JMETC and TENA Overview for NDIA M&S and DT&E Committee

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Topics

• Distributed Testing Overview
• What is JMETC?
• Example JMETC-supported testing
• Current JMETC Connectivity
• TENA Relationship to JMETC
• TENA Overview
• Summary

• Backup Slides:
  • FY11 Accomplishments
  • FY11 Community Lessons Learned / Trends
  • Future Initiatives
  • Additional TENA Information
The DoD T&E process must evolve to be:

- Agile
- Streamlined
- Affordable
- Continuous

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Goal: Distributed, Integrated Testing and Training
Aspects of the 2030 Common Vision

• Combined Test & Training
  • Real-Time TTP / SOP Development to improve SoS effectiveness and suitability (limited)

• “Black box” and “white box” testing done in parallel including:
  • System functionality
  • System effectiveness
  • System of Systems effectiveness via mission threads in an operationally relevant environment

• Fewer test runs / configurations with more meaningful collected data

• Real-Time Data Analysis & Automated Reporting

We can not achieve the vision without Distributed Testing
What is Distributed Testing?

A process, preferably persistent and continuous, for linking various geographically separated Live, Virtual, and Constructive sites and systems together in a homogenous environment, for use across the acquisition life cycle, to support and conduct the Test and Evaluation (T&E) of a system or systems-of-systems.

A new way of thinking for many in the Test and Evaluation enterprise
Distributed T&E Supports Systems Engineering (SE)

Early Injection of Authoritative systems and mission threads

Operational Need Measures of Effectiveness/Suitability

Transition

Combined DT&E / OT&E in a Joint or SoS Environment

Allocated Functions & Performance Requirements

Verification

System Measures of Perfor

Realization & Assessment

Early Operational Assessment

Persistently Integrated but disparately developed capabilities

Component Characterization

Source: DAU Acquisition Community Connection
Distributed Testing Impacts

• Distributed Testing has already demonstrated:
  • Time savings, risk reduction, cost savings
  • Efficiencies across the development and T&E process
    • Early identification of issues
    • Near real-time Test-Fix-Test
    • Move data—not people

• Distributed Testing, when fully implemented also:
  • Provides for agile, persistent T&E
  • Supports early integration of DT and OT
  • Gives SME’s an “Intensive Lab” and connective relationship with other entities in the systems-of-systems environment that they wouldn’t have otherwise.
The JMETC Mission

JMETC provides the **persistent infrastructure** and **technical expertise** to integrate live, virtual, and constructive systems for test and evaluation in a Joint systems-of-systems (SoS) environment.
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 common joint testing process and customer support team for JMETC products and distributed testing
JMETC Enabled Distributed Testing

Joint Operational Scenarios

Systems Under Test

Integrated Test Resources

- Virtual Prototype
  - TENA Standard Interface Definitions
  - TENA Common Middleware
- Hardware in the Loop Lab
  - 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 Network on SDREN

JMETC Infrastructure

Reuse Repository

Distributed Test Support Tools

Data Management Solutions
Distributed Testing Enables “Test-Fix-Test” Across the Acquisition Life Cycle

Outline Distributed Testing and JMETC requirements in TEMP

Rapid Acquisition, Developmental Test, Operational Test, Interoperability Certification, Net-Ready Key Performance Parameters testing, Joint Mission Capability Portfolio testing

By Providing

- JMETC enables continuous testing across the acquisition life cycle
- JMETC reduces acquisition time and cost

Enables early verification that systems work stand alone and in a Joint Environment

Helps find problems early in acquisition – when they are less costly to fix

Creates robust environment for common prototype analysis

Provides subject matter expertise to integrate distributed facilities

- Readily-available, persistent connectivity
- Standing network security agreements
- Common interoperability software for linking sites
- Certified test tools for distributed testing
Test Early in Acquisition Process
Recent Distributed Test at a major test facility

• C2 Interoperability upgrade to National Strategic asset

• Significant software and interoperability problems found during initial Distributed Testing

• Discovered system NOT ready for open air testing!

**IMPACT—Risk Reduction. Early Identification of Problem!**

• Early Distributed Testing led to early identification and correction of interoperability issues

• No range or flying costs!
**Post-Milestone A – Concept Development**

**Joint Surface Warfare JCTD**

**Description:**
Point Mugu Test Team demonstrated Net Enabled Weapon Link-16 capability using F/A-18E/F as launch platform, JSOW C-1 as weapon, and JSTARS as 3rd party target source.

**Sample of Measures:**
Tactical message timing between the controller and the weapon.

**IMPACT** -- Efficiency, Lower Technical Risk, and Cost Savings

- Program scheduled and executed short multiple tests for incremental software update evaluation.
- Resources expended on test & analysis and not network setup and monitoring.
Post-Milestone C – Developmental Test
B-2 Spirit ICE Data Link Test

Description:
• Assessment of B-2 Link-16 interoperability with AWACS
• Connected live B-2 on ramp at Whiteman AFB, MO, an AWACS HITL at Tinker AFB, OK, within a distributed C2 environment

Sample of Measures:
Timeliness and accuracy of message exchanges

IMPACT-- Cost Savings and Better Product
• Early testing led to early identification and correction of Link 16 interoperability issues
• No range or flying costs
Responsive T&E for Rapid Fielding
Battlefield Airborne Communication Node (BACN)

• Joint Urgent Operational Need

• Integration of BACN payload onto multiple platforms for solution to net-centric warfare challenges of:
  • Beyond line-of-sight comm
  • Relay, bridge, and range extension for ground forces and supporting aircraft

• Distributed Testing included Live-fly DT and Operational Utility Evaluation, Fall of 2010

IMPACT--Cost Savings and Better Product!

• Efficient integration of DT and OT
• All required assets not available on-site
• Distributed Testing saved “$1.2M”
• Urgent capability fielded
JMETC Connectivity

- Functional Sites: 68
- New Sites Planned: 7
- Connection Points to Other Networks: 5

- 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 24 Jul 2011

Sites in Alaska
- Ft. Greely: CRTIC

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

Sites in Hawaii
- PMRF: Bldg 105
- MHPCC

Sites in MD, DC, VA
- Aberdeen: ACCN
- Pax River:
  - (7)ESTEL E2C/D, MCL, ACETF, SAIL, ATR, E2C SIL, UASIL
  - (1) MFS
  - JMETC SYSCON
  - East Agg Rtr.
- DISA: Sky 7
- Dahlgren (2): CEDL, IWSL
- JFCOM: JSIC
- Langley (2):
  - C-GIIIF, TDLITC
  - Norfolk: COMOPTEVFOR
- Dam Neck: CDSA
- Wallops Island:
  - (2) SCSC, SSDS
- Newport News:
  - NGC VASCIC
- Hurlburt Field: C2DAC

Sites in Gulf Range
- Eglin AFB (5):
  - AOC, DTF, GWEF, KHILS, JDAT

Sites in Europe:
- JFCOM: JSIC
- Langley (2):
  - C-GIIIF, TDLITC
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Participants
Live, Virtual or Constructive

Operational
Control

Information
Presentation

Data
System
Under
Environment

Acquisition

Data
Fusion
&
Archive

Data
Display
&
Analysis

Test
Control

JFC

JMETC Connectivity to Other Ranges, Labs, and Facilities

TENA Middleware

Need: Persistent End-to-End Interoperability of Test Ranges, Labs, and Facilities
JMETC Uses TENA as its Enabling Architecture
(Can gateway to existing DIS and HLA simulations)

- TENA is:
  - Developed, upgraded, and sustained by CTEIP and JNTC
  - Middleware that provides a single, universal data exchange solution
  - Common for test and for training (core standard in JMETC and JNTC)
  - Available for download at www.tena-sda.org for free

- TENA provides:
  - Interoperability among range systems, hardware-in-the-loop laboratories, and simulations in a quick, cost-efficient manner
  - A capability to rapidly and reliably develop LVC integrations
  - A set of community-agreed object models that define the data elements used in LVC integrations – maximizes reuse from event to event
  - An auto-code generator to drastically reduce TENA incorporation time

- Newest version of TENA (version 6.0) provides:
  - Advanced data filtering (only data of interest sent over the wire)
  - Improved fault tolerance and embedded diagnostics
  - Downloadable on the TENA Website
Currently, range systems tend to be non-interoperable, “stove-pipe” systems

The purpose of TENA is to provide the architecture and the software implementation necessary to

- Enable Interoperability among range systems, facilities, simulations, C4ISR systems in a quick, cost-efficient manner, and
- Foster Reuse for range assets and for future developments

- Support the warfighter (Joint Vision 2010/2020)
- Enable simulation-based acquisition
- Foster test and training integration
- In the long term: SAVE MONEY!

Lay the Foundation for Future Test and Training Range Instrumentation

MB10-03
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!
Where TENA SDA Fits in DoD

Office Of The Secretary Of Defense (OSD)

- Secretary Of Defense
  - Deputy Secretary Of Defense
    - Gen Counsel
    - ATSD Intel OVst
    - DoD IG
    - ATSD Civ Spt
  - USD Policy
  - USD Comp
  - USD P&R
  - ASD NII
  - DOT&E
  - USD AT&L

- Congress
  - Dir Admin & Mgt
  - Dir Net Assess
  - ASD Pub Affairs
  - ASD Legislative Affairs

- Defense Agencies
  - Sec Navy
    - USec Navy
    - Ch of Navy
    - Commandant MC
  - Sec Army
    - USec Army
    - Ch of Staff Army
  - Sec Air Force
    - USec Air Force
    - Ch of Staff AF

- DOD Fld Activities
  - DUSD A&T
    - Dir Def Sys
    - DUSD Inf Tec Sec
    - DUSD Indus Policy
    - Dir Disadvantage Bus
    - Dir Proc/Acq Policy
    - Dir DCMA
  - ATSD NBC
    - Dir DR&E
    - DUSD L&MR
    - Dir Aq R&A
    - Dir Int Coop
    - Dir Spec Pgrms
    - Dir Admin
    - Dir DSB
    - Dir MDA

- Test Resource Management Center (TRMC)
  - T&ES&T
  - CTEIP
  - JMTC

- TENA SDA
TENA Software Development Activity (TENA SDA)

- TENA Software Development Activity (TENA SDA) manages sustainment and future development responsibilities for TENA for both the test and training communities

- Reports to OSD TRMC, CTEIP and the JNTC Joint Management Office (JNTC JMO) on all TENA-related activities, including but not limited to
  - Sustainment of TENA Middleware
  - Ports to different operating systems
  - Upgrades to the TENA Middleware
  - Upgrades to TENA-related tools and utilities (such as the auto-code generator)
  - Distribution of TENA Middleware
  - Distribution of source code generated from object models
  - Correction of software defects
  - Technical support to TENA users, including on-line help desk and TENA Training

- Upgrades to TENA capabilities will stem from
  - Inputs from the Services (including from the annual reports the Services provide on their implementation of TENA on their systems)
  - Inputs from the T&E Executive Agent Needs and Solutions process
  - Joint training requirements through the JNTC JMO
  - Common requirements identified by members of the TENA AMT
  - Feedback provided by TENA users
  - Results/observations from test and training events

- Other responsibilities include chairing the TENA AMT
TENA is an Open Architecture

- The Software Engineering Institute defines an Open System as “a collection of interacting software, hardware, and human components designed to satisfy stated needs with interface specifications of its components that are fully defined, available to the public, maintained according to group consensus, in which the implementations of the components conform to the interface specifications.”

- TENA is maintained according to a consensus of its users assembled as the TENA Architecture Management Team (AMT)

- TENA Middleware exists and is being used to support real events
  - Government owned, no proprietary software

- TENA is freely releasable (Distribution A) to non-US entities
  - We have many non-US users in Britain, France, Sweden, Denmark, etc.

- There are no plans for standardizing TENA in the same way as DIS and HLA have been standardized (IEEE)
  - However, we are looking into innovative mechanisms to get the same usability and confidence with TENA as we do with these standards
  - TENA’s business model is not the same as the DIS and HLA business models
TENA Overview

- **Requirements**
  - Interoperability
  - Reuse
  - Composability
  - Support Rapid Integration
  - Gradual Deployment

- **Supports**
  - Testers & Trainers
  - Joint, Army, Navy, Air Force, Agencies
  - Live, Virtual, Constructive
  - Range, Laboratories, Simulations
  - Real-Time & Non-Real-Time

- **Guiding Principles**
  - Provide middleware
  - Use real software objects
  - Maximize code generation
  - Management by users (AMT)
  - No license fee (GOTS)
Achieving Interoperability and Reuse

- **Interoperability** requires
  - A common architecture
  - An ability to meaningfully communicate
    - A common language
    - A common communication mechanism
  - A common context
    - A common understanding of the environment
    - A common understanding of time
    - A common technical process

- **Reuse and Composability** require the above, plus
  - Well defined interfaces and functionality for the application to be reused
  - Place to store reusable components
The Standard
TENA Object Model

- To enable semantic interoperability among range resource applications
- To provide the “common language” that all range resource applications use to communicate
  - It will eventually encode almost all information communicated among range resource applications

Object Model Stages
- User-Defined Objects – objects defined solely for the purpose of a given logical range by TENA users
- Candidate Objects – objects defined as potential standards, which are undergoing test and evaluation by the community prior to standardization
- TENA Standard Objects – objects which have been approved for standardization by the AMT
TENA Objects are Automatically Compiled In

- Why use compiled-in object definitions?
  - **Strong type-checking**
    - Don’t wait until runtime to find errors that a compiler could detect
  - **Performance**
    - Interpretation of methods/attributes has significant impact
    - Ability to easily handle complex object relationships
    - Conforms to current best software engineering practices

- **TENA utilizes auto-code-generation for all object definitions**
  - Ensures that every system has same source code baseline
  - Standard, validated algorithms (such as coordinate translations or unit conversions) can be embedded in TENA rather than burden software applications of managing and performing translations
  - TENA Middleware performs data marshalling/demarshalling rather than burden software applications
TENA Compliancy Levels

TENA Level 1
- Uses the TENA Middleware
- Defined as TENA Objects

TENA Level 2
- Standard use and definition of Time
- Only uses the TENA Middleware
- Uses the TENA Middleware
- Defined as TENA Objects

TENA Level 3
- Data Archiving (when available)
- Uses Standard Objects (whenever possible)
- AMO for Control
- Standard use and definition of Time
- Only uses the TENA Middleware
- Uses the TENA Middleware
- Defined as TENA Objects
JMETC Has Realized Benefits from Using TENA

- **Lowers the cost to integrate systems together**
  - Systems have been made TENA-compliant for under $20K

- **Decreases the time to integrate systems together**
  - Auto-code generator creates C++ interface (50K+ SLOC) in hours
  - Legacy systems upgraded to TENA compliance in < 1 week
  - HLA-compliant display system made TENA-compliant in 1 day

- **Lowers the cost to develop new systems**
  - New systems can use middleware (1.5M+ SLOC) & existing object models for free
  - New systems do not need to develop multiple interfaces to various range protocols

- **Lowers cost of upgrades through gradual deployment**
  - TENA can be gradually deployed (system by system) at DoD Ranges and Laboratories rather than requiring all systems be redesigned
  - Easy incorporation of existing/legacy systems

- **Improves reliability of integrating systems together**
  - Consistency checker to verify every system has compatible versions installed
  - More reliability from reusing systems from one event to the next
  - Auto-code generator ensures that every system has same baseline of source code
  - Standard, validated algorithms (such as coordinate translations or unit conversions) are embedded in TENA rather than burden software applications of managing and performing translations
JMETC Users Group

• Purpose is to focus on technical requirements and solutions relevant to current and future Distributed Testing needs.
  • Technical and Management level representatives identify core infrastructure requirements, and most importantly resolve issues
• Quarterly meetings of 250-300 JMETC customers, acquisition programs, test events, ranges, LVC sites, tools and network providers

• An established forum for the Distributed Test Community to:
  o Identify core infrastructure requirements and use cases
  o Identify, investigate, & resolve issues
  o Identify opportunities to collaborate
  o Discuss available solutions, tools, and techniques
  o Share lessons learned

Next JMETC Users Group Meeting:
• November 15-16, 2011
• Location: Baltimore, MD
• Potential Tracks:
  • User Requirements
  • Information Assurance / Security
  • Data Management
  • Distributed Test Tools
Architecture Management Team (TENA AMT)

- AMT Members:
  - Air Armament Center (AAC), Eglin AFB, FL
  - Naval Undersea Warfare Center (NUWC)
  - Redstone Test Center (RTC)
  - Electronic Proving Ground (EPG)
  - White Sands Missile Range (WSMR)
  - Naval Air Warfare Center – Aircraft Division
  - Naval Air Warfare Center – Weapons Division
  - Yuma Proving Ground (YPG)
  - P5 Combat Training System (P5CTS)
  - Joint National Training Capability (JNTC)
  - 329 Armament Systems Group (329 ARSG)
  - Pacific Missile Range Facility (PMRF)
  - T&E/S&T Non-Intrusive Instrumentation
  - integrated Network Enhanced Telemetry (iNET)
  - NAVSEA Warfare Center - Keyport
  - Dugway Proving Ground (DPG)
  - Joint Fires Integration & Interoperability Team (JFIIT)
  - Common Training Instrumentation Architecture (CTIA)
  - Army Operational Test Command (OTC), Fort Hood, TX
  - Interoperability Test and Evaluation Capability (InterTEC)
  - Naval Aviation Training Systems Program Office (PMA-205)
  - Air Force Flight Test Center (AFFTC), Edwards AFB, CA
  - Aberdeen Test Center (ATC), Aberdeen Proving Ground, MD
  - Alaska Training Range Evolution Plan (ATREP)
  - Joint Mission Environment Test Capability (JMETC)
  - Common Range Integrated Instrumentation System (CRIIS)

- Meetings every few months

- US Advising Members:
  - Boeing
  - Cubic Defense
  - DRS
  - Embedded Planet
  - EMC
  - General Dynamics – C4 Systems
  - KEnetics Incorporated
  - MAK Technologies
  - NetAcquire
  - Raytheon
  - Science Applications International Corporation (SAIC)
  - Scientific Research Corporation (SRC)
  - Scientific Solutions, Inc. (SSI)
  - Trusted Computer Solutions (TCS)

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

Summary of What TENA Has

An **Architecture** for Ranges, Facilities, and Simulations to Interoperate, to be Reused, to be Composed into greater capabilities

- **A Working Implementation of the Architecture**
  - TENA Middleware currently works on Windows, Linux, and Sun

- **A Process to Develop and Expand the Architecture**
  - CTTRA Workshops and AMT Meetings

- **A Technical Strategy to Deploy the Architecture**
  - Gateways provide interim solutions as TENA interfaces

- **A Definition of Compliancy**
  - Levels of compliancy to enhance communication among systems engineers and investment decision makers
Briefing Summary

• Distributed Testing promotes efficiencies in T&E by saving time and money and result in better, more interoperable products while reducing technical risk!

• Distributed Testing is utilized by acquisition programs today
  • Many Sites and Systems already connected via JMETC and well versed in TENA and the InterTEC tools
  • Demonstrated reliability with the capability to execute multiple events simultaneously, supporting high data rates and low latency requirements
  • Multiple examples of value added for customers
  • Provides Acquisition T&E Programs near real-time Test-Fix-Test capability

• The Future of T&E will include Distributed, Integrated Testing and Training and will enable near real time Test-Fix-Test
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

• 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

• JMETC Program Office Contact:
  • E-mail: jmetc-feedback@jmetc.org
  • Telephone: (703) 604-0350 ext. 0
  • JMETC Website: http://www.jmetc.org
# JMETC Program Points of Contact

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
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<td>703-601-5208</td>
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Backup Slides

FY11 Accomplishments & Trends
## JMETC FY 11 Accomplishments to Date

### JMETC Accomplishments

- Executed and Planned support to over 60 distinct customer test activities in FY11
- Expanded network from 57 to 66 sites with additional 9 planned
- Established network connectivity to NGC BAMS Network and UK T&E networks
- Upgraded JMETC support applications and utilities to TENA R6
- Completion of TRMC Data Management for Distributed Test (DM-DT) Draft Report
- TRMC given non-voting membership to DoD DIACAP Technical Advisory Group (TAG)
- Creation of DIACAP Knowledge Service RDT&E Community Forum
- Increased JMETC services and capabilities provided by leveraging InterTEC, Services, and Industry
- Reuse Repository usability improvements

### Selected Testing Benefits to the DoD

- Identification of Service-level and Joint interoperability gaps, shortfalls, and overlaps with current C4ISR systems and networks
- Executed testing to support C4I system-of-system interoperability certification
- MIL STD compliance testing for tactical data systems
- Demonstrate the ability to exchange and process data in support of a cost-effective Single Integrated Air Picture
- Detailed analysis of track correlation between various air & missile sensor systems
- Coalition exchange and examination of real-time air picture data
- Determined distributed system components were not ready for full live integration testing
- Initial methodologies developed to enable containment and controlled propagation of cyber effects in operationally realistic LVC environments
FY11 Lessons Learned & Trends

• More emphasis in community on “test early and often”
  • More persistence and build-up in test activities rather than a traditional “Big Bang” event approach
  • “Test – Fix – Test” approach best way to leverage JMETC persistent infrastructure

• Growth of Industry / FFRDC Connectivity
  • Industry networks at Boeing, NG, MITRE, LMHO all peered or in process of being peered
  • Discussions with other major industry partners and research centers on-going

• More in-depth Engineering Analysis in robust distributed test environments
  • Environments are complex and require thorough analysis to understand “what happened” and causality associated
  • Effort needs to shift from environment construction and test execution to improving data requirements and analysis capabilities
  • Evaluators should challenge testers to develop more robust test cases that best leverage today’s possibilities
FY11 Lessons Learned & Trends

- Growth of coalition requirements
  - JMETC, with its partners, is ready to accept Coalition test requirements
  - Establishing Coalition connectivity is still a very labor intensive process
  - JMETC is looking for ways to improve capability and streamline processes

- Expansion of JMETC Nodes at existing locations with JMETC Connectivity
  - Negligible cost / effort to add new capabilities
  - Highlights incorporation of distributed testing into normal mission operations

- JMETC continues to spend lots of resources making legacy simulations interoperate with each other
  - Conflicting interpretations of the IEEE 1278 DIS standard are the #2 cause of interoperability problems during JMETC-supported distributed testing
  - Time spent making DIS simulations interoperate is time not spent assessing System(s) Under Test performance
  - More time is spent troubleshooting gateways and DIS PDUs than would have been spent upgrading the DIS application to TENA
Infrastructure Initiatives Under Investigation

- Requirement: Support for Multiple Independent Levels of Security (MILS)
  - Investigating: 1) Enterprise CDS approach 2) Requirements sharing with MLS-JCNE

- Requirement: Connectivity to coalition partners
  - Investigating: 1) Optimizing SOPs with JTEN 2) Peering to CFBL

- Requirement: Tactical RF over WAN environments
  - Investigating: Dynamic Fast Fourier Transform (DFFT)

- Requirement: Extension of distributed test capability into remote test areas
  - Investigating: JMETC Wireless Extensions

- Requirement: JMETC Tool O&M and IA efficiencies
  - Investigating: Application Virtualization and Cloud computing
Backup Slides

Additional TENA Information
A Notional Test Facility

System Under Test (SUT)

- SUT Instrumentation
- C4I Instrumentation

Field Telemetry Stations
- Telemetry Processors
- Telemetry Displays

GPS Ground Stations
- GPS Systems
- Range Control Displays

Radar Stations
- Radar Processing

Optics Tracking Mounts
- Optics Control Systems
- Flight Safety Displays

Flight Safety Transmitters
- Flight Safety System
- Target Control Displays

Target Control System

Other Range Systems
- Other Displays

Virtual & Constructive Models
- Virtual & Constructive Display

Data Fusion System
- Video Distribution System

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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)

Challenges grow exponentially when you need to interoperate with other facilities
Facility modernization must be gradual

New systems, upgraded systems, and existing systems must co-exist and preferably work together while supporting customer test/training events.

When do you want to discover integration issues?

- During development?
- During initial integration?
- During pre-event range check-outs?
- During actual test & training 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
(Software Library of Data Exchange Functions)

- 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
A **Logical Range Object Model (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.

The LROM is the common object model shared by all TENA resource applications in a logical range.

The concept of an LROM is necessary because ranges and events have unique requirements not used every time by everyone.

- As time progresses, each LROM will contain more standard elements and fewer elements that are chosen on an *ad hoc* basis.

TENA may be deployed gradually— the LROM concept supports this requirement.
TENA Meta-Model
Release 6
# 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

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*MB10-03*
# Key Release 6 Improvements and New Capabilities

## New Middleware Capabilities
- Advanced Filtering
- OM Subsetting
- SDO State Observation
- Separate Inbound/Outbound ORBs

## Metamodel and Model Improvements
- Fundamental Sizes
- Const Qualifier
- Optional Attributes
- Advanced Filtering
- OM Subsetting
- SDO State Observation
- Separate Inbound/Outbound ORBs

## New Event Management Capabilities
- Object Model Consistency Checking
- Remote Object Termination
- Execution Manager Fault Tolerance
- Enhancements to Diagnostics
- TENA Console
- Code Installation Layout

## Usability Improvements
- Observer Pattern (with Callback Aggregation)
- Separate Inbound/Outbound ORBs
- SDO State Observation
- Separate Inbound/Outbound ORBs

### Enhanced data distribution
- Optimized network usage

### Better ways to define data
- Remove ambiguity

### Improved reliability
- Enhanced troubleshooting

### Easy to use
- Harder to use wrong
Snapshot on DIS

- Distributed Interactive Simulation (DIS)
  - 55 Defined Messages (All data must be defined within these 55 messages)
  - State updates can only be sent “best-effort” (UDP) over the network
    - Requires data to be “heart-beat” at regular intervals (because a user can not be guaranteed the data was received on the other end)
  - All messages broadcasted to all systems on the network
    - Each receiver must parse thru all data to find the data of interest to their system
  - User must develop software interface to create and send DIS messages
  - User must translate all position data to WGS-84
    - User must incorporate, verify, and validate translation algorithms themselves
Snapshot on HLA

High Level Architecture (HLA)

- User can define any set of data to send
  - No common core set to start from universally accepted
- Data can be sent both “best-effort” (UDP) and “reliable” (TCP)
  - Using reliable protocols (when appropriate) can avoid the need to “heart-beat” data
- Data can be sent just to those systems interested
  - Publish/Subscribe mechanism curtails the need for each system to parse thru all data
- User must acquire/procure a Run-Time Infrastructures (RTI) (a.k.a. ‘middleware’)
  - RTIs from different vendors do not interoperate – for the LVC integration to work, all organizations must procure and install the same RTI – supporting different LVC integrations can require organizations to procure multiple RTIs from different vendors and switch between them (installing/reinstalling)
- User must develop the software interface to HLA
  - No data marshalling is provided by the HLA RTI, so users must consider which OS (Windows, Linux, etc.) is being used by other users in the LVC
- User can use whatever coordinate system they wish
  - If the LVC integration requires translation between coordinate systems, the user must incorporate, verify, and validate translation algorithms themselves
Test and Training Enabling Architecture (TENA)

- User can define any set of data to send – but a common core set to start from is available
  - Core object models coordinated thru Architecture Management Team (AMT) consisting of all Services both test and training with industry participation
- Data can be sent both “best-effort” (UDP) and “reliable” (TCP)
  - Using reliable protocols (when appropriate) can avoid the need to “heart-beat” data
  - TENA includes a sequence number in the header of “best-effort” messages to ease data analysis (easier to flag data lost on the network)
- Data can be sent just to those systems interested
  - Publish/Subscribe mechanism curtails the need for each system to parse thru all data
- TENA Middleware provided to users at no charge
  - Alleviates the need for users to procure middleware themselves
- User must develop software interface to TENA
  - TENA Middleware provides data marshalling so users do not need to worry about what OS (Windows, Linux, etc.) are being used in the LVC integration
  - TENA provides an auto-code generation capability that generates the bulk of the software interface for the user
- User can use whatever coordinate system they wish
  - TENA core object models provide validated translation software between coordinate systems – users do not need to worry about coordinate translation