Using Joint Mission Environment Test Capability (JMETC) and Test and Training Enabling Architecture (TENA) for successful Distributed Testing

Gene Hudgins

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:

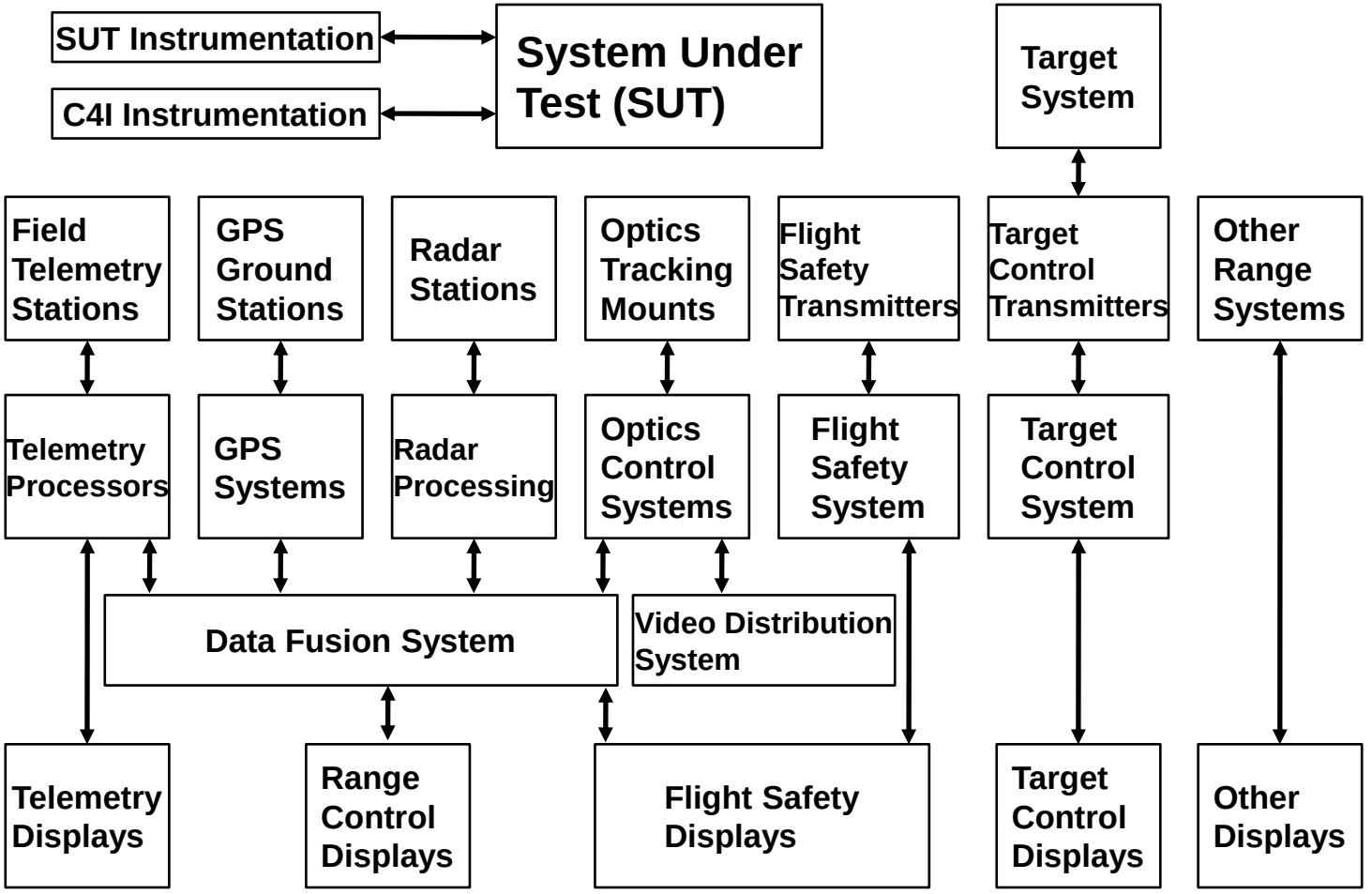
- **Enable interoperability among range, C4ISR, and simulation systems used across ranges, HWIL facilities, and development laboratories**
- **Leverage range infrastructure investments across the DoD to keep pace with test and training range requirements**
- **Foster reuse of range assets and reduce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

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

Benefits of TENA

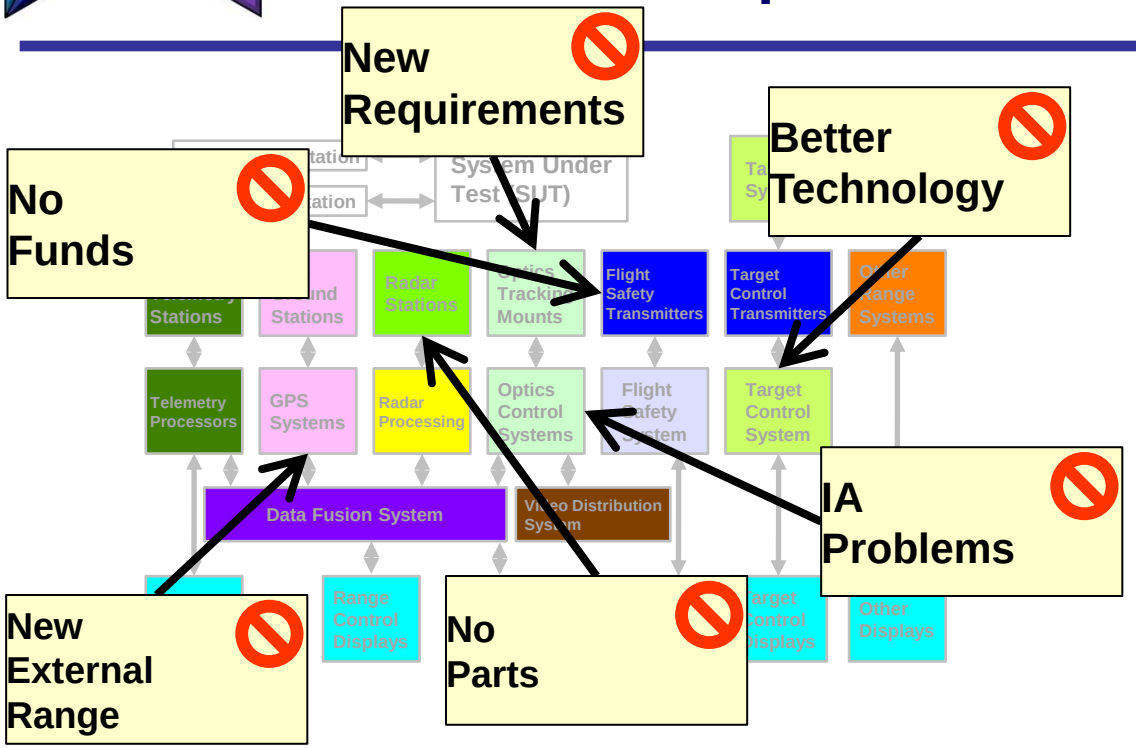
- **All TENA software and support is free to users**
- **TENA is the most capable and sophisticated interoperability solution**
- **TENA software is thoroughly tested and very reliable**
- **TENA Auto-Code Generation makes creating a TENA application as simple as possible**
  - TIDE Tool manages installation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

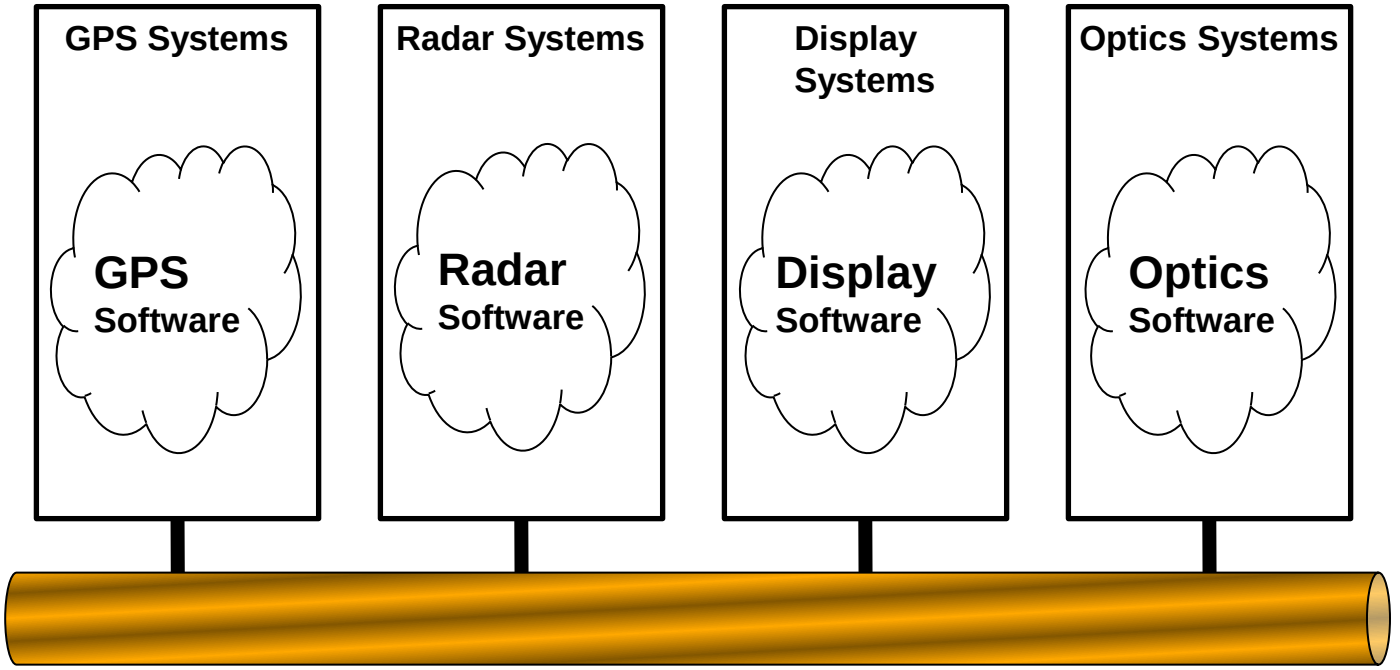
- **Range Specific Development Challenges**
  - Multiple Sponsors and Funding Sources
  - Evolving Test and Training Requirements
  - Expansion of Inter-Range Connectivity
  - Information Assurance Policies and Procedures
  - Range Modernization Must Be Gradual

Previous Range Infrastructure Standardization Approaches

- **Standardize on computer/networking hardware**
  - Many ranges have been locked into particular computer vendors (e.g., SGI, Sun) or network technology (e.g., ATM, 2400 baud modem) that have constrained their ability to modernize systems efficiently
- **Standardize on programming language**
  - Many ranges have encountered problems with being able to maintain code developed with older programming languages and compilers
- **Standardize on the network protocol**
  - Many range protocols only support UDP broadcast or multicast, which can cause problems when connecting with external networks
- **Standardize on the message format**
  - Many message protocols emphasize the specific bit layout of message formats which prevents evolution for newer technology and requirements

Systems get designed around elements that are difficult to upgrade often resulting in a fragile collection of gateways and brittle systems

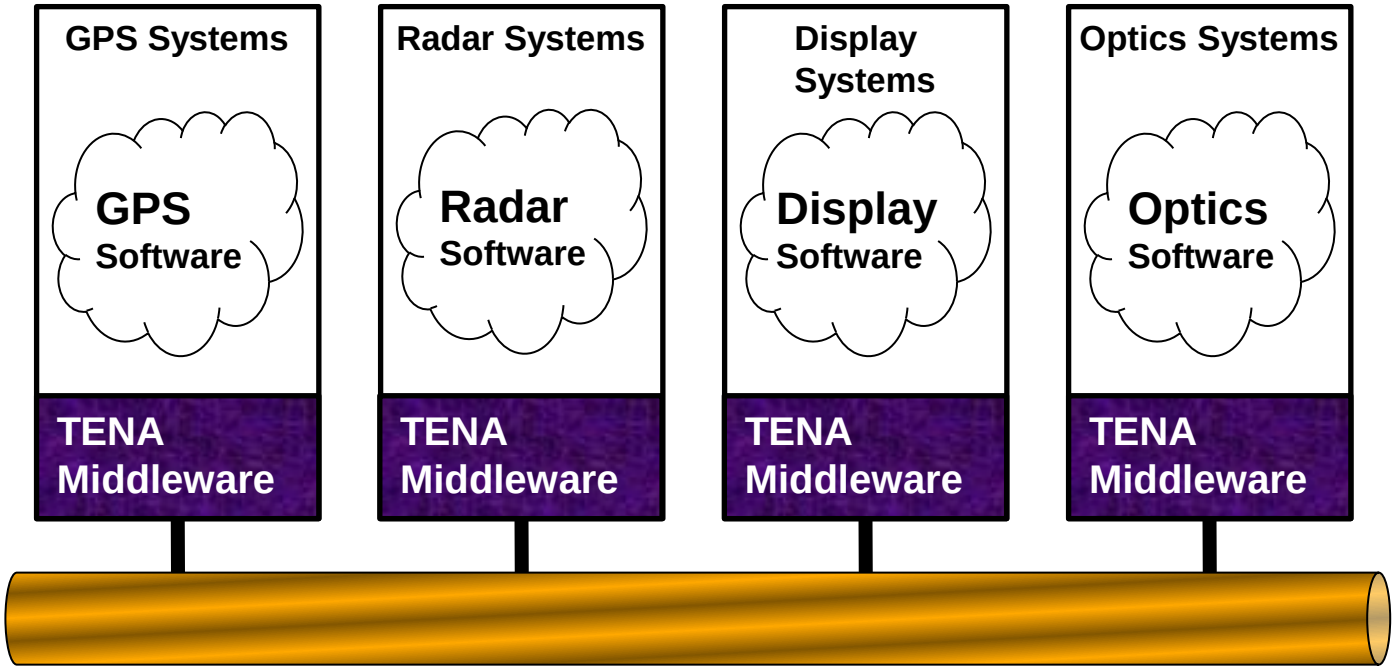
Anatomy of Range Systems



- **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.**

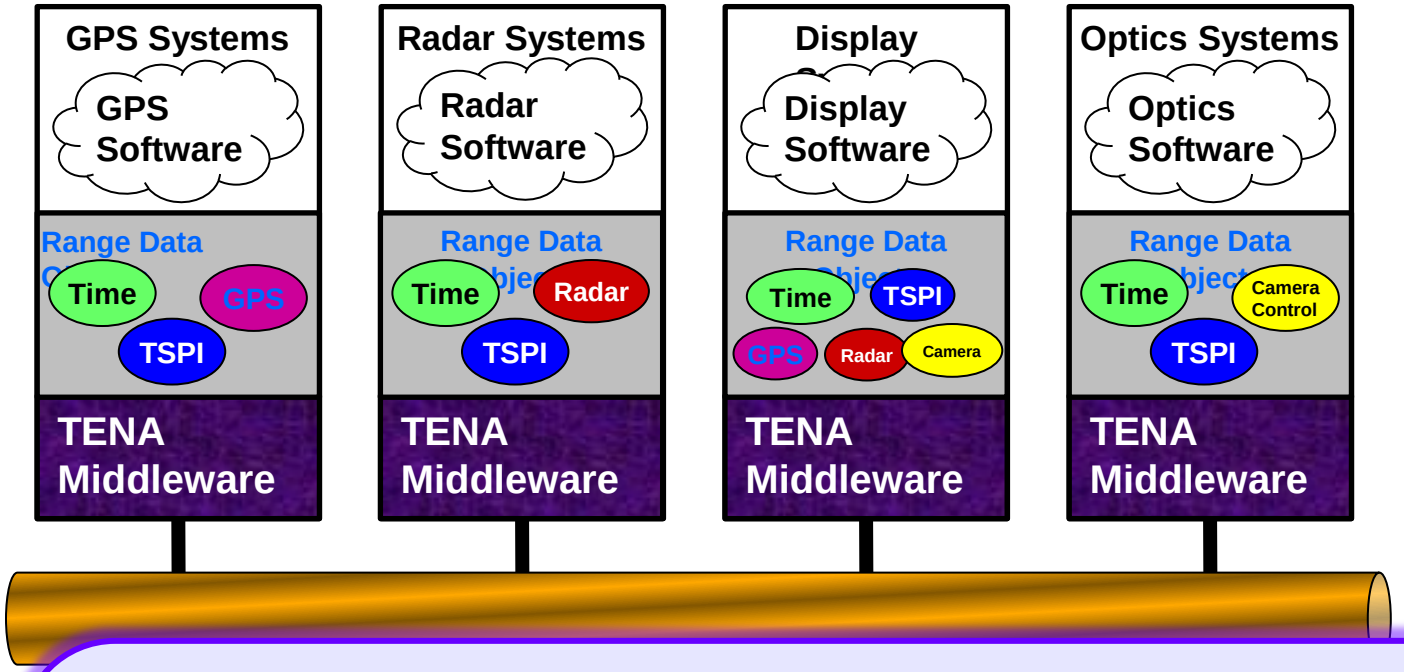
TENA Middleware

(Software Library of Data Exchange Functions)



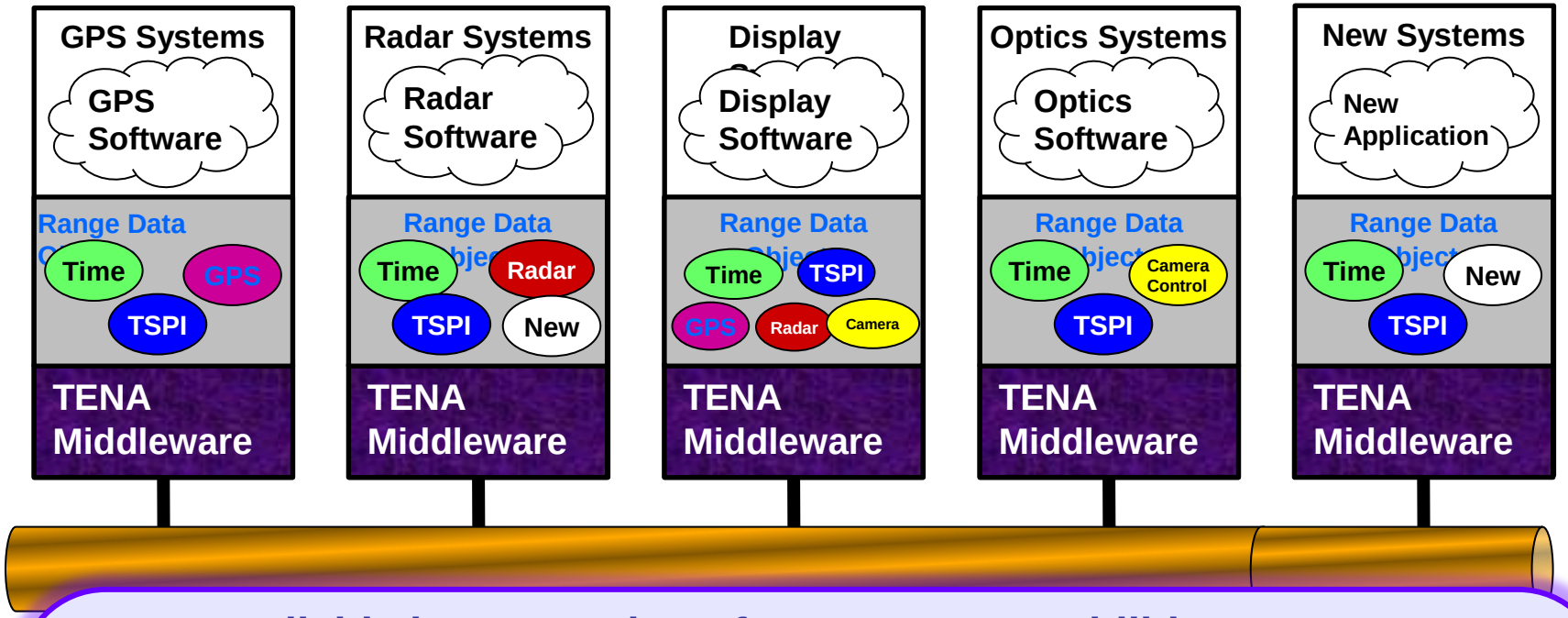
- **TENA Middleware is a set of software that performs real-time data exchange between systems**
  - **Support for C++, Java, and .NET programming languages**
- **TENA Middleware available for ~40 platforms, including:**
  - **Windows XP, Vista, 7/8, Server 2008/2012 (32- and 64-bit)**
  - **Linux: Fedora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

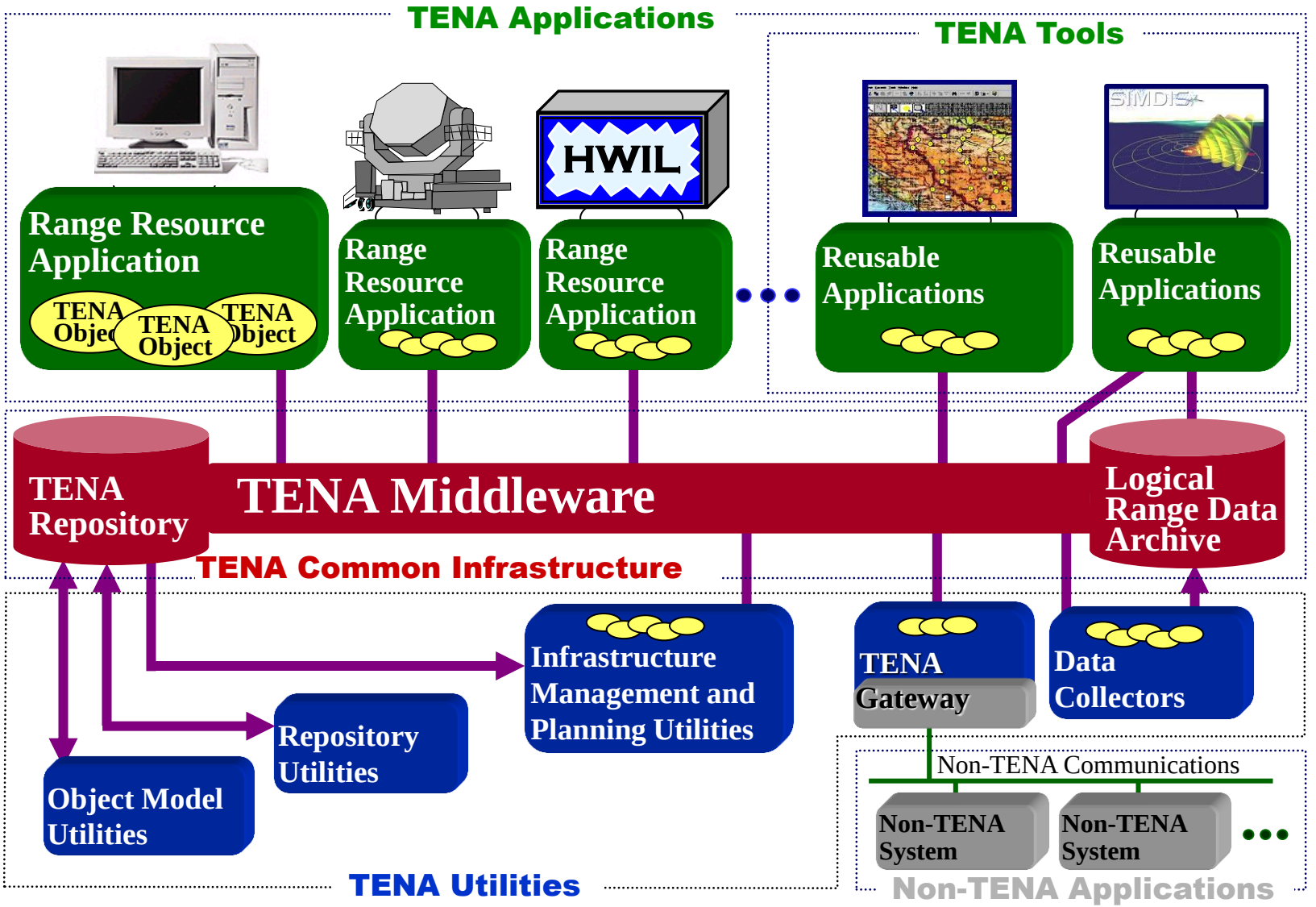


- Easy, reliable incorporation of new range capabilities
  - Known data exchange software (TENA Middleware)
  - Reuse standard range objects (Standard TENA Object Models)
    - Auto-code generate any new object models
  - Range interface on new application verified while application is developed (verification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



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

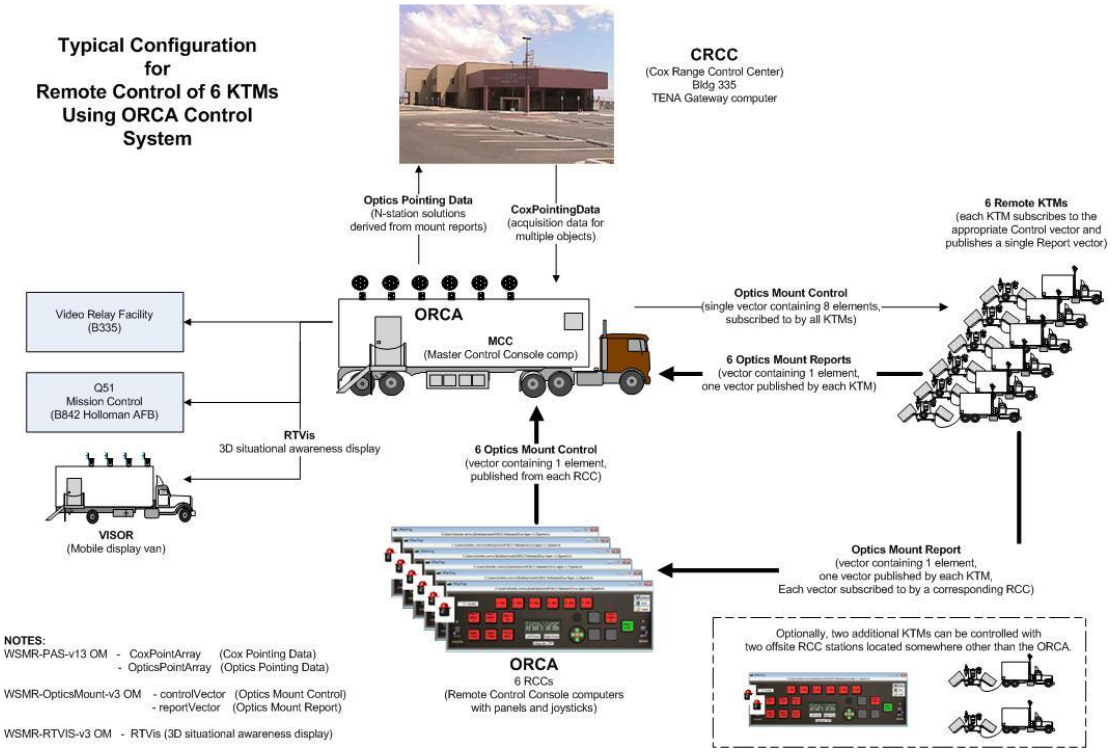
TENA Information Assurance (IA) Activities

- **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

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)

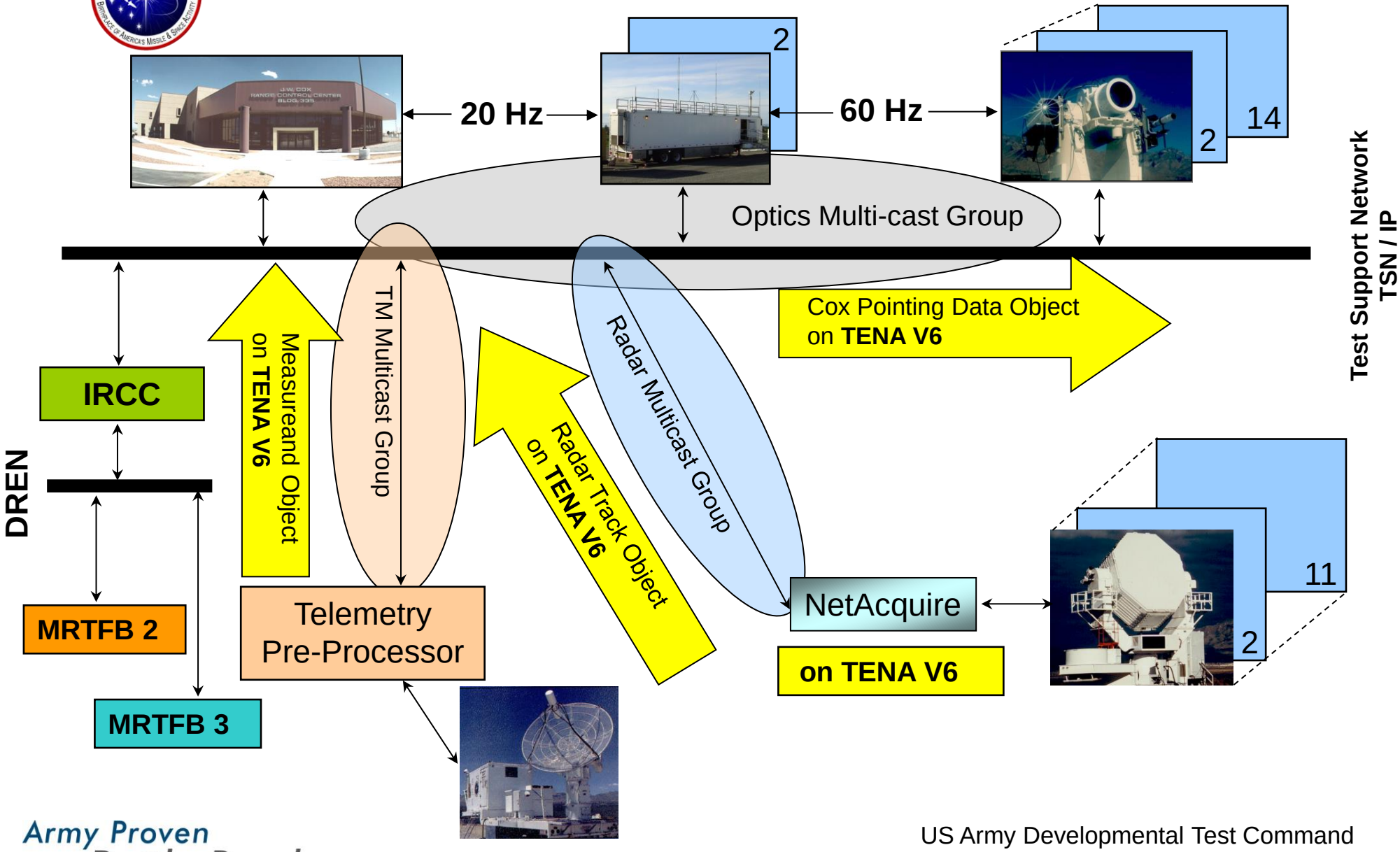
- **TENA has been supporting the real-time distributed operation of the WSMR optics systems for the past 5 years, including data exchange and remote operation**
  - **Based on the success of optics, TENA is being expanded to other range systems**



"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



Army Proven
Battle Ready

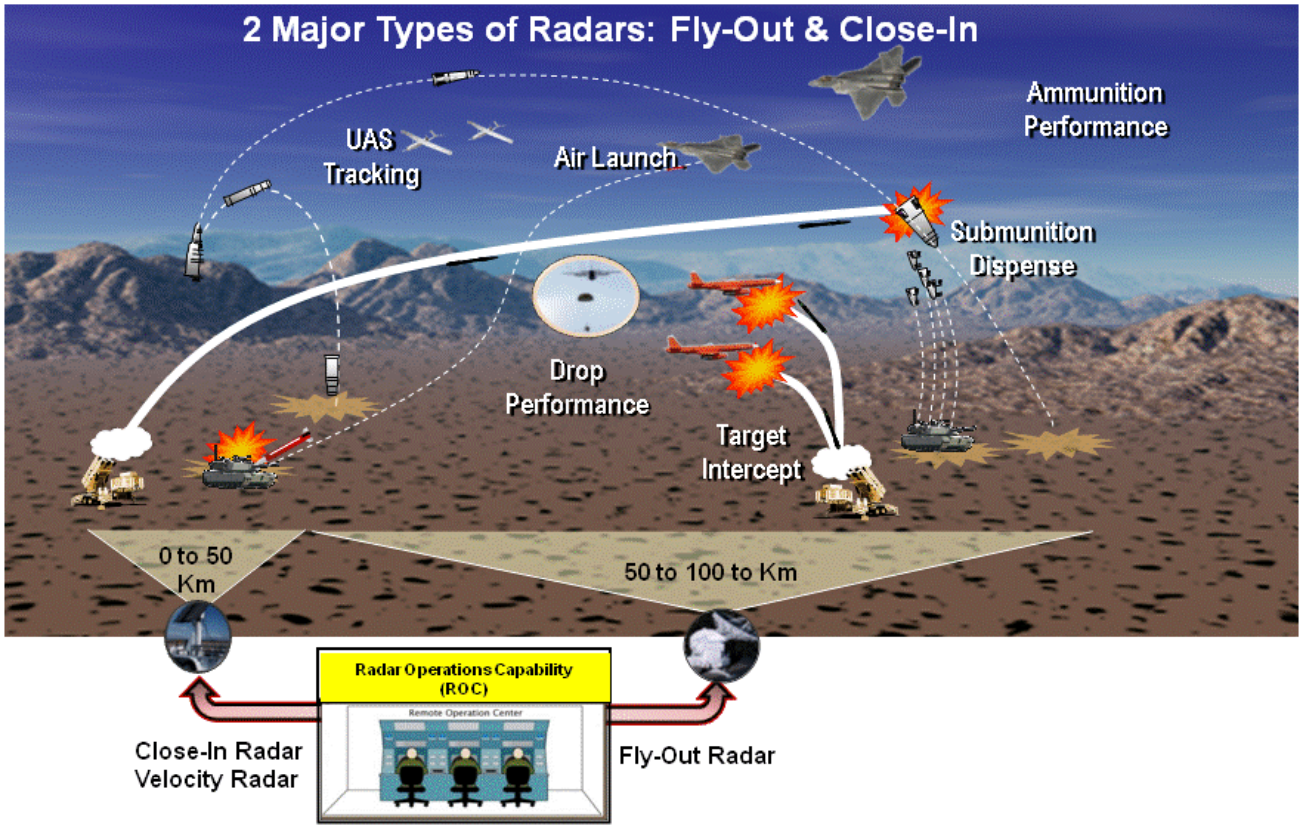
US Army Developmental Test Command

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

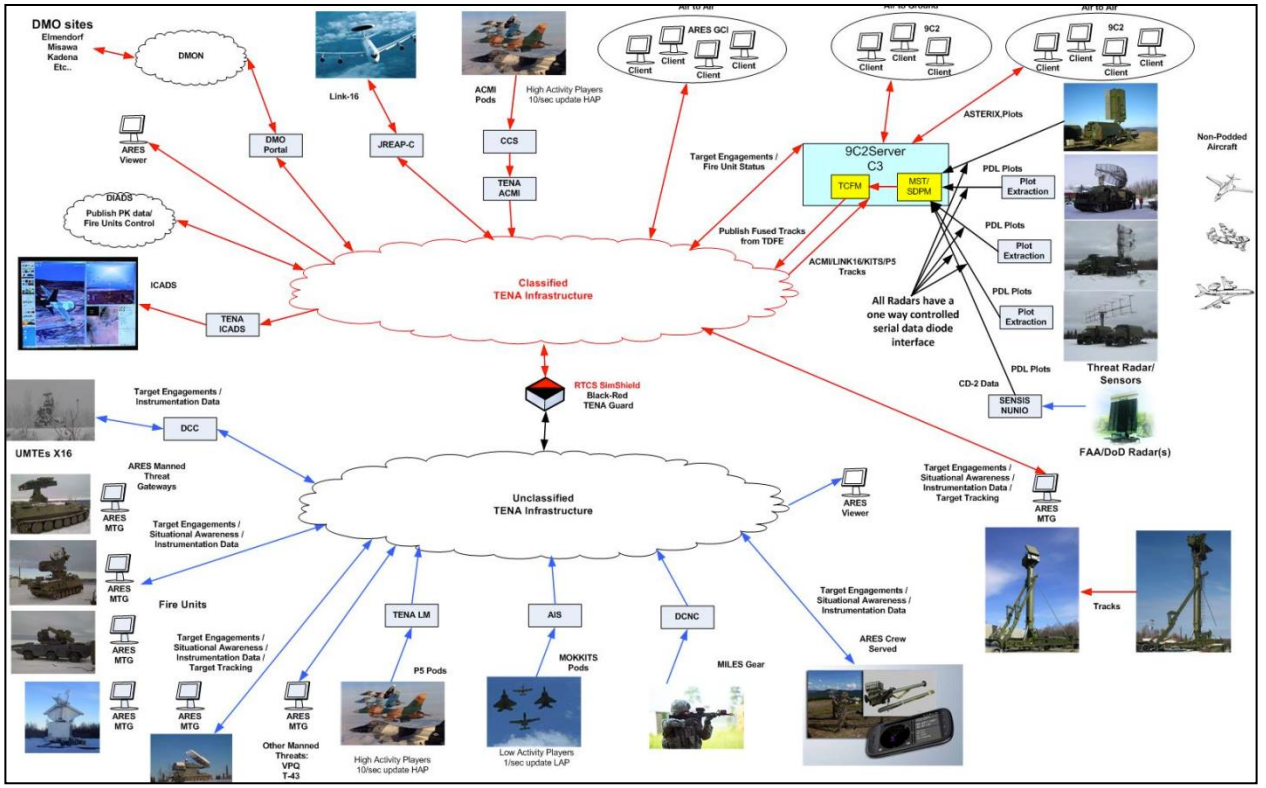
Range Radar Replacement Program (RRRP)

- **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**

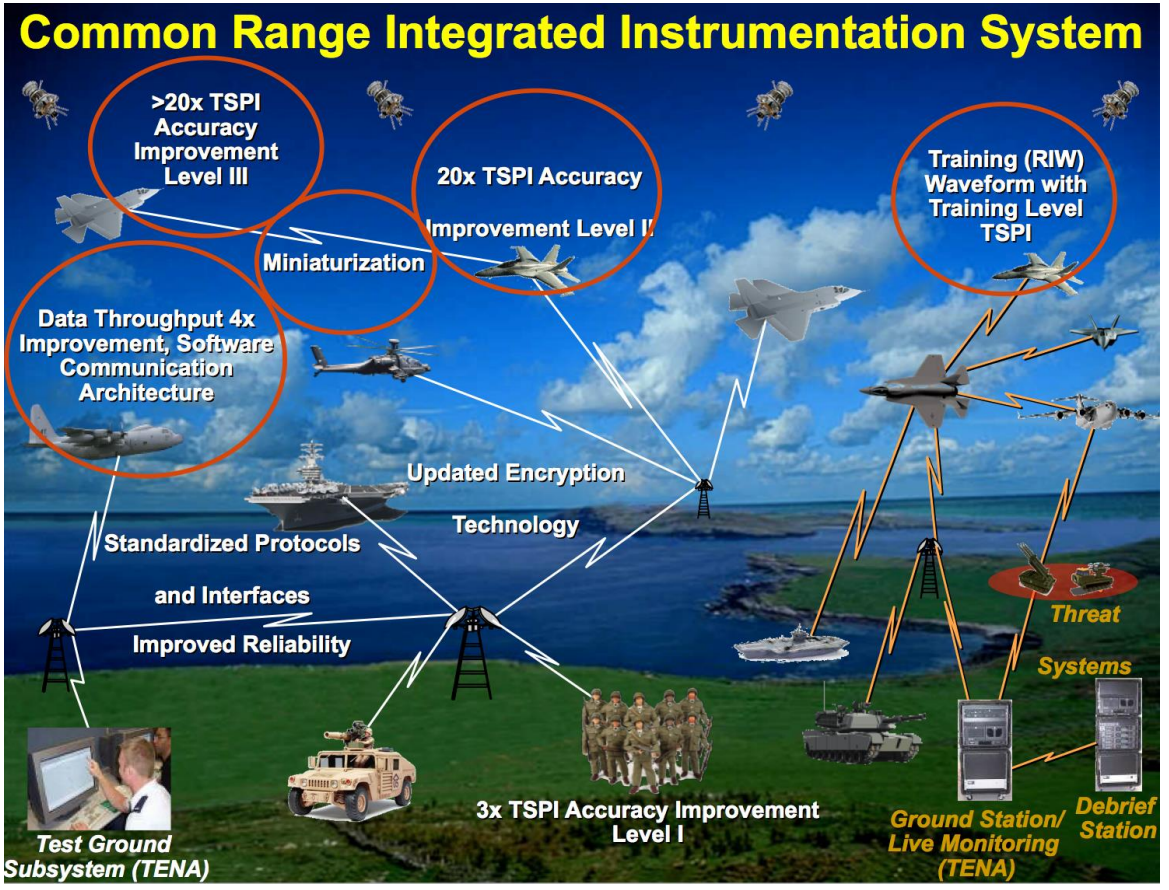


"TENA is the greatest thing that ever happened to us. We couldn't be doing today with all these systems–and we couldn't have all the participants that we do–if it weren't for TENA"

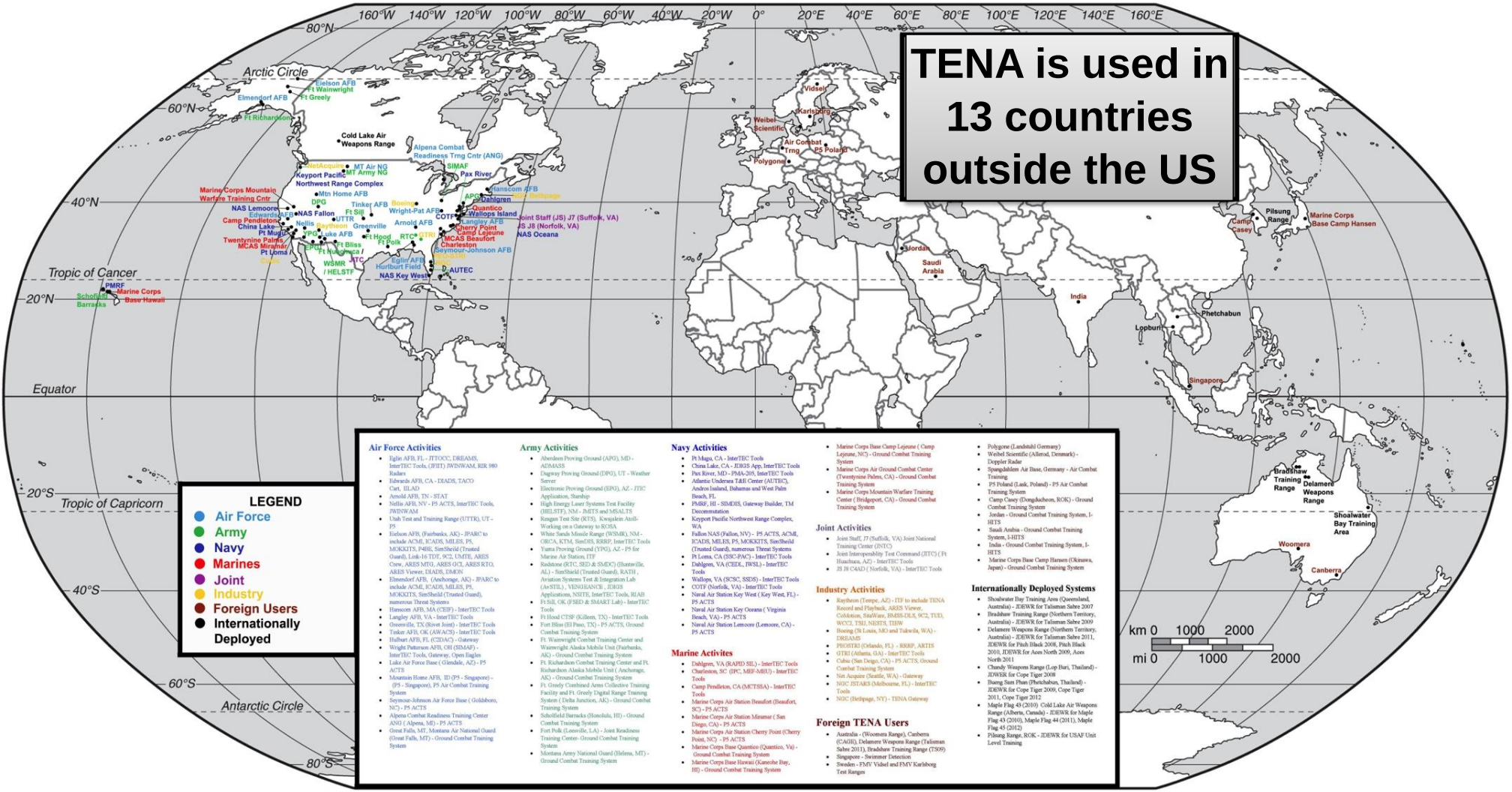
Billy D. Smith
Chief of electronic combat training requirements for Red Flag at JPARC

Common Range Integrated Instrumentation System (CRIIS)

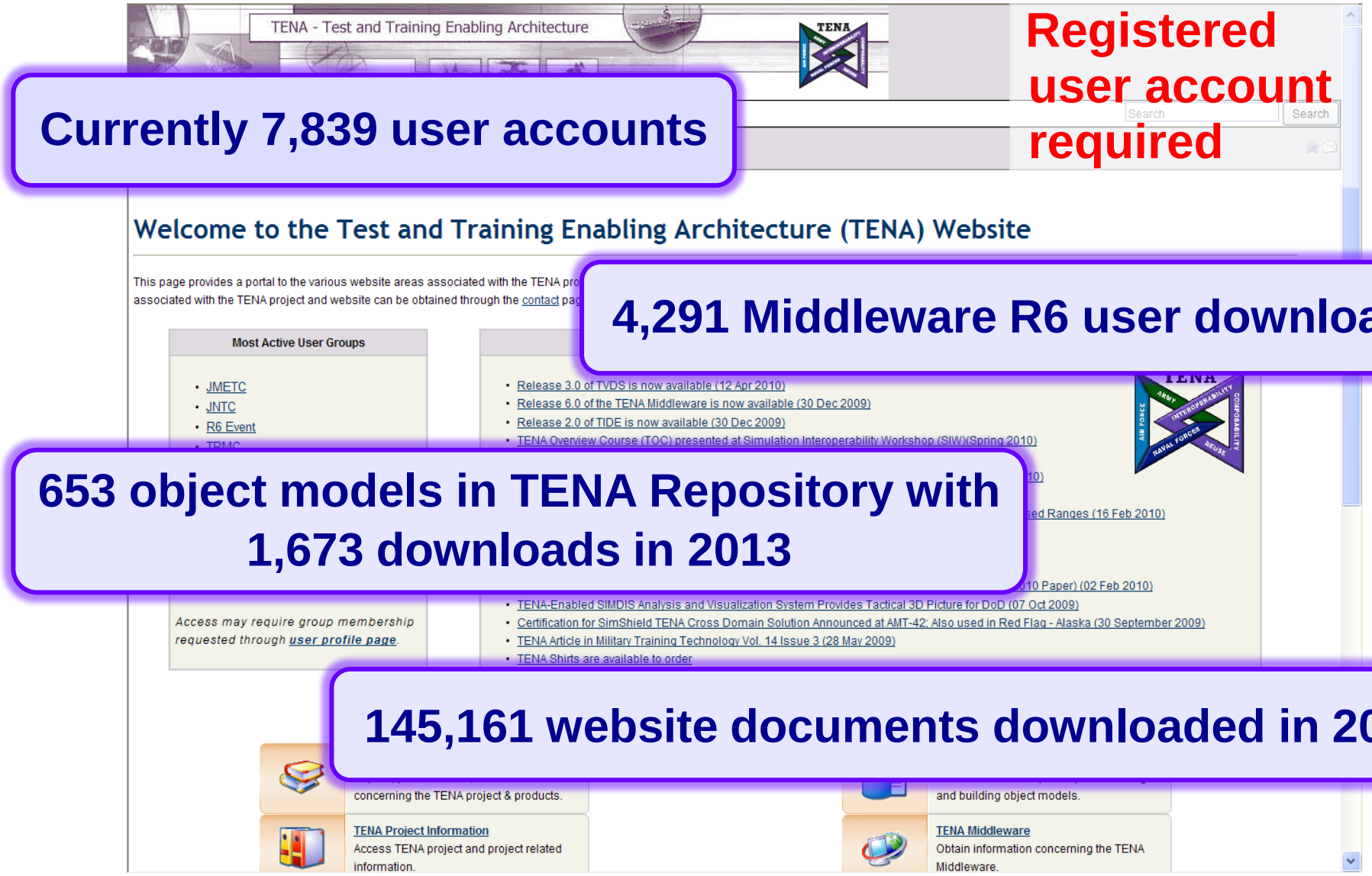
- **TENA specified in CRIIS acquisition program requirements for ground system communication**
  - TENA project providing port to Green Hills Real-Time Operating System, which is used in ground stations and air platforms



Worldwide Use of TENA



TENA Web Portal
http://www.tena-sda.org/



Registered user account required

Currently 7,839 user accounts

4,291 Middleware R6 user downloads

653 object models in TENA Repository with 1,673 downloads in 2013

145,161 website documents downloaded in 2013

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 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

Boeing LabNet Tukwila
Keyport NUWC
Ft. Lewis EPG

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, BAMS
Point Loma:
SSC-PAC 59140
SSC-PAC HAIPE
SSC-PAC JEDI
West Agg Rtr.
Rancho Bernardo, NGC BAMS

Sites in Hawaii
PMRF: Bldg 105
MHPCC

Dugway Proving Ground
Kirtland AFB DMOC
Tinker AFB AWACS
Raytheon Tucson
Yuma PG
Ft. Sill (2): FSED, SMART Lab
WSMR IRCC
Ft. Bliss MCC
Ft Huachuca: (5) JITC, JTDL, CMIS, JTRS, EPG
Ft Hood (2): CTSF, TTEC
Greenville Rivet Joint
Boeing LabNet Berkeley
Crane (2): NSWC RDT&E, NTN Lab
WPAFB: SIMAF
Redstone (10): SMDC
RTC: DTCC, DISTL
SED: Patriot, THAAD, FAAD, GSIL, JLENS, MUSE, C-RAM
AMRDEC
JMETC NOSC
GTRI
Charleston (2): SSC Data Ctr, MEF-MEU, WNW
Eglin AFB (5): AOC, DTF, GWEF, KHILS, JDAT
CCF
Melbourne NGC JSTARS
Orlando NCR
LMCO Global Vision Network

Rome NY AFRL
Hanscom AFB CEIF
Newport NUWC
Bethpage: NGC Triton
Bethpage: NGC BAMS
Moorestown: CSEDS
Aberdeen: ATC-STE, SRW RIL
Pax River: (9) E2C, E2D, MCL, ACETEF, SAIL, ATR, E-2C SIL, UASIL, MFS
JMETC SYSCON
East Agg Rtr.
Dahlgren: (2) CEDL, IWSL; (1) Rapid-SIL/C2
JS J8 DDC4 C4AD
Langley (2): C-GIIF, TDLIT
Norfolk COMOPTEVFOR
Dam Neck CDSA
Dam Neck JMETC NOSC
Wallops Island (2): SCSC, SSDS
Newport News NGC VASCIC
McLean MITRE NSEL
Kingstowne SAIC

Army
Air Force
Navy
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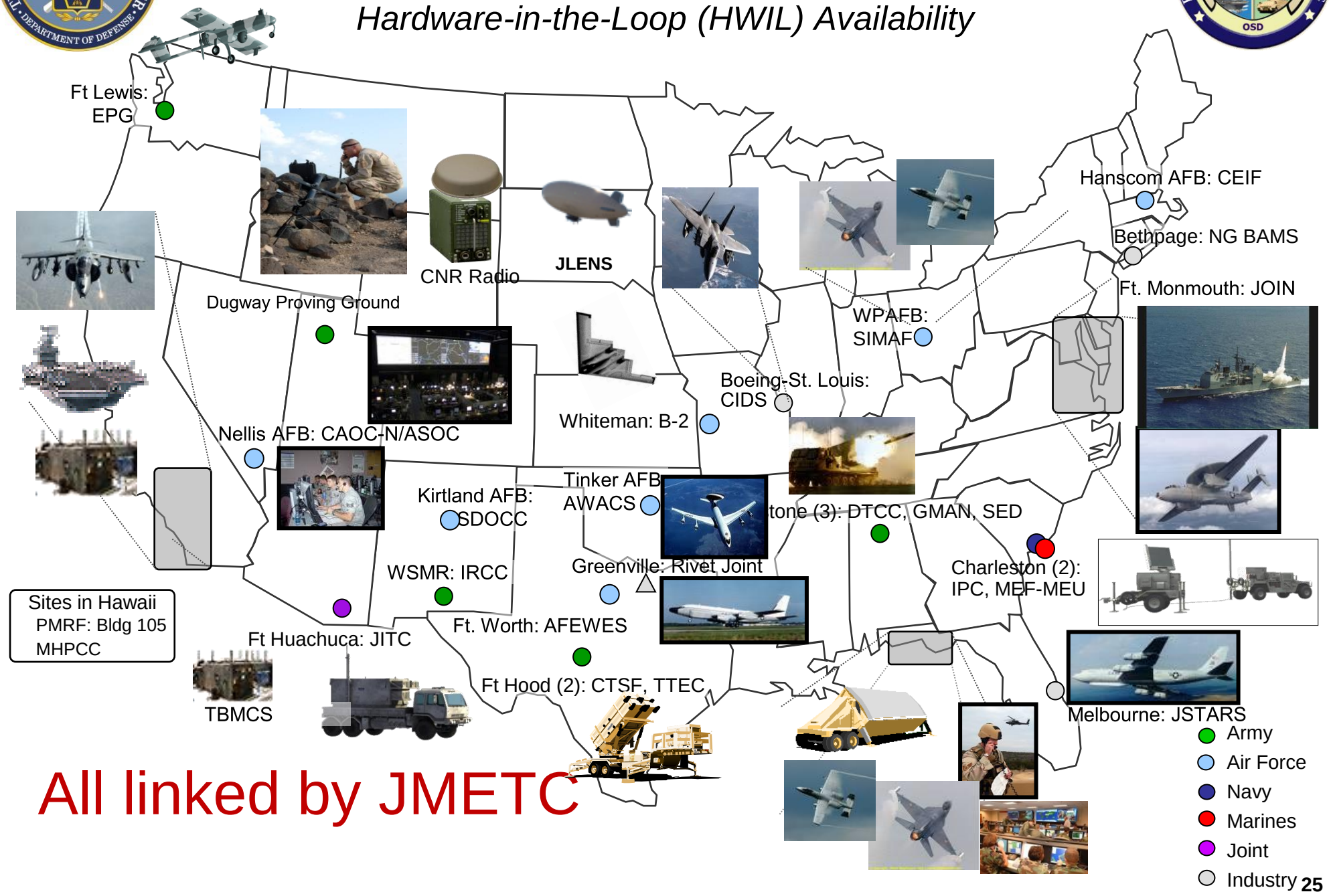
As of 10 Feb 2014

How a Test Planner Should View JMETC

Hardware-in-the-Loop (HWIL) Availability



All linked by JMETC

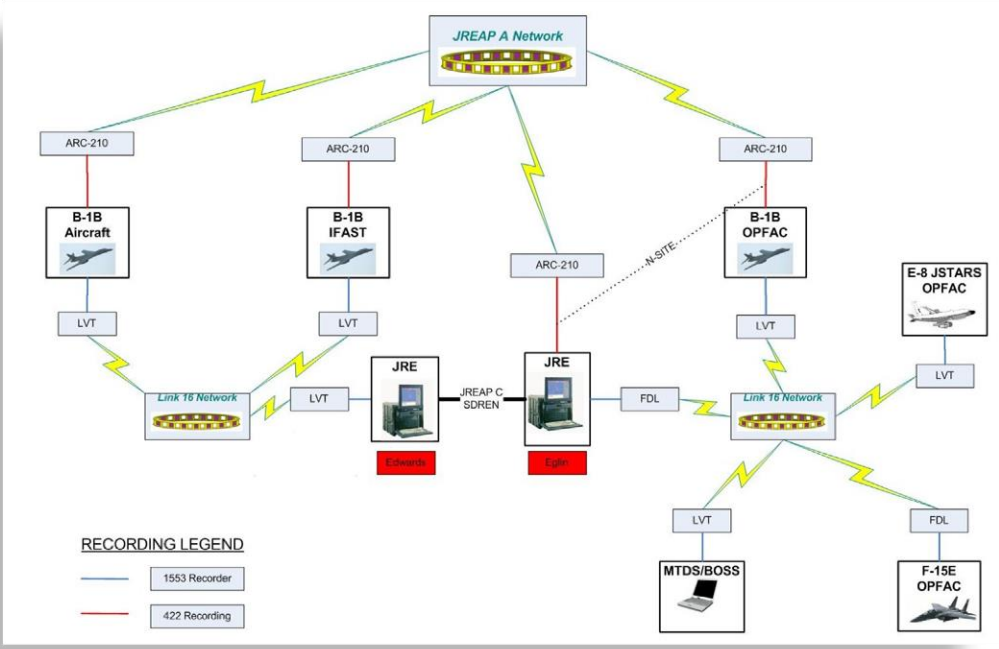
JMETC Event Support Services

- 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

JMETC Customer Testing Success

B-1 Fully Integrated Data-Link (FIDL) Testing

- FIDL PM requested testing of fixes made on issues identified in previous distributed test
- JMETC connected 46 TS Datalinks Test Facility at Eglin AFB to Ridley Mission Control Center
- B-1 flew in the Edwards airspace and received Link 16 data from distributed sites
- Allowed for weather and maintenance delays without incurring additional test costs
- Follow-on from 2009 testing



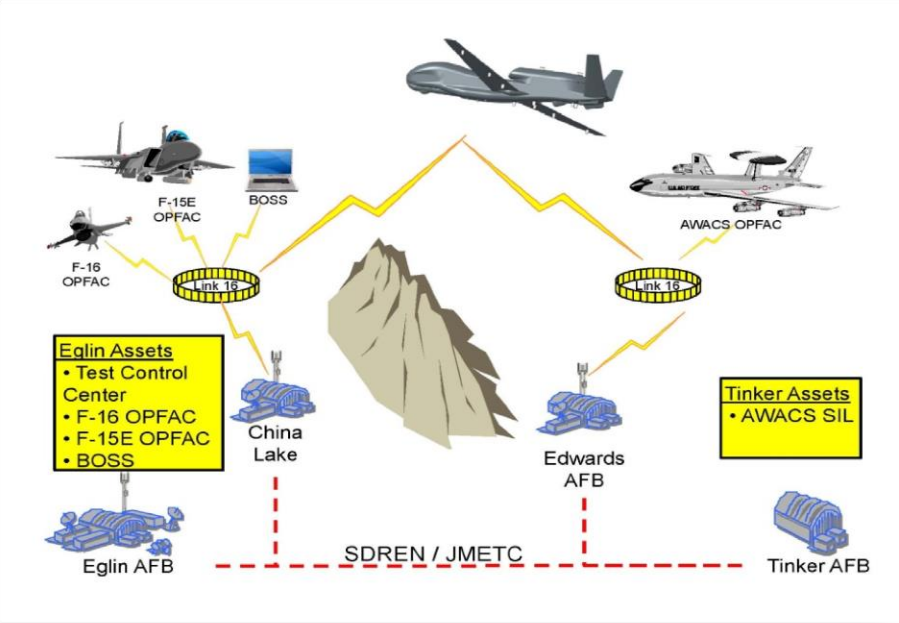
IMPACT

- **Significant cost savings**
- **Tested Link 16 data exchange with several platforms using a single live fly asset**
- **Supported over 30 hours of live fly test time**
- **2009 distributed testing showed system not ready**

JMETC Customer Testing Success

Battlefield Airborne Communication Node (BACN) Joint Urgent Operational Need

- Integration of BACN payload onto multiple platforms for solution to urgent in-theater need :
  - Combat requirement for beyond line-of-sight comm
  - Relay, bridge, and range extension for ground forces and supporting aircraft
- Distributed Testing in Fall 2010 included Live-fly , DT, and Operational Utility Evaluation



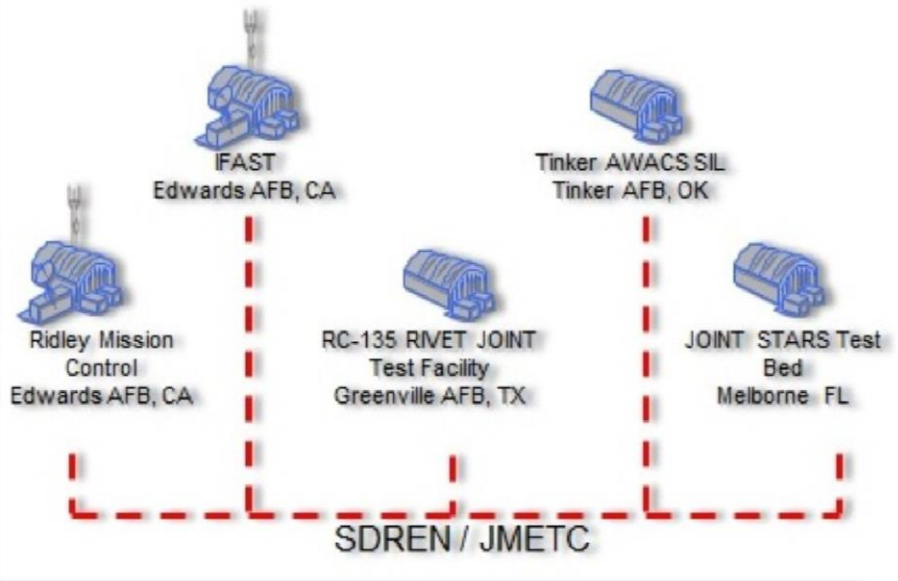
IMPACT

- **Efficient integration of DT and OT**
- **Testing completed despite many of the required assets not being available on-site**
- **Distributed Testing saved "$1.2M" (OTA)**
- **Urgent capability fielded-quickly!**

JMETC Customer Testing Success

B-52 Combat Network Communications Technology (CONECT) Ground Interoperability Test

- Regression testing of software upgrades made based on previous tests
- Demonstrated JREAP interoperability TDL network messages between several weapon systems
- Connected HWIL facilities at Edwards AFB, Tinker AFB, and Melbourne, FL



IMPACT

- **Increased B-52 operational effectiveness**
- **Provided improved mission flexibility, increased situational awareness, new network-centric capabilities**
- **JMETC infrastructure supported rapid test-fix-test cycle of the CONECT messaging capabilities**

JMETC Customer Testing Success

Correlation / Decorrelation Interoperability Test (C/DIT) Coalition Testing

- A Joint Integrated Air and Missile Defense Organization (JIAMDO/J8) Joint Distributed Engineering Plant (JDEP) sponsored event
- Assess correlation/de-correlation interoperability of STANAG 5516 Ed 4 and Mil-Std 6016D for the E-2C and E-3D.
- Assess STANAG 5602 Ed 3 interoperability between the US & UK platforms using their SIMPLE protocol communication devices

IMPACT

- **Improved Coalition Interoperability**
- **US: HE2K (E2C), ESTEL, Pax River, MD**
- **UK: E3D (baseline UK04v10), RAF Waddington**
- **Demonstrated JMETC ability to connect to Coalition partners.**

JMETC Customer Testing Success

AIM-9X Air to Air Missile Captive Carry Tests

(On-going)

- Capability to remotely observe live seeker head video and real-time position of the test aircraft presented in a 'gods-eye' view of the China Lake Range
- Remotely monitor live aircraft communications between the test aircraft and China Lake Range Control
- JMETC connects Naval Air Warfare Center Weapons Division China Lake, CA Open Air Range to the COMOPTEVFOR Norfolk, VA via the Integrated Battlespace Arena (IBAR)

IMPACT

- **Increased capability for Operational Testers to observe more DT & OT test flights (20 captive carry tests and 10 live fire tests)**
- **Reduced COMOPTEVFOR's OTA's test observation time from 3 days (including travel) to actual range test time**
- **Utilized existing JMETC infrastructure, IA and engineering expertise in coordination with Navy MRTFB facility to deliver capability with no additional cost to Operational Testers**

Major FY13 Events

Customer	Event	Execution Dates	Onsite Support
Navy	Accelerated Mid-Term Interoperability Improvement Program (AMIIP)	Oct 2012 - Sep 2013	**Yes**
Joint	JITC Joint Interoperability Tests (JIT)	Oct 2012 - Sep 2013	**Yes**
Air Force	Air Force Systems Interoperability Test (AFSIT)	Oct 2012 - Sep 2013	**-**
Navy	MQ-4C TRITON	Oct 2012 - Sep 2013	**Yes**
Joint	Joint Track Manager Concept - Demonstration (JTMC-D)	Oct 2012 - Sep 2013	**Yes**
Joint	JIAMDO Correlation/De-correlation Interoperability Test (C/DIT) Coalition and U.S. only	Oct 2012 - Sep 2013	**Multiple**
Joint	JIAMDO Joint Tactical Air Picture (JTAP)	Oct 2012 - Sep 2013	**Multiple**
Air Force	AGILE Fire Phase VII	Jan 2013 - Mar 2013	**Multiple**
Joint	InterTEC Cyber Event (ICE) FY13	Oct 2012 – Feb 2013	**Multiple**
Navy	Virtual Rapid Prototyping Laboratory	Jan 2013 – Feb 2013	**Yes**
Joint	Red Flag	Jan 2013 – Mar 2013	**Yes**
Navy	Joint Distributed IRCM Ground test System(JDIGS)	Oct 2012 - Sep 2013	**-**
Air Force	AIM9x	Feb 2013	**Yes**
Marine Corp	G/ATOR	Feb 2013 – Apr 2013	**Yes**
Air Force	AGILE Fire Phase VIII	Jun 2013 - Sep 2013	**Multiple**

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:

Dec 11-12, 2012
Location: Charleston, SC
Tracks:
- User Requirements
- Networking
- Data Management
- Threat Systems (FOUO)
- Cyberspace T&E (FOUO)

Users Group #06

Users Group #07

Users Group #08

Users Group #09

Users Group #10

Users Group #11

Users Group #12

Users Group #13
- 22-23 March 2011
- Norfolk, VA
- ~200 participants
- Plenary session:
  - JFCOM Senior Leaders
- Tracks:
  - User Requirements
  - IA / Security
  - Networking
  - Data Management
  - InterTEC Tools

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 Summer 2014**
    - **Next JMETC User Group Summer 2014**

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