Utilizing Joint Mission Environment Test Capability (JMETC) and Test and Training Enabling Architecture (TENA) for Risk Reduction in Distributed Testing

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Historically, range systems tend to be developed in isolation, focused on specific requirements, and constrained by aging techniques/technologies.

Range infrastructures have grown organically with minimal coordination or sharing, resulting in duplicated effort and many “stove-pipe” systems.

The purpose of TENA is to provide the necessary enterprise-wide architecture and the common software infrastructure to:

- **Enable interoperability** among range, C4ISR, and simulation systems used across ranges, HWIL facilities, and development laboratories.
- **Leverage range infrastructure investments** across the DoD to keep pace with test and training range requirements.
- **Foster reuse** of range assets and reduce cost of future developments.

**Working with the Range Community to Build the Foundation for Future Test and Training Range Infrastructure**
Benefits of TENA

- All TENA software and support is free to users
- TENA is the most capable and sophisticated interoperability solution
- TENA software is thoroughly tested and very reliable
- TENA Auto-Code Generation makes creating a TENA application as simple as possible
  - TIDE Tool manages installation and configuration, upgrading and maintenance
  - Auto-generated starting points mean you never start with a blank page
  - Rapid development of real-time, distributed, LVC applications
  - Auto-generated test programs make integration a snap
- TENA’s technical approach emphasizes cost savings and reliability
  - The TENA software is hard to use wrong
  - TENA catches many user errors at compile time rather than run time
  - TENA Tools provide unprecedented understanding of an event
- TENA has a standard object model enhancing interoperability
- The TENA web site/repository has extensive documentation, training, and collaboration capabilities
- TENA has a plan for evolution and funding to execute this plan!
A Notional Test Range

TENA is designed (and has experience) as the common communication infrastructure for these range systems.
Range System and Infrastructure Development Challenges

- General Development Challenges
  - Multiple Developers and Development Groups
  - Different Timelines and Delivery Dates
  - New Computing and Communication Technologies

- Range Specific Development Challenges
  - Multiple Sponsors and Funding Sources
  - Evolving Test and Training Requirements
  - Expansion of Inter-Range Connectivity
  - Information Assurance Policies and Procedures
  - Range Modernization Must Be Gradual
Traditionally, all developers must develop (often independently at different times) code that performs the function of data exchange between systems.

- Data preparation, packet marshalling/demarshalling, network communication, error handling, etc.
TENA Middleware
(Software Library of Data Exchange Functions)

- TENA Middleware is a set of software that performs real-time data exchange between systems
  - Support for C++, Java, and .NET programming languages
- TENA Middleware available for ~40 platforms, including:
  - Windows XP, Vista, 7/8, Server 2008/2012 (32- and 64-bit)
  - Linux: Fedora 12/14/16/19, Red Hat 4/5/6, CentoOS 6, SUSE (32- and 64-bit)
  - Embedded Devices: Overo Gumstix (beta release)
- TENA Object Models are auto-code generated software interfaces that include data formats, data definitions, and common algorithms.
- Auto-coded interface software can be standard TENA Object Models that the community has designed and agreed upon, or they can be designed for unique user requirements.
- Standard TENA Object Models already developed include:
  - Time, TSPI, Coordinate Systems (including conversions), GPS, Radar, Telemetry, Event Control, Video Distribution, Weather.
Adding New Range Capabilities

- Easy, reliable incorporation of new range capabilities
  - Known data exchange software (TENA Middleware)
  - Reuse standard range objects (Standard TENA Object Models)
    - Auto-code generate any new object models
  - Range interface on new application verified while application is developed (verification performed during software compile)
  - TENA Middleware verifies new application is using the same formats & algorithms when the application is started
Core Architectural Tenets of TENA

- **Promote Computer Enforceable System Interfaces**
  - For meaningful interoperability, systems should formally define their interfaces for the particular data produced or consumed and the services/algorithms provided or required.
  - Generic interfaces may look appealing, but significant costs exist with performance, interoperability, and maintenance that are overlooked with this perceived flexibility.

- **Utilize Auto-Code Generation to Raise the Abstraction Level**
  - Distributed programming is hard! Define higher level abstractions to automatically generate properly designed and tested source code for common distributed programming solutions—similar to comparison of modern programming languages to assembly code.

- **Let Computer Detect Interoperability Errors as Early as Possible**
  - When would you like to detect interoperability problems? Many system errors can be detected by the computer during the development phase, reducing overall expense.

- **Design the Middleware to Make it Hard to Use Wrong**
  - TENA Middleware is defined from a defensive posture that minimizes the opportunity for improper usage and run-time anomalies.

- **Anticipate Better Techniques and Technologies**
  - Maintain separation between interfaces and implementations to simplify transition to improved techniques and technologies when appropriate.
How do we integrate TENA into our existing environment?

- **Gradual Deployment**
  - TENA can be introduced into an existing environment in a gradual manner in which certain systems are replicated using TENA functionality.
  - These initial systems will typically require temporary gateways to bridge between TENA and the legacy protocol and systems.

- **Gateway with Legacy Protocol and Systems**
  - TENA gateway systems are well understood, and a separate project, PRITEC, has even created a Gateway Builder product to facilitate automated gateway creation.
  - Migration to TENA can be coordinated with respect to publishing/subscribing characteristics to minimize any performance degradation caused by the gateway.

- **Utilize Redundancy during Testing**
  - Access to both the legacy and the upgraded TENA system provides system redundancy during initial testing and operational deployment to minimize risk.

TENA can be introduced to a range gradually using a properly designed protocol gateway system.
Architecture Management Team (TENA AMT)

- **AMT Members:**
  - Aberdeen Test Center (ATC), Aberdeen Proving Ground, MD
  - Air Armament Center (AAC), Eglin AFB, FL
  - Air Force Flight Test Center (AFFTC), Edwards AFB, CA
  - Alaska Training Range Evolution Plan (ATREP)
  - Army Operational Test Command (OTC), Fort Hood, TX
  - Common Range Integration Instrumentation Systems (CRIIS)
  - Common Training Instrumentation Architecture (CTIA)
  - Dugway Proving Ground (DPG)
  - Electronic Proving Ground (EPG)
  - Integrated Network Enhanced Telemetry (iNET)
  - Interoperability Test and Evaluation Capability (InterTEC)
  - Joint Fires Integration & Interoperability Team (JFIIT)
  - Joint National Training Capability (JNTC)
  - Naval Air Warfare Center – Aircraft Division
  - Naval Aviation Training Systems Program Office (PMA-205)
  - NAWC – Weapons Division
  - NAVSEA Warfare Center - Keyport
  - Naval Undersea Warfare Center (NUWC)
  - P5 Combat Training System (P5CTS)
  - Pacific Missile Range Facility (PMRF)
  - Redstone Technical Test Center (RTTC)
  - T&E/S&T Non-Intrusive Instrumentation
  - White Sands Missile Range (WSMR)


**Meetings every few months**
*(Due to Gov’t travel restrictions these meetings have been paused)*

**US Advising Members:**
- BMH Associates, Inc.
- Boeing
- Cubic Defense
- DRS
- Embedded Planet
- EMC
- MAK Technologies
- NetAcquire
- SAIC
- Scientific Research Corporation (SRC)
- Scientific Solutions, Inc. (SSI)

**International Participation**
- Australia
- Denmark
- France
- Singapore
- Sweden
- United Kingdom
TENA Information Assurance (IA) Activities

- Air Force Evaluated/Approved Product List (E/APL)
  - Software Certification for TENA Middleware Version 6.x
- Navy Application & Database Management System (DADMS)
  - Approved 6/27/2011
- Army Certificate of Networthiness (CoN)
  - Covers TENA Middleware, TENA Utilities, and TENA-enabled applications
- S/DREN (Secret/Defense Research and Engineering Network)
  - TENA protocol and TENA-based applications approved for DREN and SDREN sites
- NIPRnet
  - JTTOCC (which includes TENA Middleware) obtained ATO on NIPRnet
- Air Force 46th Test Wing DIACAP
  - InterTEC tool suite (includes TENA Middleware) completed DIACAP testing, ATO submission in process
- DoD PPSMO Category Assurance List (CAL)
  - Conditional approval for TENA use on classified and unclassified network enclave, awaiting final approval
- Unified Cross Domain Management Office (UCDMO)
  - TENA-enabled Cross Domain trusted guard SimShield v2.2.0.1 on baseline list

TENA project works with IA organizations to reduce cost and delays to improve IA considerations with TENA applications.
TENA has been supporting the real-time distributed operation of the WSMR optics systems for the past 5 years, including data exchange and remote operation. Based on the success of optics, TENA is being expanded to other range systems.

“TENA has functioned extremely well in our network environment and the rigorous requirement of 60 Hz updates to the instrumentation.”

Charlie Conroy
WSMR Optics Development Engineering Lead
A Compelling, Comprehensive Range Instrumentation Use Case at White Sands

20 Hz 60 Hz

Optics Multi-cast Group

Cox Pointing Data Object on TENA V6

NetAcquire on TENA V6

Telemetry Pre-Processor

IRCC

MRTFB 2

MRTFB 3
TENA specified in RRRP acquisition program requirements for radar system communication with other range systems

TENA project supporting the design and evaluation of object models for these tracking radars that are planned to be deployed to WSMR, Yuma, Redstone, and Aberdeen ranges.
TENA at Joint Pacific Alaska Range Complex (JPARC)

- TENA enables JPARC to provide force-on-force (FOF) training capability that fully integrates and supports joint and coalition components for both air and ground training in live, virtual, and constructive (LVC) domains.

“TENA is the greatest thing that ever happened to us. We couldn’t be doing today with all these systems—and we couldn’t have all the participants that we do—if it weren’t for TENA”

Billy D. Smith
Chief of electronic combat training requirements for Red Flag at JPARC
Common Range Integrated Instrumentation System (CRIIS)

- TENA specified in CRIIS acquisition program requirements for ground system communication
  - TENA project providing port to Green Hills Real-Time Operating System, which is used in ground stations and air platforms
Worldwide Use of TENA

TENA is used in 13 countries outside the US
Currently 8,378 user accounts

206 separate activity groups

16.5 million page hits in 2014

Helpdesk cases resolved in 2014 was 2,452

Currently supporting 40 computer platforms

1,198 different object models

Repository software downloads of 2,877 in 2014

727 middleware development kits downloaded in 2014
What is JMETC?

• A corporate approach for linking distributed facilities
  • Enables customers to efficiently evaluate their warfighting capabilities in a Joint context
  • Provides compatibility between test and training

• A core, reusable, and easily reconfigurable infrastructure
  • Consists of the following products:
    • Persistent connectivity
    • Middleware
    • Standard interface definitions and software algorithms
    • Distributed test support tools
    • Data management solutions
    • Reuse repository

• Provides customer support team for JMETC products and distributed testing
JMETC Connectivity

- Functional Sites: 78
- New Sites Planned: 15
- Connection Points to Other Networks: 7

- Dedicated, trusted connectivity on SDREN (part of the GIG)
- Encrypted for Secret – System High
- DISA-registered IP address space
- Active monitoring of network performance
- Capable of supporting multiple simultaneous test events

As of 10 Feb 2014
How a Test Planner Should View JMETC

Hardware-in-the-Loop (HWIL) Availability

All linked by JMETC
JMETC Event Support Services

• Pre-Test / Test Integration Emphasis:
  • Test Development/Design
    • Convert customer infrastructure requirements into JMETC-provided infrastructure solutions
  • Network Engineering
    • Designs, configures, establishes, and baselines connectivity solutions for test customers
  • IA Engineering
    • Ensures strong security posture for entire JMETC infrastructure
    • Works with JMETC sites directly to mitigate risks associated with IA and security
  • User Support
    • Ensures JMETC sites have the knowledge, skills, abilities, and site-specific examples to address test resource interoperability issues
    • Realizes test workarounds to event-specific interoperability issues

• Test Execution Emphasis:
  • JMETC SYSCON
    • Verifies infrastructure readiness and proactively troubleshoots problems as they are discovered
    • Partnership with NAVAIR AIC 5.4.1
  • Event Support
    • Provides direct support to customer test activities on an as-needed basis

• Post Test Emphasis:
  • Capture Lessons Learned and Infrastructure Gaps/Limitations
## Major FY14 Events

<table>
<thead>
<tr>
<th>Customer</th>
<th>Event</th>
<th>Execution Dates</th>
<th>Onsite Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navy</td>
<td>Joint Distributed IRCM Ground test System (JDIGS)</td>
<td>Oct 2013</td>
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<tr>
<td>Navy</td>
<td>Accelerated Mid-Term Interoperability Improvement Program (AMIIP)</td>
<td>Ongoing</td>
<td>Yes</td>
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<tr>
<td>Joint</td>
<td>JITC Joint Interoperability Tests (JIT)</td>
<td>Ongoing</td>
<td>Yes</td>
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<tr>
<td>Air Force</td>
<td>Air Force Systems Interoperability Test (AFSIT)</td>
<td>Ongoing</td>
<td>-</td>
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<tr>
<td>Navy</td>
<td>MQ-4C TRITON</td>
<td>Ongoing</td>
<td>-</td>
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<tr>
<td>Navy</td>
<td>Virtual Rapid Prototyping Laboratory</td>
<td>Jan 2013 – Feb 2013</td>
<td>Yes</td>
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<tr>
<td>Air Force</td>
<td>AGILE Fire Phase VIII</td>
<td>Oct 2013 - Feb 2014</td>
<td>Multiple</td>
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<tr>
<td>Joint</td>
<td>Snakehead</td>
<td>Oct 2013 - Dec 2013</td>
<td>Yes</td>
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<tr>
<td>Navy</td>
<td>Advanced Anti-Radiation Guided Missile (AARGM)</td>
<td>Ongoing</td>
<td>Yes</td>
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<tr>
<td>Navy</td>
<td>Multi Site Training Capability Test (MSTCT)</td>
<td>Ongoing</td>
<td>-</td>
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<tr>
<td>DOT&amp;E</td>
<td>Enterprise Cyber Range Environment (ECRE)</td>
<td>Dec 2013 - Jun 2014</td>
<td>Multiple</td>
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<tr>
<td>Joint</td>
<td>JIAMDO Correlation/De-correlation Interoperability Test (C/DIT)</td>
<td>Coalition</td>
<td>Multiple</td>
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<tr>
<td>Army</td>
<td>Apache Block 3 JIT Risk Reduction</td>
<td>Mar 2014 - Apr 2014</td>
<td>Yes</td>
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<tr>
<td>Navy</td>
<td>Integrated Warfare Center (IWC) LVC Demo</td>
<td>Apr 2014 - May 2014</td>
<td>Multiple</td>
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<tr>
<td>Air Force</td>
<td>F-35 Information Exchange Requirements (IERs) Test</td>
<td>Jun 2014</td>
<td>TBD</td>
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</table>
Summary

• TENA offers significant benefits to the range community
  • Common data standards, interfaces, communication software, and tools to improve interoperability, reuse, and long-term sustainability of range assets for reduced O&M

• TENA is the CTEIP architecture for future instrumentation, the JNTC architecture for Live integration, and an enabling technology for JMETC

• JMETC provides inter-range connectivity and supports the full spectrum of Joint testing, supporting many customers in many different Joint mission threads

• TENA and JMETC are:
  • Being built and evolved based on customer requirements
  • Partnering with Service activities and leveraging existing capabilities
  • Coordinating with JNTC to bridge test and training capabilities
  • Provide a forum for users to develop and expand the architecture

     • Next TENA AMT-52 2015
     • Next JMETC User 2015
Important Contact Information

• TENA Website:  http://www.tena-sda.org
  • Download TENA Middleware
  • Submit Helpdesk Case (http://www.tena-sda.org/helpdesk)
    • Use for all questions about the Middleware

• JMETC Program Office Contact:
  • E-mail: jmetc-feedback@jmetc.org
  • Telephone: (571) 372-2699
  • JMETC Website: http://www.jmetc.org – under construction

• TENA Feedback:  feedback@tena-sda.org
  • Provide technical feedback on TENA Architecture or Middleware
  • Ask technical questions regarding the TENA architecture or project
  • Provide responses to AMT action items
  • Request TENA training