Testing Smarter, Not Harder: Utilizing TENA and JMETC

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TENA and JMETC

User Support Lead

TENA Mission

- **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:

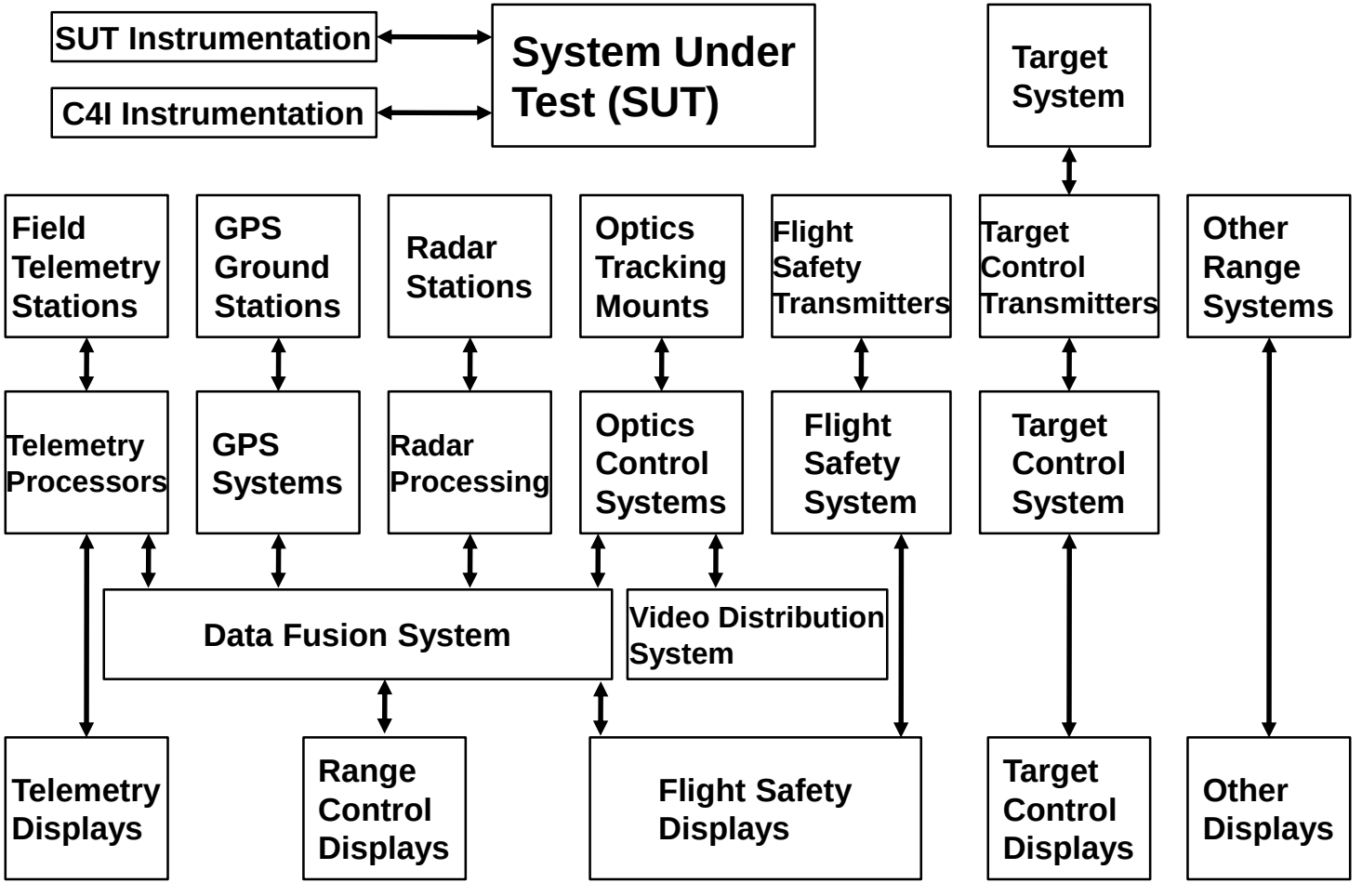
- **Enable interoperability among range, C4ISR, and simulation systems used across ranges, HWIL facilities, and development laboratories**
- **Leverage range infrastructure investments across the DoD to keep pace with test and training range requirements**
- **Foster reuse of range assets and reduce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

Working with the Range Community to Build the Foundation for Future Test and Training Range Infrastructure

Benefits of TENA

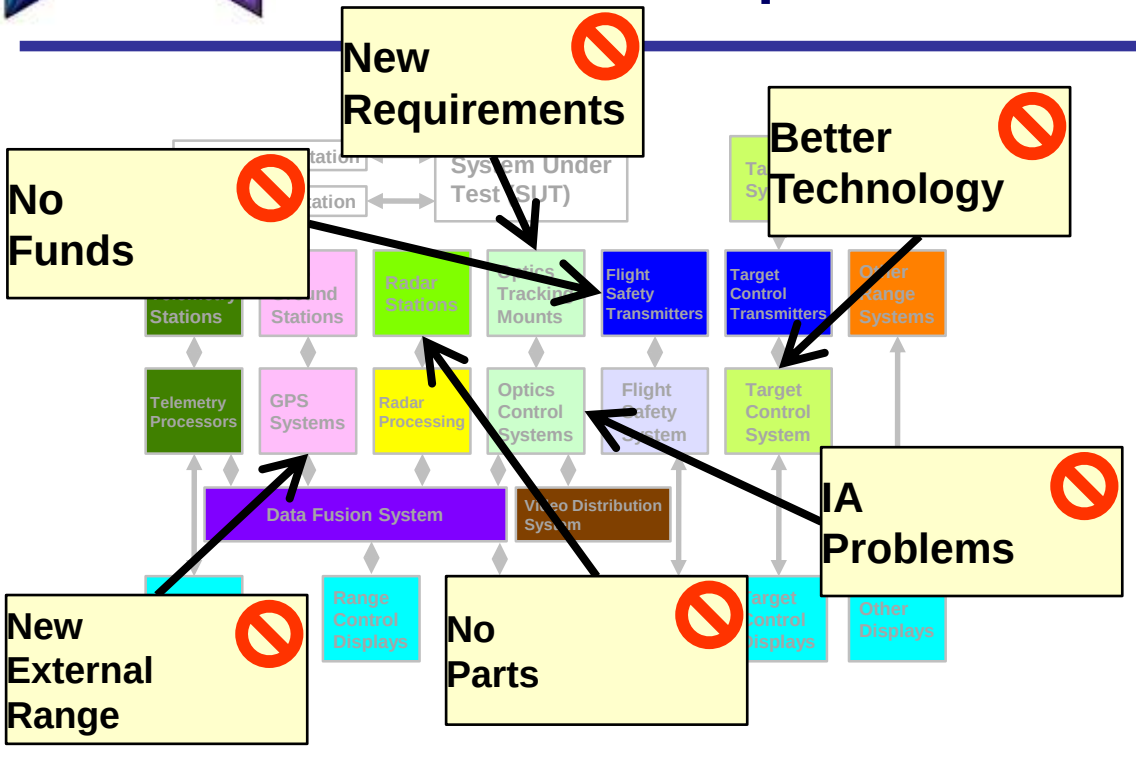
- **All TENA software and support is free to users**
- **TENA is the most capable and sophisticated interoperability solution**
- **TENA software is thoroughly tested and very reliable**
- **TENA Auto-Code Generation makes creating a TENA application as simple as possible**
  - TIDE Tool manages installation 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

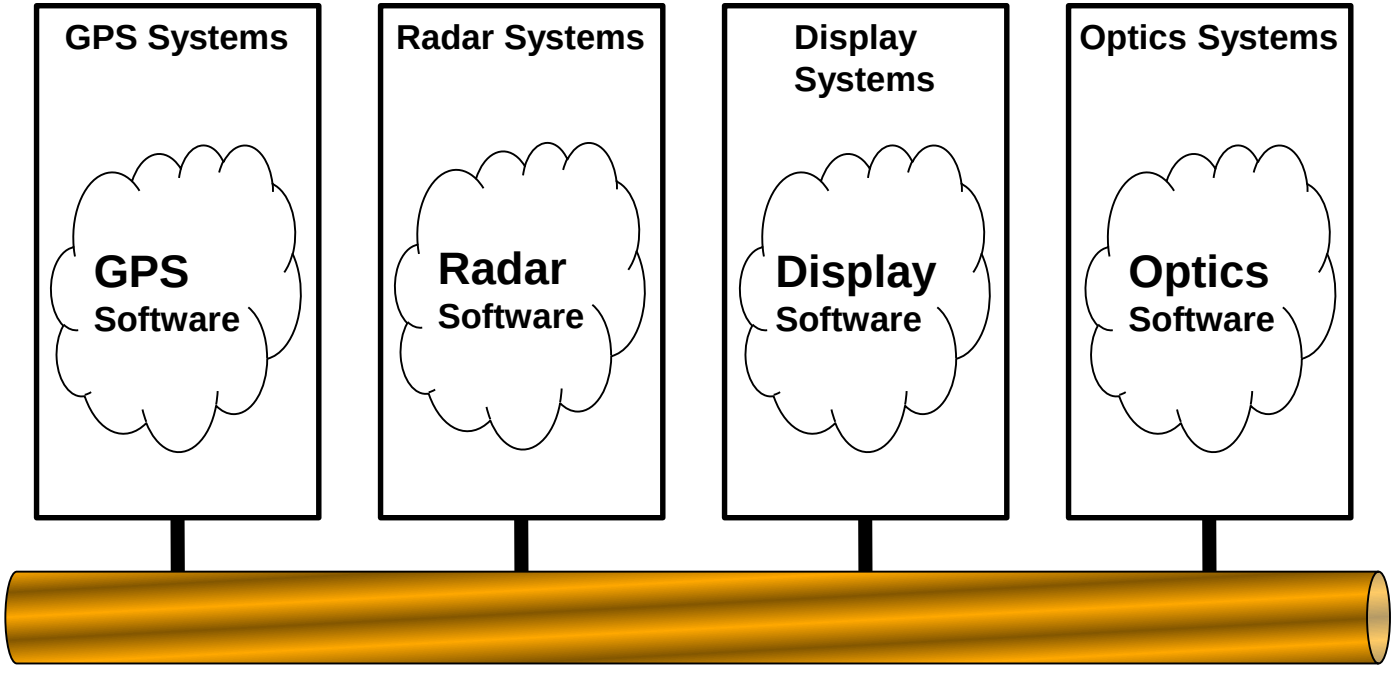
Range System and Infrastructure Development Challenges



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

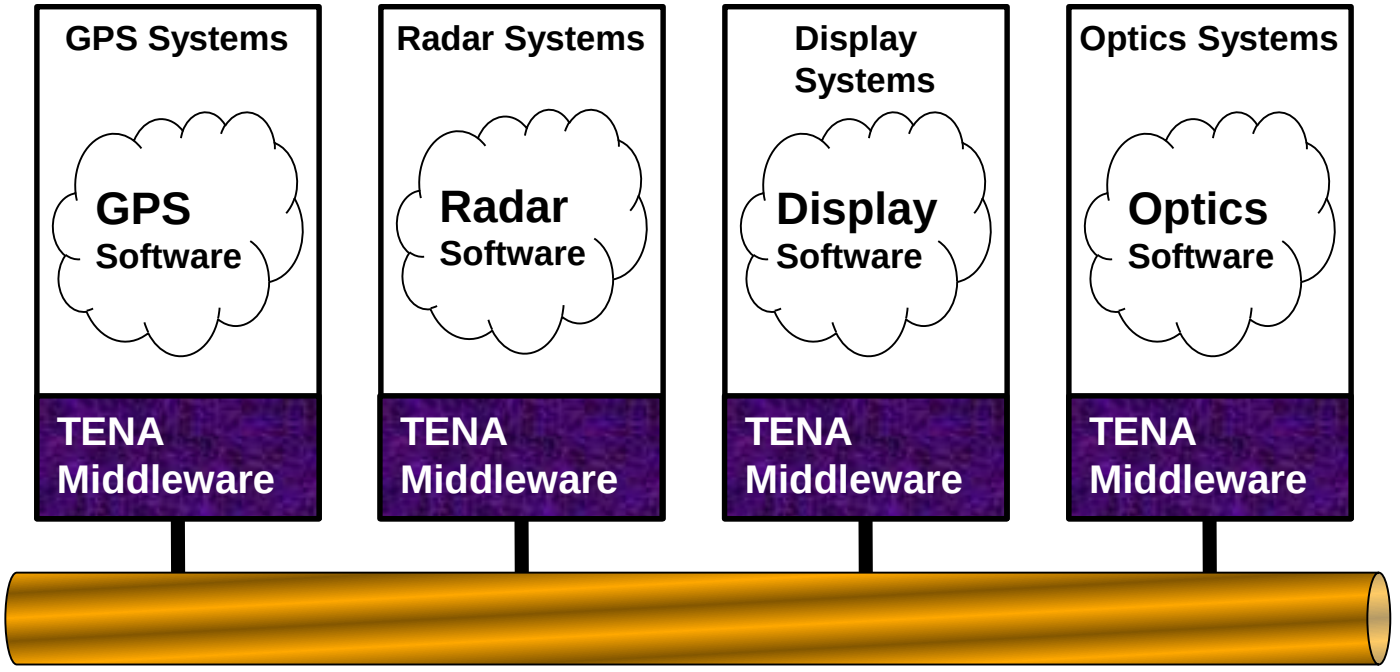
- **Range Specific Development Challenges**
  - Multiple Sponsors and Funding Sources
  - Evolving Test and Training Requirements
  - Expansion of Inter-Range Connectivity
  - Information Assurance Policies and Procedures
  - Range Modernization Must Be Gradual

Anatomy of Range Systems



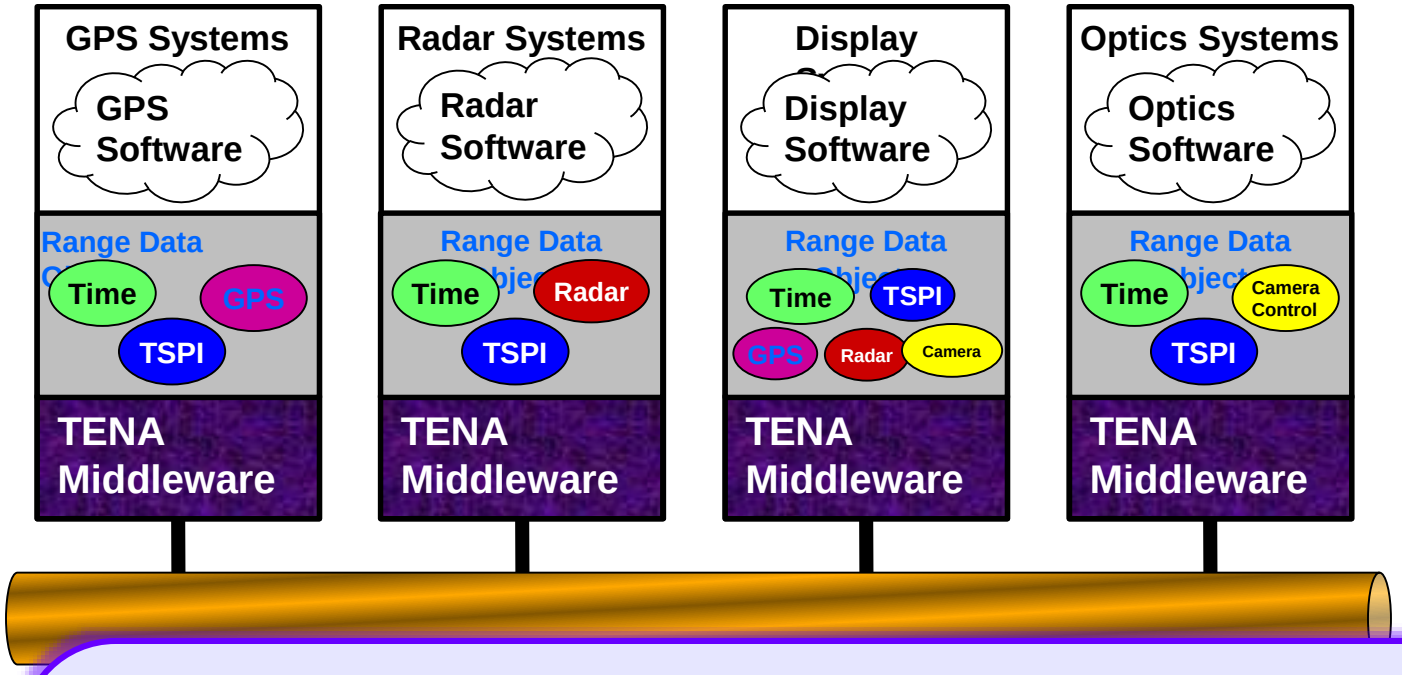
- **Traditionally, all developers must develop (often independently at different times) code that performs the function of data exchange between systems**
  - **Data preparation, packet marshalling/demarshalling, network communication, error handling, etc.**

TENA Middleware
(Software Library of Data Exchange Functions)



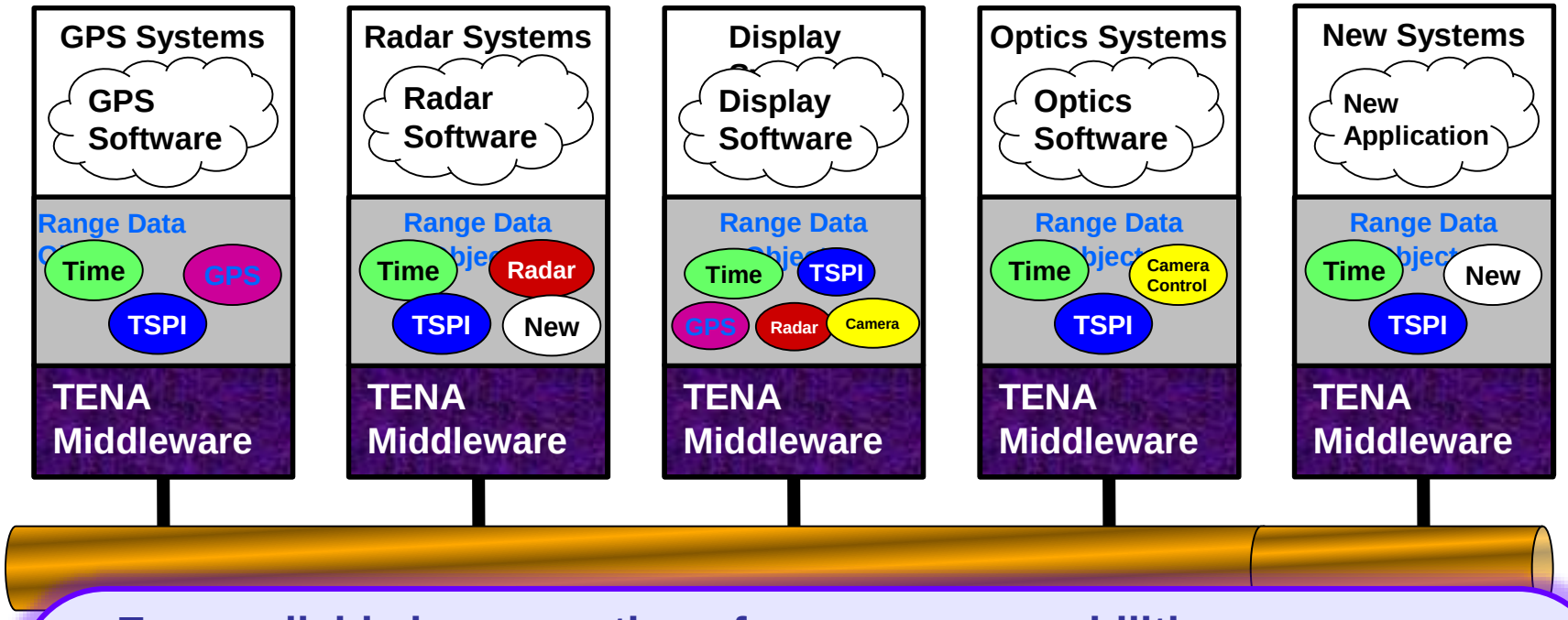
- **TENA Middleware is a set of software that performs real-time data exchange between systems**
  - **Support for C++, Java, and .NET programming languages**
- **TENA Middleware available for ~40 platforms, including:**
  - **Windows XP, Vista, 7/8, Server 2008/2012 (32- and 64-bit)**
  - **Linux: Fedora 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
(Range Data Formats & Algorithms)



- 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

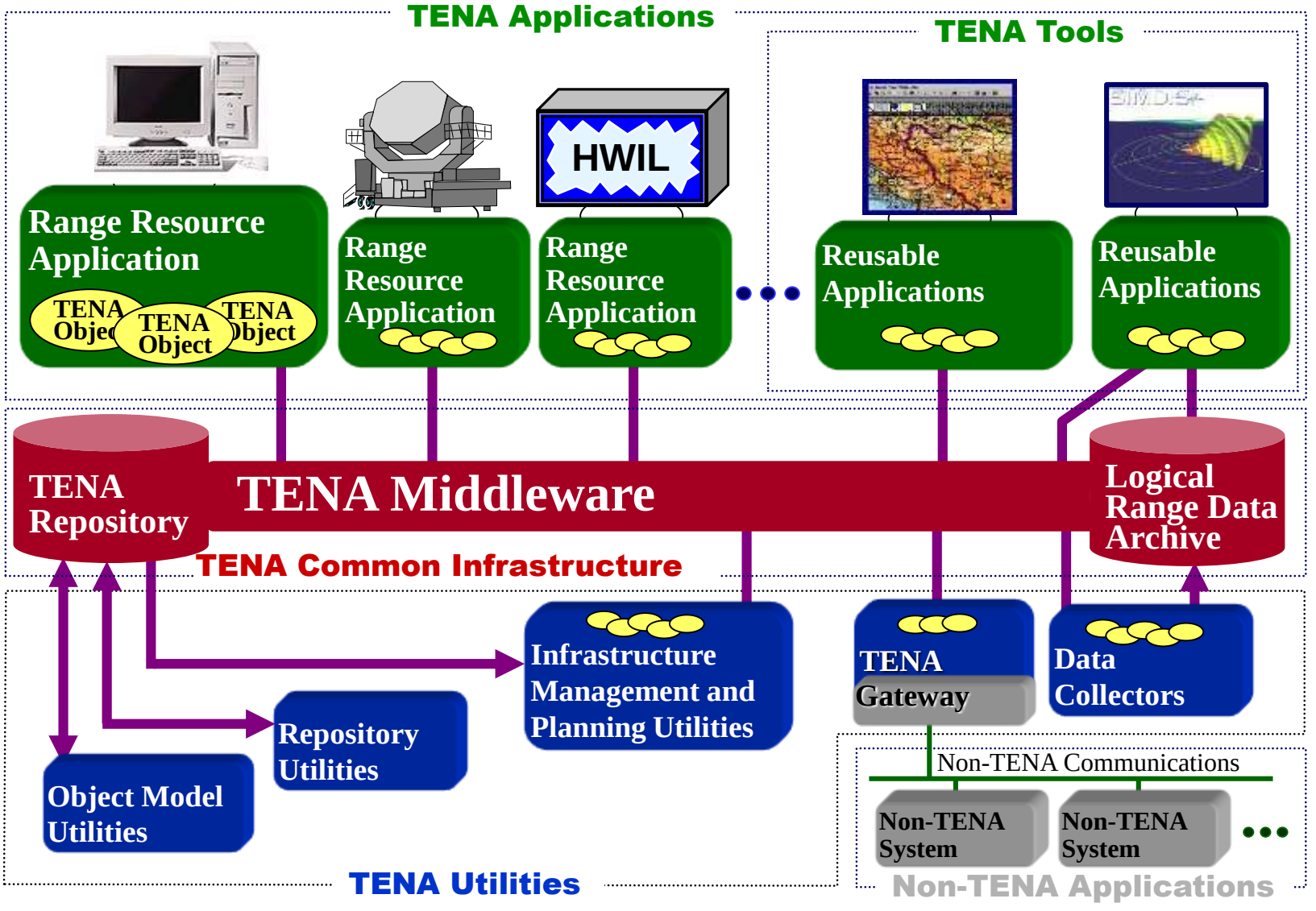


- Easy, reliable incorporation of new range capabilities
  - Known data exchange software (TENA Middleware)
  - Reuse standard range objects (Standard TENA Object Models)
    - Auto-code generate any new object models
  - Range interface on new application verified while application is developed (verification 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

TENA Architecture Overview



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)
- **Design Decisions / Trade-offs / Status / Technical I… Learned / Use Cases / Testing / Issues & Concerns … Resolution**

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

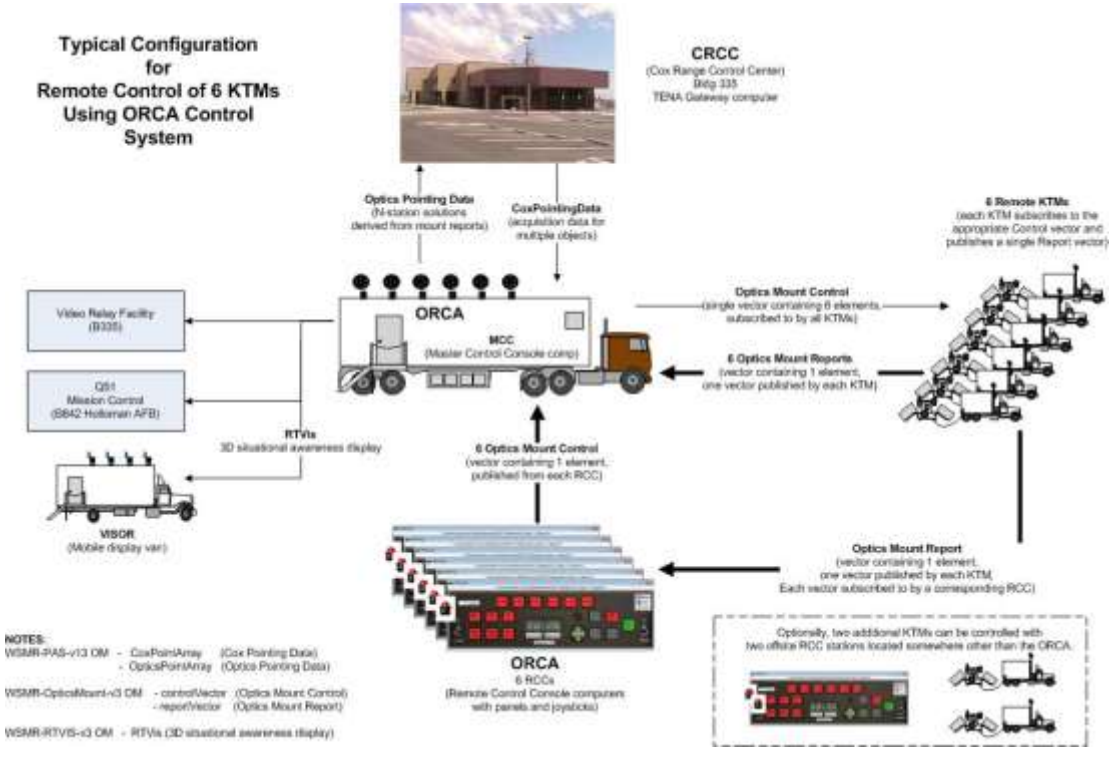
TENA Information Assurance (IA) Activities

- **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
- **Joint RDT&E Reciprocity Overlay Team (JRROT)**
  - Foundational set of controls for basing reciprocity determinations for RDT&E

TENA project works with IA organizations to reduce cost and delays to improve IA considerations with TENA applications

TENA at White Sands Missile Range (WSMR)

- **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**

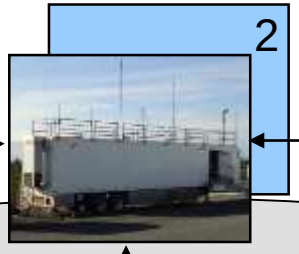


"TENA has functioned extremely well in our network environment and the rigorous requirement of 60 Hz updates to the instrumentation."

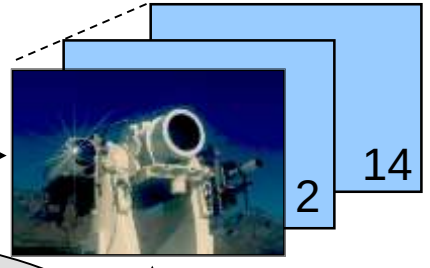
Charlie Conroy
WSMR Optics Development Engineering Lead

A Compelling, Comprehensive Range Instrumentation Use Case at White Sands

20 Hz



60 Hz



Optics Multi-cast Group

Test Support Network
TSN / IP

Cox Pointing Data Object
on **TENA V6**

Measureand Object
on **TENA V6**

TM Multicast Group

Radar Multicast Group

Radar Track Object
on **TENA V6**

IRCC

DREN

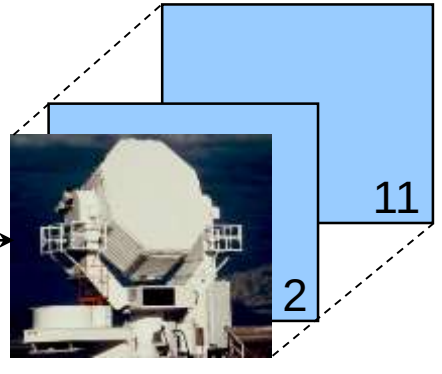
MRTFB 2

MRTFB 3

Telemetry
Pre-Processor

NetAcquire

on TENA V6

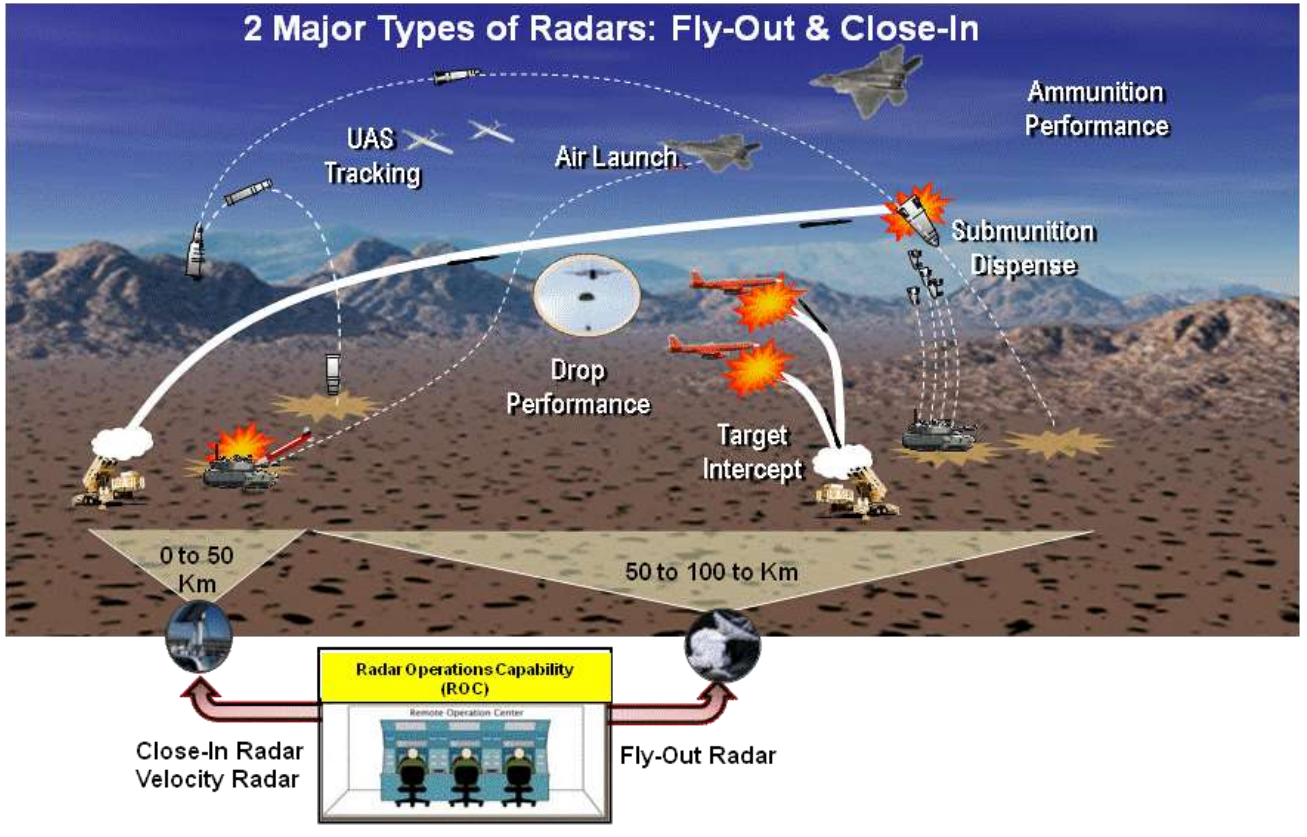


Army Proven
Battle Ready

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

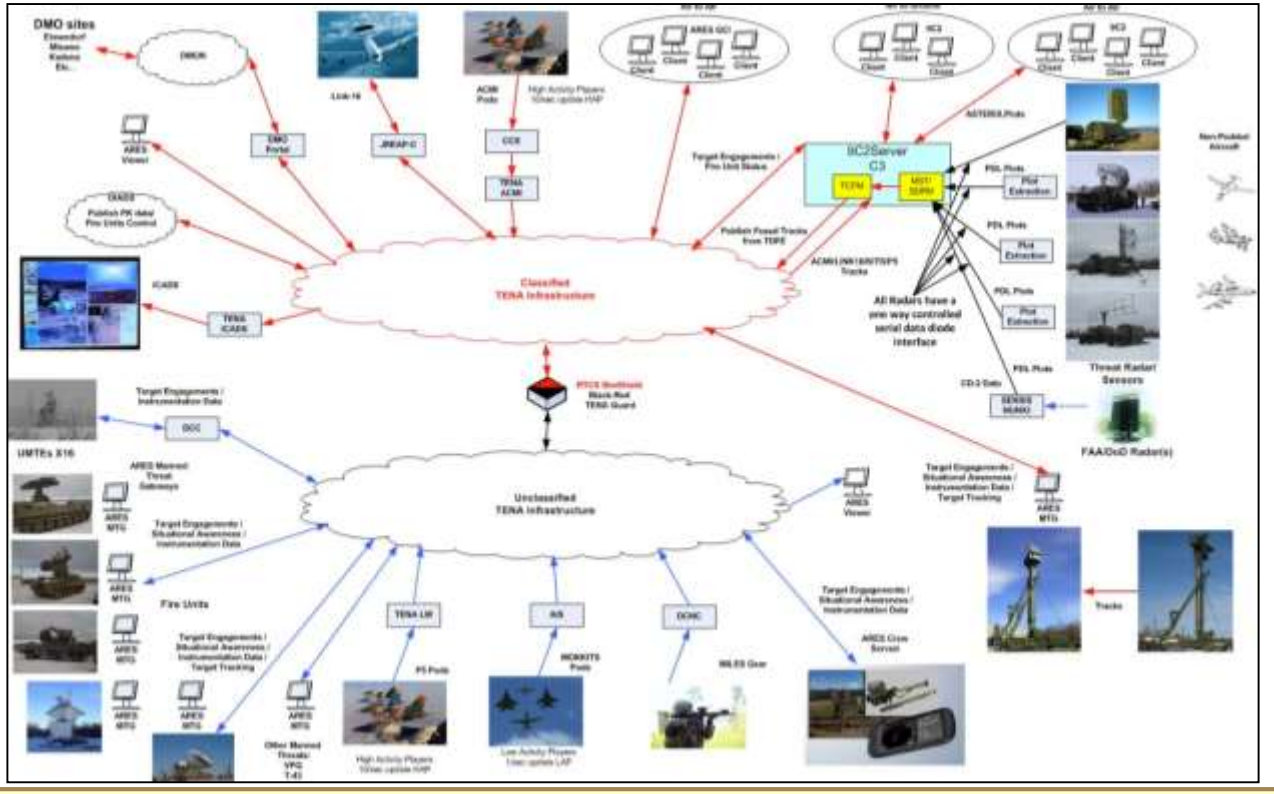
Range Radar Replacement Program (RRRP)

- **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**

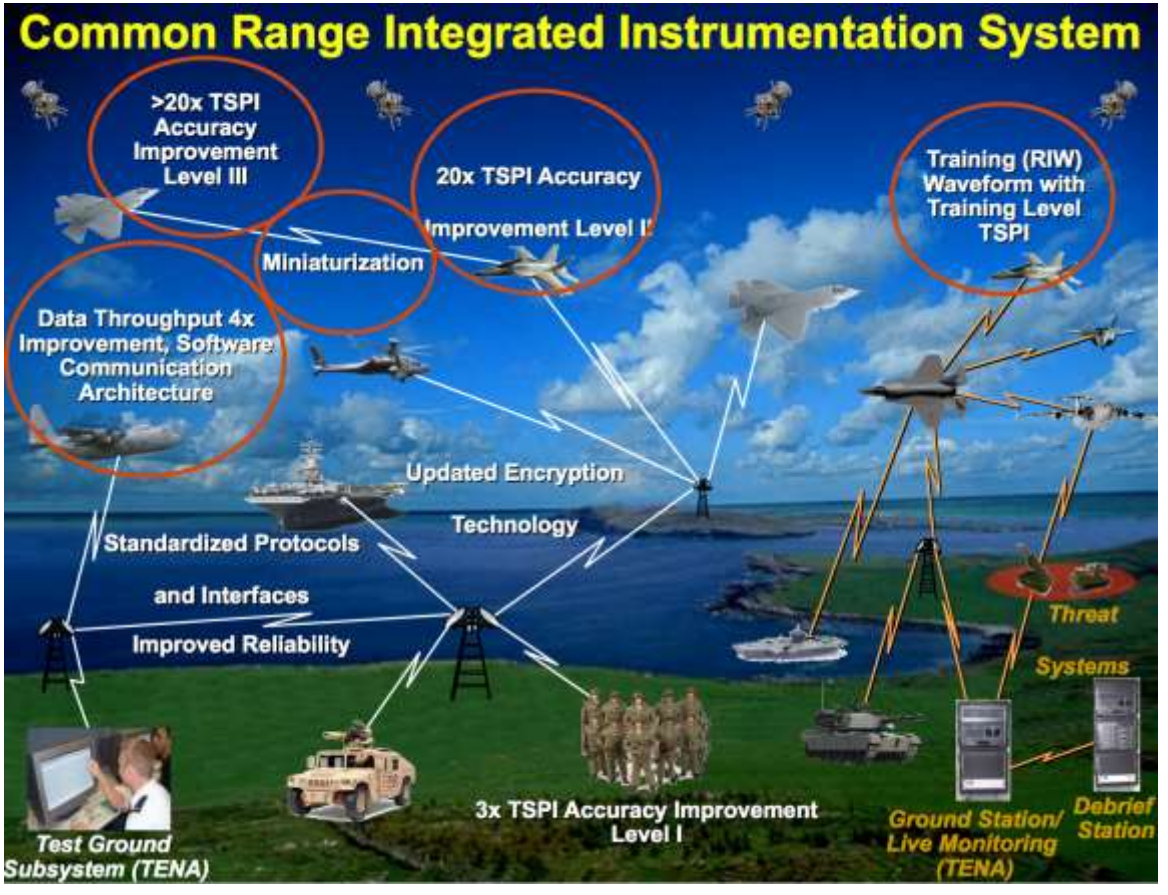


"TENA is the greatest thing that ever happened to us. We couldn't be doing today with all these systems–and we couldn't have all the participants that we do–if it weren't for TENA"

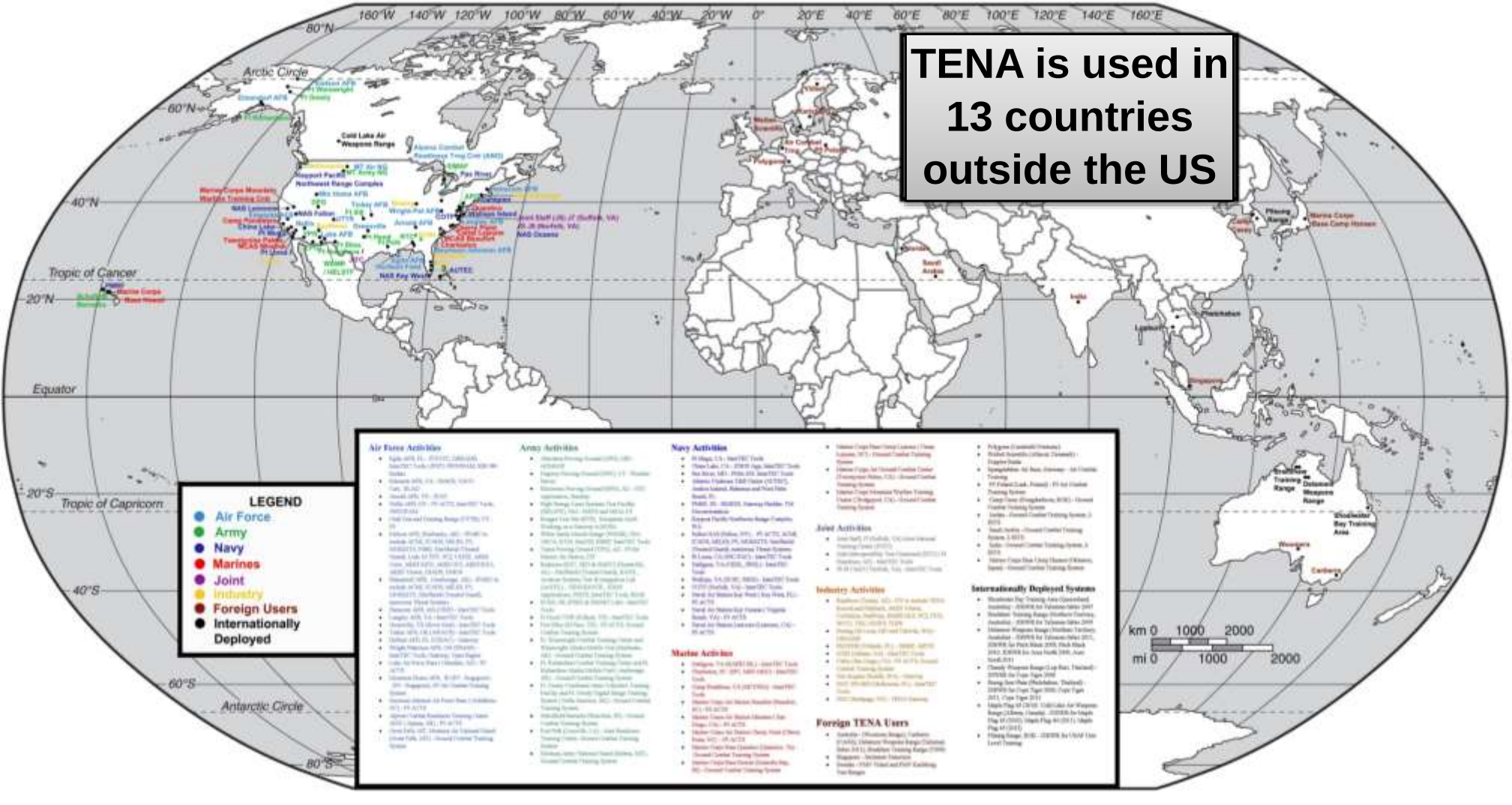
Billy D. Smith
Chief of electronic combat training requirements for Red Flag at JPARC

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



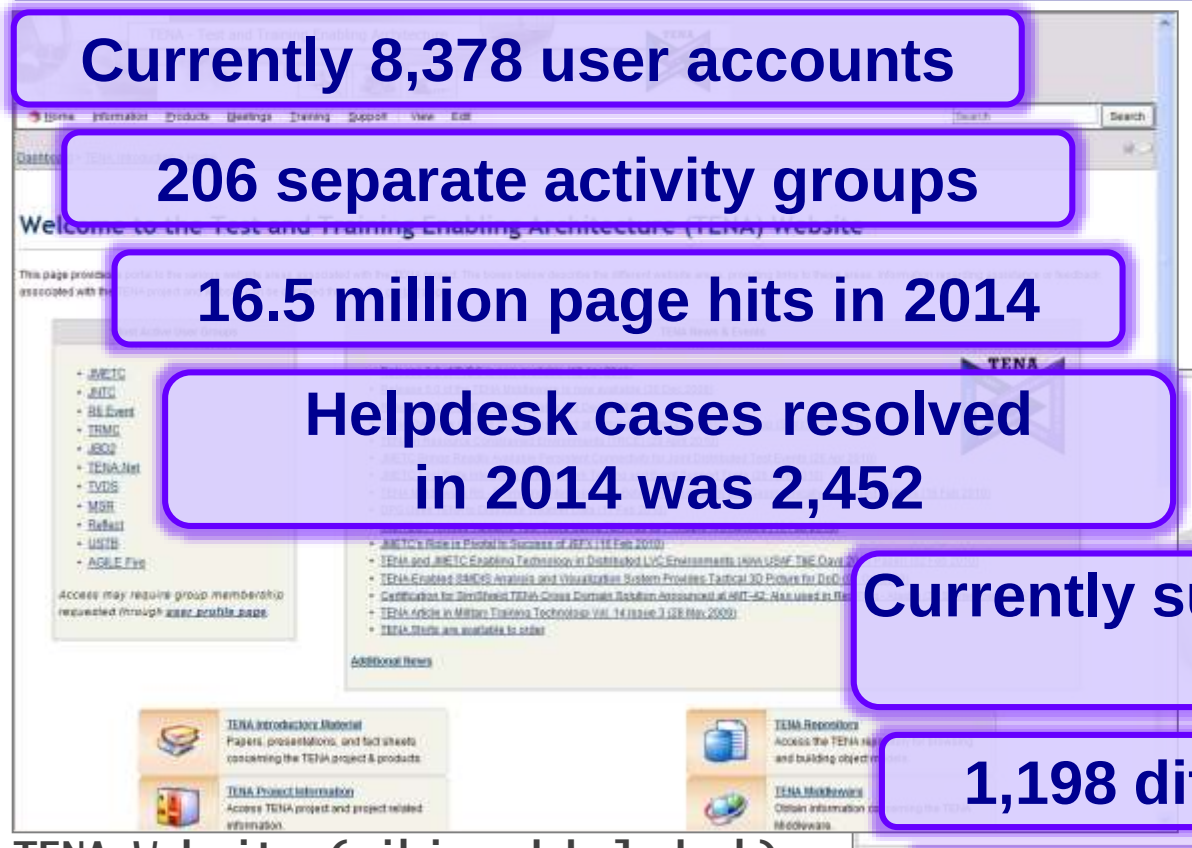
TENA Website Services
https://www.tena-sda.org/

Currently 8,378 user accounts

206 separate activity groups

16.5 million page hits in 2014

Helpdesk cases resolved in 2014 was 2,452



TENA Website (wiki and helpdesk)

TENA Software Repository

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

JMETC Network using SDREN

TENA Software, Object Models, Tools, Repository

- Provides customer support team for JMETC products and distributed testing

JMETC SECRET Network (JSN)

Functional Sites: 76
New Sites Planned: 9
Connection Points to Other Networks: 7

- Leverages the SECRET Defense Research and Engineering Network (SDREN) for connectivity
- Operates only at the SECRET classification
- Continuous monitoring, troubleshooting, and optimization of the end-to-end network infrastructure
- Capable of supporting numerous simultaneous test events

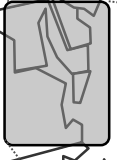
Boeing LabNet Tukwila
Keyport NUWC
Site in Alaska
Ft. Greely: CRTC
Edwards (2): Ridley
412th EWG IFAST
China Lake (3): F/A-18, IBAR, TSPIL
Point Mugu (3): ITEC, EA-6B. EW CyCon
Camp Pendleton: MCTSSA
Corona: NSWC
Palmdale, Triton
Point Loma:
SSC-PAC 59140
W. Interconnect Rtr.
Rancho Bernardo
NGC Triton
Sites in Hawaii
PMRF: Bldg 105
MHPCC
Dugway Proving Ground
USSTRATCOM
WPAFB: SIMAF
Crane (2): NSWC RDT&E, NTN Lab
Boeing LabNet Berkeley
Redstone (10): SMDC
RTC: DTCC, DISTL
SED: Patriot, THAAD, FAAD, GSIL, JLENS, MUSE, C-RAM
AMRDEC
Kirtland AFB DMOC
Tinker AFB AWACS
Raytheon Tucson
Yuma PG
Ft. Sill (2): FSED, SMART Lab
Greenville Rivet Joint
WSMR IRCC
Ft. Bliss MCC
Ft Huachuca: (5) JITC, JTDL, CMIS, JTRS, EPG
Ft Hood (2): CTSF, TTEC
Eglin AFB (5): AOC, DTF, GWEF, KHILS, JDAT
GTRI
Charleston (2): SSC Data Ctr
MEF-MEU
LMCO Global Vision Network
Melbourne NGC JSTARS
Rome NY AFRL
Newport NUWC
Moorestown: CSEDS
Aberdeen: ATC-STE
Dahlgren: IWSL
Rapid-SIL/C2
(2) DOC, ICSTF
Pax River: (9) E2C, E2D, MCL, ACETEF, SAIL, ATR, E-2C SIL, UASIL, MFS
JMETC SYSCON
East Interconnect Rtr.
JS J8 DDC4 C4AD
Langley TDLITC
Norfolk COMOPTEVFOR
Dam Neck CDSA
Wallops Island (2): SCSC, SSDS
Newport News NGC VASCIC
McLean MITRE NSEL
Kingstowne JMETC / TENA SDA Lab
Richmond NRO CTE

As of 14 Jan 2015

Army
Air Force
Navy
Marines
Joint
Industry
Academia

How a Test Planner Should View JMETC

Hardware-in-the-Loop (HWIL) Availability



Ft Lewis: EPG

CNR Radio

JLENS

Dugway Proving Ground

WPAFB: SIMAF

Hanscom AFB: CEIF

Bethpage: NG BAMS

Ft. Monmouth: JOIN

Boeing-St. Louis: CIDS

Whiteman: B-2

Nellis AFB: CAOC-N/ASOC

Kirtland AFB: SDOCC

Tinker AFB AWACS

tone (3): DTCC, GMAN, SED

Greenville: Rivet Joint

WSMR: IRCC

Charleston (2): IPC, MEF-MEU

Sites in Hawaii
PMRF: Bldg 105
MHPCC

Ft Huachuca: JITC

Ft. Worth: AFEWES

Ft Hood (2): CTSF, TTEC

TBMCS

Melbourne: JSTARS

Army
Air Force
Navy
Marines
Joint
Industry

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

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

Example JMETC Customer: Joint Strike Fighter Record and Playback

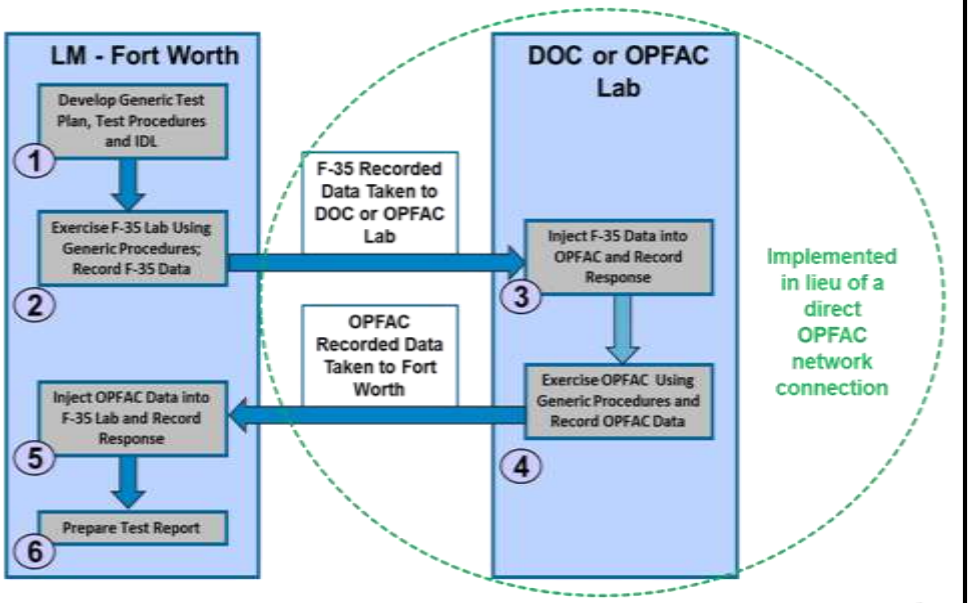
JPO Estimated Cost Savings: $10.8M

Overview

Issue:
- Unable to connect F-35 HW/SW-in-the-loop missions systems labs to various OPFAC labs due to concerns that real-time interface could not be implemented consistent with F-35 security requirements

Goal:
- Establish repeatable (portable) processes to evaluate F-35 Data Link Information Exchange Requirements (IERs) not verifiable through laboratory testing

Systems:
- FA-18, Aegis, LHD, F-15, F-16 , JSTARS, E2-C, EP-3, EA-6B, and AWACS



Solution

Solution:
- Adopt Record/Playback Approach
- Connect F-35 HW/SW-in-the-loop Mission systems labs to various OPFAC Labs via SDREN
- Use F-15 OPFAC instance as F-35 surrogate to expand interactions with C2s and increase number of messages that can be tested
- Add dedicated CATB vs. OPFAC flight test at end of SDD to verify high value/dynamic IERs

Benefits:
- Reduces execution costs and total event time span
- Leverages test planning/execution expertise at 46th TS
- Potential to use similar approach in UK

Stakeholders / Phases

Lead Organization: F-35 JPO Interoperability Verification, Test and Accreditation (IVT&A) Team

Sites:
- Air Force: Eglin, Greenville Rivet Joint, Tinker
- Navy: China Lake, Dahlgren, Dam Neck, Pax River, Pt. Mugu
- Coalition: United Kingdom (future)

Test Phases:
- Phase 1 - Surveillance Tracks/Ref. Pts. Message Verification
- Phase 2 - Dynamic Execution – S-35 with AWACS C2
- Phase 3 - Dynamic Execution – S-35 with JSTARS C2
- Phase 4 - S-35/JSTARS Imagery and Free Text Exchange
- Phase 5 - Dynamic Execution – F-16C
- Phase 6 - F-35 Playback

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