TENA and JMETC Enabling Interoperability Among Ranges, Facilities, and Simulations

Briefing for: 28th Annual NDIA T&E
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TENA Architecture Overview

TENA Applications

Range Resource Application
TENA Object
TENA Object
TENA Object

Range Resource Application

Range Resource Application

Reusable Applications

Reusable Applications

Non-TENA Communications

Non-TENA System

Non-TENA System

Non-TENA Applications

TENA Utilities

Object Model Utilities

Repository Utilities

Infrastructure Management and Planning Utilities

TENA Gateway

Data Collectors

Logical Range Data Archive

TENA Common Infrastructure

TENA Middleware

TENA Repository

TENA Tools
## Benefits of Using TENA

- Saves Money
- Saves Time
- Optimized for Real-time Performance
- Reliability
- Security / Information Assurance
- Designed for Future Technology Insertion
- Eases Incorporation of New Range Capabilities
- On-line Documentation & Help Desk
- Aligns to Policy
A Notional Test Range

- **SUT Instrumentation**
- **C4I Instrumentation**

**System Under Test (SUT)**

- Field Telemetry Stations
- GPS Ground Stations
- Radar Stations
- Optics Tracking Mounts
- Flight Safety Transmitters
- Target Control Transmitters
- Target Control System
- Flight Safety System
- Target Control Displays
- Other Displays

**Data Fusion System**

- Telemetry Displays
- Range Control Displays
- Video Distribution System
- Flight Safety Displays
- Target Control Displays
- Other Displays

**A Notional Range**

- Past Approaches
- Challenges
- Range Sys Anatomy
- TENA Middleware
- TENA Obj. Models
- TENA Examples
- TENA Testing
Past Approaches

- Standardize on computer platform
- Standardize on a network protocol
- Standardize on a data protocol
- Develop a variable message packet

Everything gets designed around the most difficult system to upgrade
Development Challenges

- Multiple Sponsors (Funding Sources)
- Multiple Developers (Development Groups)
- Different Timelines (Delivery Dates)
Development Challenges

- Range modernization must be gradual
  - New systems, upgraded systems, & existing systems must co-exist and preferably work together while supporting customer test events

- When do you want to discover integration issues?
  - During development?
  - During initial integration?
  - During pre-test range check-outs?
  - During actual test events?

Range modernization must be gradual, with new systems, upgraded systems, and existing systems co-existing and working together to support customer test events.

When to discover integration issues:
- During development?
- During initial integration?
- During pre-test range check-outs?
- During actual test events?
Traditionally, all developers must develop code that performs the function of data exchange between systems.

- Data packing, message packing, network protocols, packet padding, network flow control, etc.
TENA Middleware is a set of software that performs real-time data exchange between systems.

- TENA Middleware available for ~40 platforms, including:
  - Windows (XP, Server 2003, Vista, 64-bit)
  - Linux (Fedora 6/8/9/12, RedHat 4/5, SUSE, Overo)
  - Mac OS X 10.6 (Intel 64-bit)
  - Solaris 8/10
TENA Object Models
(Range Data Formats & Algorithms)

- TENA Object Models are auto-code generated software interfaces that include data formats, data definitions, and common software algorithms
- Auto-coded interface software can be standard TENA Objects that the community has designed and agreed on – 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, SUT Description, Event Control, Video Distribution, Weather data
Adding New Range Capabilities

- Easy, reliable incorporation of new range capabilities
- Known data exchange software (TENA Middleware)
- Reused standard range data objects (Standard TENA Object Models)
  - Auto-code generate any new data objects
- Range interface on new application verified while the application is being developed (verification performed during software compile)
- TENA Middleware verifies new application is using same formats & algorithms when the application is started on the network
Some Examples of TENA Usage

- InterTEC (C4ISR stim/sim/collection)
- JDAS (data archive)
- TVDS (video distribution)
- JMITS (live range IR threat emulator)
- SIMDIS (range display)
- Starship (event control)
- Gateways (translators to DIS & HLA)
- CTIA (training instrumentation)
- ARDS (precision TSPI)
- CRIIS (next generation precision TSPI)
- P5 (precision TSPI / ACMI)
- NACTS (precision TSPI / ACMI)
- SimShield (trusted data guard)
- Reflect (data playback)
- MatLab (data analysis)
- Execution Manager GUI (event control)
- IVT (interface/network verification tools)
- JAAR (after action review)
- JIMM (constructive simulation)
- JSAF (constructive simulation)
- DCIT (distributed monitoring)
- Link-16 translator (Link-16 over WAN)
- PET (air picture data analysis system)
- JWinWAM (test assessment tool)
- Real-time Casualty Assessment System
- ICADS (individual combat aircrew dis. sys.)
- ATREP (training instrumentation)
- iNET (wireless networking)
- CRS-P (constructive simulation)
- AEA HWIL (airborne electr. attack lab)
- OT-TES (tactical engagement sys for OT)
- ADMAS (embedded vehicle instruments)
- HWIL RF threat injection system
- Radars (tracking, surveillance, miss-distance,)
- Range optics (high fidelity remote control)
- Threat systems
- UAV remote control of sensors
- Range safety systems
- Embedded instrumentation
- Weather server (distribution of weather data)
- Player ID server (Unique ID for entities)
- Open air range acoustic sensors
- Undersea hydrophone instrumentation
- Live video – synthetic scene integration
TENA Automated Test Harness
("eye chart") Illustration

Each column represents a different test for a particular configuration.

TENA Test Harness automatically performs ~1,800 separate tests on TENA Middleware & TENA Object Models in configurations based on user experiences over the past decade.

Each test result is color coded with link to specific details.

Each row represents a different computer platform.
TENA Web Portal
http://www.tena-sda.org/

Currently 6,977 user accounts
Registered user account required

Averaging ~250 downloads of TENA Middleware per month

47,942 downloads of TENA Standard Object Models in FY11

Object Model Compiler ran 4,192 times in FY11 by TENA users in the field

241,682 documents downloaded in FY11
TENA On-Line Documentation

- Installation Guide and Release Notes
  - Simplifies user navigation

- Middleware Guide arranged in individual topic pages
TENA Console

- TENA Console is a GUI-based event management tool used to evaluate and monitor applications and network
  - Utilizes capabilities automatically built into the middleware
  - Multiple TENA Consoles can be run anywhere on the network

- Application Diagnostics
  - Evaluate middleware and application configuration parameters to detect incorrect settings
  - Obtain runtime diagnostic values related to the state and performance of the application

- Network Monitoring
  - Perform TCP and (unobtrusive) UDP Multicast “ping” operations between applications to test communication
  - Establish continuous ping operations to notify operators of transient network problems

- Application Alerts
  - Notify operators of application warnings that require investigation
TENA Console

TENA Console - tipple.tena-sda.org:55100

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There are 4 unresponsive applications.
There are 2 failures to send ping requests.
There are 17 winning ping replies.
The TENA Integrated Development Environment (TIDE) is a tool designed to assist range system developers in the creation, development, testing and deployment of TENA-enabled range systems.

- Designed to make upgrades fast & efficient
- Assists in developing a new TENA application
- Easy migration of new Middleware versions
- Easy incorporation of Object Model updates
- Can compare & contrast Object model differences

**TIDE 2.0**
- Available at: [http://www.tena-sda.org/tide](http://www.tena-sda.org/tide)
The TENA team is available to offer advice and assist any organization looking to use TENA

- Advice on overall design approach and trade-offs to consider
- Recommended Object Models to reuse
- Recommendations on how to design new Object Models
- Implementation / Code Designs Reviews
- Awareness of similar systems and lessons learned
- Hands-on training classes on TENA capabilities
- Hands-on training classes on using “TIDE” (a TENA Development Tool)
  - Eases developing TENA interface
  - Assists incorporating different Object Models
  - Upgrade utility for HLA applications migrating to TENA

Opportunity to Get Assistance in Using TENA

E-mail request to: feedback@tena-sda.org
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!
### Key Release 6 Improvements and New Capabilities

#### New Middleware Capabilities
- Advanced Filtering
- OM Subsetting Support
- SDO State Processing Support
- Self-Reflection Option
- Object Reactivation
- Separate Inbound/Outbound ORBs

#### Metamodel and Model Improvements
- Fundamental Sized Type Aliases
- Const Qualifier
- Optional Attributes
- SDO Initializers
- Middleware Metadata
- Middleware IDs

#### New Event Management Capabilities
- Object Model Consistency Checking
- Remote Object Termination
- Execution Manager Fault Tolerance
- Embedded Diagnostics
- TENA Console

#### Usability Improvements
- Observer Pattern (with Callback Aggregation)
- Local Methods Factory Registration
- Code Installation Layout
Key Release 6 Improvements and New Capabilities

**New Middleware Capabilities**
- Advanced Filtering
- OM Subsetting
- SDI Initializers
- Separation of Activation
- Separate Inbound/Outbound ORBs

**Enhanced data distribution**
- Optimized network usage

**Metamodel and Model Improvements**
- Fundamental Sizes
- Const Qualifier
- Optional Attributes
- SDO Initializers
- Middleware Metadata
- Middleware IDs

**Enhanced ways to define data**
- Remove ambiguity

**New Event Management Capabilities**
- Object Model Consistency Checking
- Remote Object Termination
- SDO State Processing Support
- Self-Reflection Option
- Object Reactivation
- Separate Inbound/Outbound ORBs

**Improved reliability**
- Enhanced troubleshooting

**Usability Improvements**
- Observer Pattern (with Callback Aggregation)
- Local Methods Factory Registration
- Code Installation Layout

**Easy to use**
- Harder to use wrong

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TENA Architecture Management Team (AMT)

- **AMT**: A technical forum providing an open dialogue between users and TENA developers to understand current issues and agree on solutions
  - Provide more insight to current capabilities and on emerging technical challenges to discuss a common approach to satisfying requirements

- **AMT Process**: Identify issues, vet concerns, debate potential solutions, and agree on a way forward with active participation from all stakeholders
  - TENA maintained according to consensus of its users assembled as the AMT
  - TENA design and improvements driven from the AMT exchange
  - Current improvements to the next release of TENA are a direct result from vote by AMT members at previous meeting
  - Industry heavily participates at AMT meetings

- **AMT Schedule**: Quarterly *(AMT-49 is May 10 in Phoenix, AZ)*

Registration Open on [https://www.tena-sda.org](https://www.tena-sda.org)
Architecture Management Team (TENA AMT)

- AMT Members:
  - 329 Armament Systems Group (329 ARSG)
  - Aberdeen Test Center (ATC), Aberdeen Proving Ground, MD
  - Air Armament Center (AAC), Eglin AFB, FL
  - Air Force Flight Test Center (AFFTC), Edwards AFB, CA
  - Army Operational Test Command (OTC), Fort Hood, TX
  - 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
  - NAWC – Weapons Division
  - Naval Aviation Training Systems Program Office (PMA-205)
  - Naval Undersea Warfare Center (NUWC)
  - NAVSEA Warfare Center - Keyport
  - 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 3 months

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

- International Participation
  - Australia
  - Denmark
  - France
  - Singapore
  - Sweden
  - United Kingdom

Network Migration At White Sands
The Test Support Network – A Perfect TENA Incubator

3400 Square miles
3000 Instrumented sites
255 Fiber optic sites
1400 Miles fiber optic cable
1928 Miles of copper cable
2401 Miles of inductance cable
31 Tech control facilities
  - 7 Manned as required
25 TSN unmanned shelters
5000 Computer Accounts
100 Servers

DREN/S Bandwidth  OC 12
NIPR Bandwidth 18 Mb
SIPR Bandwidth 5 Mb
TSN-IP Network 10 Gb

8 Major Nodes
33 Minor nodes w/ Connection Pedestals
Red / Black Capability
DWDM near completion – could increase bandwidth 10x

OPSEC Review, 4 May 11 - APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED
A Compelling, Comprehensive Range Instrumentation Use Case at White Sands

Optics Multi-cast Group

20 Hz

60 Hz

Cox Pointing Data Object on TENA V6

NetAcquire on TENA V6

Telemetry Pre-Processor

TM Multicast Group

Radar Track Object on TENA V6

Radar Multicast Group

Measureand Object on TENA V6

DREN

IRCC

MRTFB 2

MRTFB 3

Test Support Network TSN / IP

OPSEC Review, 4 May 11 - APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED
TENA and RRRP

- Use of TENA will facilitate Remote Operations and Interoperability of the Ranges’ Radar Systems

- TENA Instrumentation Radar Object Models will be used for all communications external to the individual Radar Systems
  - Pointing data for optics, telemetry, or other radars
  - Remote Single Integrated Air Picture (SIAP)

- Development of TENA Instrumentation Radar Object Models
  - Developed initial Instrumentation Radar TSPI Object Model
    - Received input from Test Center SMEs
    - For CW Doppler and Pulse radar systems
  - Instrumentation Radar Object Models will be finalized after contract award
Common Range Integrated Instrumentation System

Data Throughput 4x Improvement, Software Communication Architecture

Miniaturization

>20x TSPI Accuracy Improvement Level III

20x TSPI Accuracy Improvement Level II

Updated Encryption Technology

Standardized Protocols and Interfaces

Improved Reliability

3x TSPI Accuracy Improvement Level I

Test Ground Subsystem (TENA)

Training (RIW) Waveform with Training Level TSPI

Ground Station/Debrief Station

Live Monitoring

Threat Systems
## TRMC Investment Programs Overview

### T&E/S&T
- Established in FY2002
- Develops technologies required to test future warfighting capabilities
- 6.3 RDT&E funds
- ~$100M / year
- 9 current Tech areas
  - Directed Energy
  - Hypersonics
  - Netcentric Systems
  - Unmanned Systems
  - Multi-Spectral Sensors
  - Non-intrusive Instruments
  - Spectrum Efficiencies
  - Electronic Warfare
  - Cyberspace Test

### CTEIP
- Established in FY1991
- Develops or improves test capabilities that have multi-Service utility
- 6.4 RDT&E funds
- ~$140M / year
- 51 current projects
  - 25 projects developing core Joint capabilities
    - 2 projects improving interoperability test cap.
  - 8 projects improving threat representations used in testing
  - 14 projects addressing near-term OT shortfalls

### JMETC
- Established in FY2007
- Provides corporate infrastructure for distributed Joint testing
- 6.5 RDT&E funds
- ~$10M / year
- 69 current sites
  - Expanding to 70 sites
- Maintains
  - Network connections
  - Security agreements
  - Integration software
  - Interface definitions
  - Distributed test tools
  - Reuse repository
TENA in Resource Constrained Environments (TRCE) Project Addresses These Issues

- Improve TENA’s support for variable quality and low data rate network links including wireless networks
- Expand TENA’s support for handheld and embedded instrumentation computational platforms

- Low Data Rate Networks
  - TENA must be able to establish and maintain data connections on low data rate networks
  - Need to optimize use of low data rate networks to support relevant operational scenarios

- Wireless Networks
  - Current range environments use wireless links extensively for various systems under test

- Variable Quality Networks
  - T&E systems poorly tolerate high loss, link failure, or heterogeneous links
  - Need to provide data continuity for degraded or heterogeneous networks

- Specification of Interests
  - Subscribers must be able to specify data “interests” to more efficiently use available & limited network resources

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
RelayNode 1.0

- Auto-generated application that will support a wide range of object models
- Can be deployed at strategic points geographically on the LAN/WAN
- Supports each device connection in separate thread
- Will eventually support Bluetooth and Zigbee devices
Alaska Training Range Evolution Program (ATREPP) use of TENA

ATREPP’s intent is to enhance the existing Pacific Alaska Range Complex air and ground capabilities by providing a 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.

High Side
• TENA ICADS
• TENA ACMI
• TENA 9C2
• TENA DIADS
• TENA SimShield

Low Side
• TENA MOKKITS
• TENA MILES 2000
• TENA I-HITS
• TENA UMTE
Range Department/Division Heads:

PMRF’s high-level direction for future information technology is to move to the TENA Object Model standard for information exchange between PMRF systems and between PMRF and other ranges.

The PRITEC program produced a TENA-Enabled Range Roadmap (attached). The roadmap explains the way PMRF will transition from the IT infrastructure today to a TENA-enabled range of the future. All PMRF personnel are directed to ensure that resources expended to modernize, improve, upgrade or replace existing or new capabilities at PMRF will be in compliance with the roadmap. Deviations from, or changes to, the roadmap must be approved by the CIO or above.

All new initiatives must be briefed to the CIO to demonstrate their TENA compatibility, and to receive CIO approval before they can proceed. This briefing shall also include; who the government system owner will be, what the source of funding is, what the support/sustainability plan is throughout the system lifecycle, what the IA plan is, etc. The CIO will create a guidance memorandum identifying the standard content for the briefing.

Bottom line: Any new IT initiatives, including servers, sensors, radars, telemetry, data processing, and software initiatives need to actually implement TENA whenever possible or be capable of implementing TENA immediately when called upon to do so.

Aloha
Jack
Technical Director
Pacific Missile Range Facility
Enhance interoperability through use of DoD standard interfaces and middleware

Take advantage of features of TENA Middleware for intra-range data processing (e.g., publish-subscribe mechanism for control of data flow)

Create opportunity to reuse and leverage TENA applications and tools developed for other ranges

Make PMRF developed TENA applications available to other ranges

Leverage DoD joint test infrastructure provided by JMETC

PRITEC Migrates PMRF to TENA
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 Virtual Private Network using SDREN

TENA Software, Object Models, Tools, Repository
Summary

- **TENA** offers significant benefit to the Ranges and fosters the mission of the RCC with common data standards, common instrumentation interface, common data exchange, common tools, engineering support, and a plan for long term sustainability for reduced O&M.
- **JMETC** supports the full spectrum of Joint testing, supporting many customers in many different Joint mission threads.
  - CVN-21, JSF, MMA, NECC, DD1000, WWF, BAMS, JIAMDO
- **TENA** is the CTEIP architecture for future instrumentation, the JNTC architecture for Live integration and an enabling technology for **JMETC**.
- **TENA** and **JMETC**:
  - Being built 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
    - JMETC User Groups, TENA AMT Meetings
    - Next Meeting is week of May 7-10 in Phoenix, AZ
TENA Website: www.tena-sda.org
  - Download TENA Middleware

JMETC Website: www.jmetc.org

TENA Feedback: feedback@tena-sda.org
  - Provide technical feedback on TENA Architecture or Middleware

JMETC Feedback: jmetc-feedback@jmetc.org

TENA SDA Contact
  - Telephone: (571) 372-2714

JMETC Program Office Contact
  - Telephone: (571) 372-2699
JMETC Enables Distributed Testing

Joint Operational Scenarios

Integrated Test Resources

- Virtual Prototype
  - TENA Standard Interface Definitions
  - TENA Common Middleware
- Hardware in the Loop
  - TENA Standard Interface Definitions
  - TENA Common Middleware
- Installed Systems Test Facility
  - TENA Standard Interface Definitions
  - TENA Common Middleware
- Range
  - TENA Standard Interface Definitions
  - TENA Common Middleware
- Environment Generator
  - TENA Standard Interface Definitions
  - TENA Common Middleware
- Threat Systems
  - TENA Standard Interface Definitions
  - TENA Common Middleware

JMETC Connectivity on SDREN

Reuse Repository

Distributed Test Support Tools

Data Management Solutions

* TENA: Test and Training Enabling Architecture
JMETC Benefits

• Provides Department-wide capability for:
  • Evaluation of a weapon system in a joint context
  • DT, OT, Interoperability Certification, Net-Ready KPP compliance testing, Joint Mission Capability Portfolio testing, etc.

• Provides test capability aligned with JNTC
  • Both use TENA architecture
  • Both use Network Aggregator

• Reduces time and cost by providing
  • Readily available, persistent connectivity with standing network security agreements
  • Common integration software for linking sites
  • Distributed test planning support tools

• Provides distributed test expertise
JMETC Connectivity

- Functional Sites: 69
- New Sites Planned: 11
- Connection Points to Other Networks: 6

- 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

Sites in Alaska
- Ft. Greely: CRTC

Sites in So Cal
- Edwards (2): Ridley, 412th EWG IFAST
- China Lake (3): AV-8B, F/A-18, IBAR
- TSPIL
- Point Mugu (2): ITEC, EA-6B
- El Segundo: NGC B-2
- Camp Pendleton: MCTSSA
- Corona: NSWC
- Palmdale, NGC BAMS
- Point Loma: SSC-PAC 59140, SSC-PAC HAPE
- West Agg Rtr.
- Rancho Bernardo, NGC BAMS

Sites in Hawaii
- PMRF: Bldg 105
- MHPCC

Sites in Gulf Range
- Hurbutt Field: C 2DAC
- Eglin AFB (5): AOC, DTF, GWEF, KHLS, JDAT

As of 09 Jan 2012
JMETC Users Group Meetings

- Identify core infrastructure requirements and use cases
- Identify, investigate, & resolve issues
- Identify opportunities to collaborate
- Discuss available solutions, tools, and techniques
- Share lessons learned

Last JMETC Users Group Meeting:
- November 15-16, 2011
  - Location: Baltimore, MD
    - Tracks:
      - User Requirements
      - Information Assurance / Security
      - Data Management
      - Distributed Test Tools
      - Cyberspace T&E (FOUO)