment (SECA) test event. The support to 3CE was provided for the following JMETC tools and utilities: Interface Verification Tool (IVT), TENA

Middleware in a 3CE environment, and TENA-HLA gateway development using the Gateway Builder tool.

The SECA provided a means to integrate 3CE activities and conduct a quantitative assessment of Standard Operating Procedures, the 3CE Capability Development/System Engineering Process, Analytic Data Requirement Process, Model Selection Process, and 3CE Interoperability. Some of the JMETC objectives of the event were to demonstrate that the DREN could support distributed LVC testing, demonstrate more efficient technical integration using JMETC Core infrastructure aspects, demonstrate TENA capability of supporting distributed LVC test activities, and demonstrate TENA interoperability with HLA-based simulations. Figure 1 illustrates the networked sites and systems used in 3CE FY06 SECA.

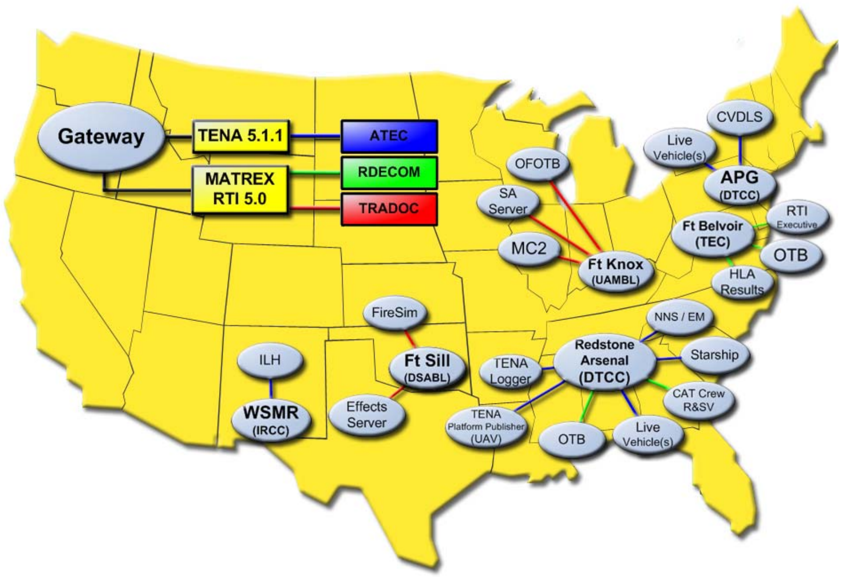

Figure 1. 3CE FY06 SECA Site Map

A JMETC technical team, including members of the TENA User Support Team, supported the integration of assets from three Army commands bridging Analysis, Research & Development, and Testing & Evaluation to integrate modeling and simulation across the acquisition process and provided common tools required for distributed testing. Based on the activities supporting the FY06 SECA integration, the following JMETC objectives have been verified:

- The DREN has proven stable, and once configured to support multi-cast, it has proven to be robust and reliable for distributed LVC testing.
- The JMETC Technical team demonstrated the value of JMETC-provided tools and utilities when executing pre-test integration activities, troubleshooting integration issues, and executing post-test procedures.
- Throughout the event planning and execution process, the TENA web site repository provided excellent online collaboration for 3CE team members.

The JMETC IO Range event used a TENA-enabled Video Distribution System (VDS) to provide a distributed visualization capability to the IO Range during the JNTC Austere Challenge 2006 (AC06) exercise. Development of the IO Range VDS was accomplished through collaboration between the IO Range and the JMETC programs and resulted in a first time achievement of bringing real-time visualization of live fire IO events to the combatant commanders (COCOM), both CONUS and OCONUS, via the Secret Internet Protocol Router Net (SPIRNet).

The IO Range concept was based on an early TENA Data Stream Framework prototyped in FY2004 and leveraged a non-TENA Video Capture & Distribution System being developed for the Redstone Technical Test Center. The JMETC development team was able to quickly adapt their solution (see figure 2) using TENA and required less than four weeks to develop, implement, test, and integrate for the exercise.

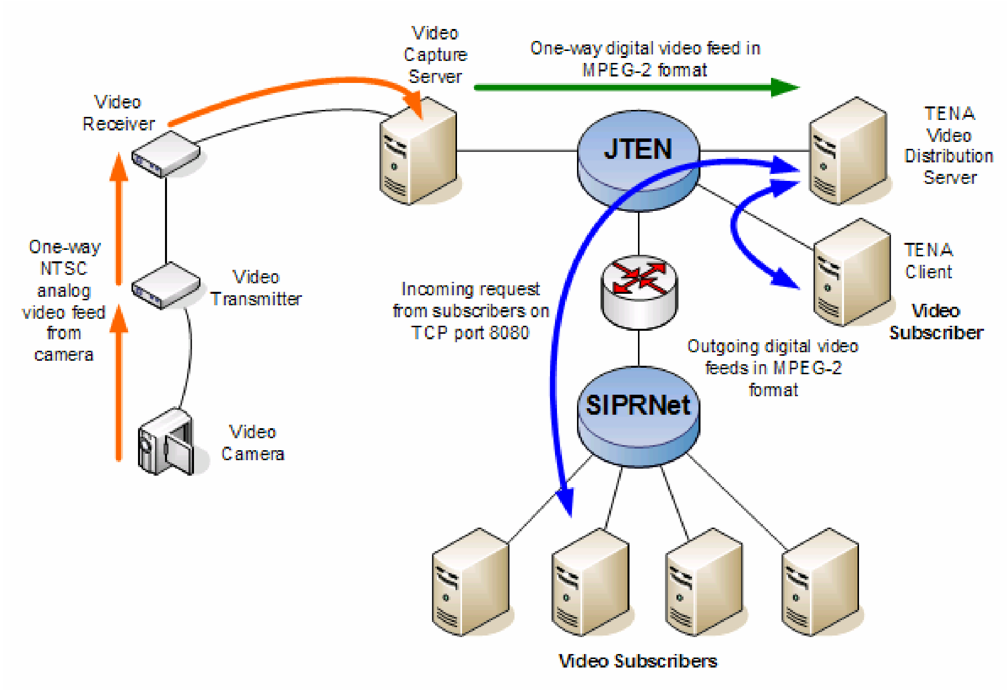

Figure 2. TENA-Enabled Video Distribution System

The IO RANGE requirements for the VDS included: 1) a solution for injecting video streams into SIPRNet; 2) an ability to distribute to multiple end user systems at a minimum 1 frame/sec, with seconds of latency, resolution to support projection over limited bandwidth connections; 3) an ability to record video for playback; and 4) an ability to playback video using a COTS Viewer (Microsoft MediaPlayer).

For IO RANGE/AC06, the real-time video stream was provided from a single source bridged into the network. The TENA Video Distribution Server published availability of data streams via a VideoStream object and published availability of recorded streams for playback via a VideoStreamServer object. TENA Video Distribution clients would discover the availability of VideoStream objects and request data stream files to be streamed for replay. TENA-enabled clients could display and request available live and replay video sources. Non-TENA clients display video sources requested by TENA-enabled clients or server using URL information passed via secure voice/email.

The IO Range VDS supported over thirty clients during the AC06 exercise without a single failure of the TENA VDS. The auto-code generated distribution provided by TENA (see auto-code generation paragraphs beginning on page 6) enabled the JMETC developers to greatly reduce the time needed to integrate and test their software.

The IO Range brought transformational IO capabilities to the IO community during AC06, providing the warfighter a standing, robust environment for experimentation, testing training, exercises, and operational rehearsal. In support, JMETC brought a technology solution using the TENA common operating environment and an experienced, quick response development and integration support team.

USED BY JMETC, TENA OFFERS INTEROPERABILITY AND RESOURCE REUSE

By providing interoperability and reuse capabilities, TENA is well designed for supporting JMETC. Interoperability is the characteristic of an independently developed software element that enables it to work together with other elements toward a common goal. Interoperability focuses on what is common among software elements. Reuse is the ability to use a software element in a context for which it was not originally designed, so reuse focuses on the multiple uses of a single element and requires well-documented interfaces. To achieve interoperability, a common architecture, an ability to meaningfully communicate (including a common language and a common communication mechanism), and a common context (including the environment and time) must be present. To bring the efficiency and economic advantages of interoperability and reuse to the DoD test and training ranges, FI 2010 developed TENA. The FI 2010 program completed the initial interoperability and reuse efforts in early Fiscal Year 2005, and the continuing interoperability and reuse refinement of TENA is now managed by the TENA Software Development Activity (TENA SDA).

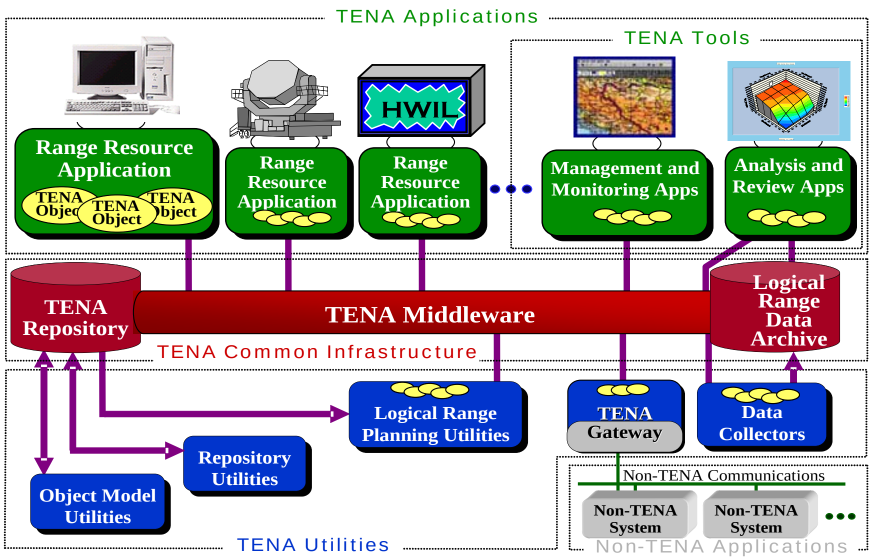

Figure 3. TENA Architecture Overview

The TENA architecture is a technical blueprint for achieving an interoperable, composable set (composibility is defined as the ability to rapidly assemble, initialize, test, and execute a system from members of a pool of reusable, interoperable elements) of geographically distributed range resources—some live, some simulated—that can be rapidly combined to meet new testing and training missions in a realistic manner. Please refer to Figure 3. TENA is made up of several components, including a domain-specific object model that supports information transfer throughout the event lifecycle, common real-time and non-real-time software infrastructures for manipulating objects, as well as standards, protocols, rules, supporting software, and other key components.

The TENA Middleware combines distributed shared memory, anonymous publish-subscribe, and model-driven distributed object-oriented programming paradigms into a single distributed middleware system. This unique combination of high-level programming abstractions yields a powerful middleware system that enables the middleware users to rapidly develop complex yet reliable distributed applications. The TENA Middleware, available for download at the TENA SDA web site, http://www.tena-sda.com, is currently at Release 5.2.2 and supports many platforms/compilers, including Ardence ETS – NetAcquire, Microsoft Visual C++ 7.1 (bundled);

Embedded Planet (Embedded Linux OS), GCC 3.2.2 (bundled)

Linux – Fedora Core 5, GCC 4.1.1;

Linux – Fedora Core 6, GCC 4.1.1;

Linux – Fedora Core 6 64-bit, GCC 4.1.1;

Linux – Red Hat Enterprise Workstation 4, GCC 3.4.4;

Linux – Red Hat Enterprise Linux 5, GCC 4.1.1;

Linux – SUSE 10.1, GCC 4.1.0;

Mac OS X 10.4.7, GCC 4.0.1:

Solaris 10, Sun SPRO 5.8 Patch 121017-10

Solaris 10 64-bit, Sun SPRO 5.8 Patch 121017-10

Windows 2000 SP4, Microsoft Visual C++ .NET 2003 SP1 (aka Visual C++ 7.1);

Windows Server 2003 R2 Standard SP2, Microsoft Visual C++ .NET 2003 SP1; and

Windows Server 2003 R2 Standard SP2 64-bit, Microsoft Visual C++ .NET 2003 SP1.

A significant benefit for TENA users is **auto-code generation** which was shown to greatly reduce the time needed to integrate and test software in the JMETC IO Range demonstration. The TENA Middleware is designed to enable the rapid development of distributed applications that exchange data using the publish-subscribe paradigm. While many publish-subscribe systems exist, few possess the high-level programming abstractions presented by the TENA Middleware. The TENA Middleware provides these high-level abstractions by using auto-code generation to create a complex Common Object Request Broker Architecture (CORBA) application. As such, the TENA Middleware offers programming abstractions not present in CORBA and provides a strongly-type-checked framework interface that is much less error-prone than the existing CORBA API. These higher-level programming abstractions combined with a framework designed to reduce programming errors enable users quickly and correctly to express the concepts of their applications. Re-usable standardized object interfaces and implementations further simplify the application development process.

Through the use of auto code generation, other utilities, and a growing number of common tools, TENA also provides an enhanced capability to accomplish the routine tasks which are performed on the test and training ranges in support of exercises. The steps in many of the tasks are automated, and the information flow is streamlined between tools and the common infrastructure components through the enhanced software interoperability provided by TENA. TENA utilities facilitate the creation of TENA-compliant software and the installing, integrating, and testing of the software at each designated range. This complex task falls to the Logical Range Developer, which, in this phase, performs the detailed activities described in the requirement definitions and event planning, and the event construction, setup, and rehearsal activities of the Logical Range Concept of Operations. While some manual exercise and event setup is required at ranges, TENA tools, as they are developed and become accepted across the range community, make exercise pre-event management easier.

One TENA tool that has received widespread usage and praise is the Logical Range Object Model (LROM) Test Tool. The LROM consists of those object definitions, derived from whatever source, that are used in a given logical range execution to meet the immediate needs and requirements of a specific user for a specific range event. To ensure that the TENA users benefited fully from the use of a LROM, the LROM Test Tool was developed to support the integration testing of the TENA applications used during large-scale DoD exercises. The first version of the LROM Tool was developed for the TENA interface testing of applications used for the Joint Red Flag 2005 (JRF 05) exercise. Since JRF 05, the tool has evolved in capabilities to support not only integration testing of applications before an exercise but to provide real-time monitoring, logging, and statistics gathering during an exercise as well.

Considered the “defacto” test tool for all TENA applications, it has also expanded to support many different user LROMs and has been upgraded as new TENA middleware versions and object-model versions came about and new user requirements were added. In addition, the latest version provides the capability to convert Distributed Interactive Simulation (DIS) Entity State, Weapon Fire and Detonation Protocol Data Units (PDU) to the appropriate TENA object-model Stateful Distributed Object (SDO) classes and messages. Also, the latest version of the LROM Test Tool can operate in three different roles, either stand-alone or in combination. The roles are data subscriber, data publisher, or DIS to TENA gateway.

Cubic Corporation and JFCOM users have provided very positive feed back about the tool’s capabilities, and the tool has been accepted across the wide-spread DoD range community. The tool has been accredited by the JFCOM JNTC for use in major exercises and is also used by the JFCOM Joint Advance Training Technology Laboratory (JATTL) to certify all other TENA applications. Beside JMETC and the JMETC VPN, other LROM Test Tool users include the Joint Interoperability Test Command (JITC), and the JITC Defense Information System Network-Leading Edge Services (DISN-LES).

TENA SUPPORT FOR TENA USERS

TENA SDA has developed a highly utilitarian website that provides a wide range of support for the TENA user, including an easy process to download the middleware which is free. The website also offers a help desk, repository, and user forums that will address any problems with the middleware download and implementation. TENA SDA is very aware of the need to inform range managers and train TENA users, and the TENA SDA presents regular training classes that are designed to meet the attendees' needs from an overview of TENA to a technical introduction to TENA to a hands-on, computer lab class for the TENA Middleware. JMETC has a page on the web site to support its ongoing VPN testing and upcoming JMETC events.

CONCLUSION

Today's military is devoted to the old but enduring concept of "training the way you fight." The result of that field-proven approach can be read in the Third Infantry Division (Mechanized) After Action Report, Operation Iraqi Freedom (3 July 2003): "The roots of the division's successful attack to Baghdad are found on the training fields of Fort Steward, Fort Irwin, and Kuwait. The division crossed the line of departure with a mature and trained group of staff officers, commanders, and soldiers." (http://www.globalsecurity.org/military/library/report/2003/3id-aar-jul03.pdf) It is a report that was foreshadowed in historian Flavius Josephus's observation in his 78 A.D. book, *The War of the Jews*, nearly 2000 years ago, that to the most powerful army of that time (Rome), military exercises were unbloody battles, battles were bloody exercises, and "it is the reason they (soldiers) bear the fatigue of battle so easily."

But it is not enough to gather military forces and weapons in a difficult training and test environment and subject them to individual, group, and system challenges, the measure of the training and testing of the men and women of the military and the weapon systems they use must be taken accurately and timely. The TENA and JMETC complement has facilitated taking that measure.