

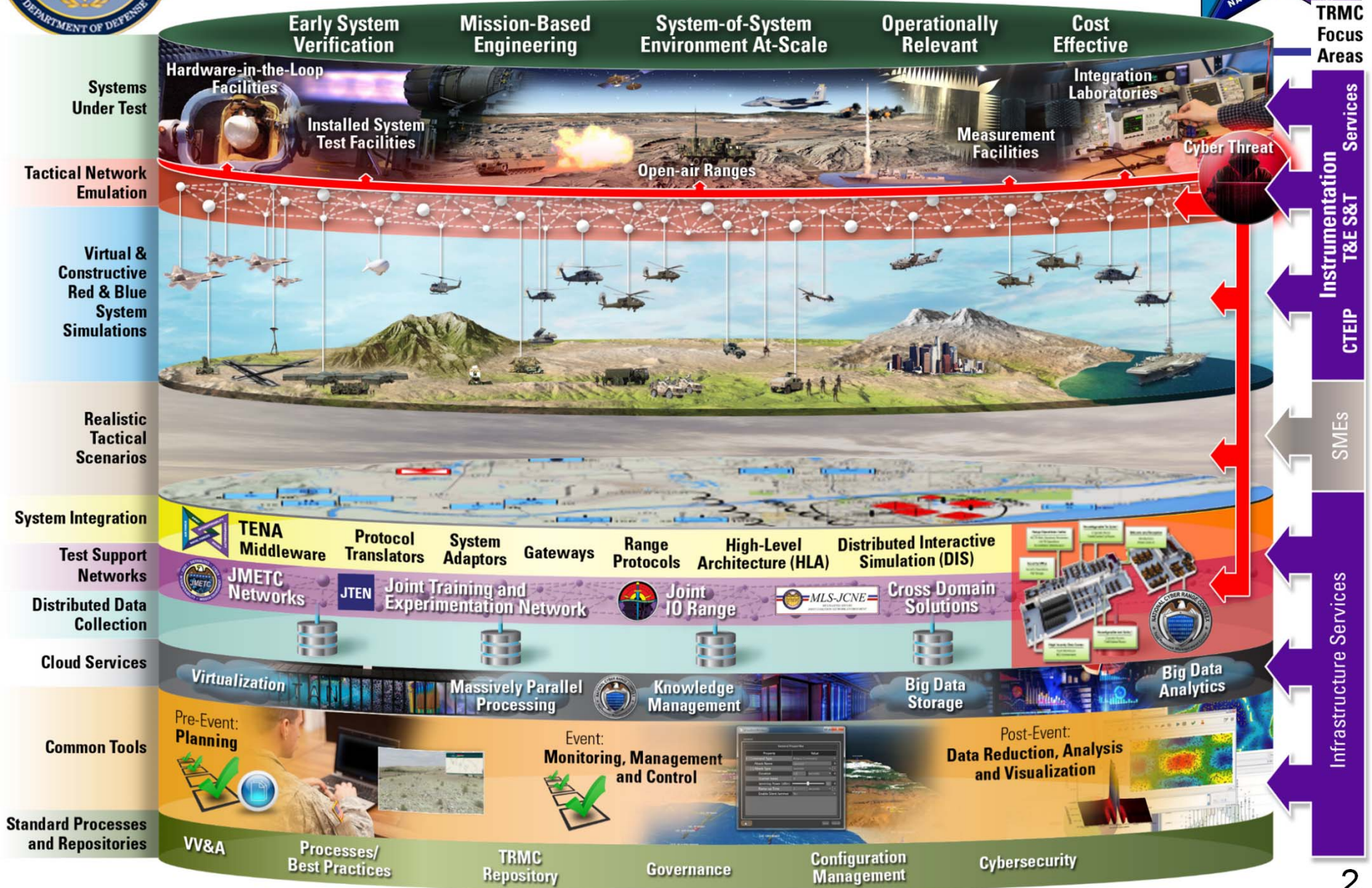
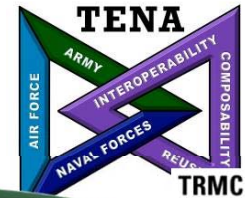
Test and Training Enabling Architecture (TENA) Overview

October 2019



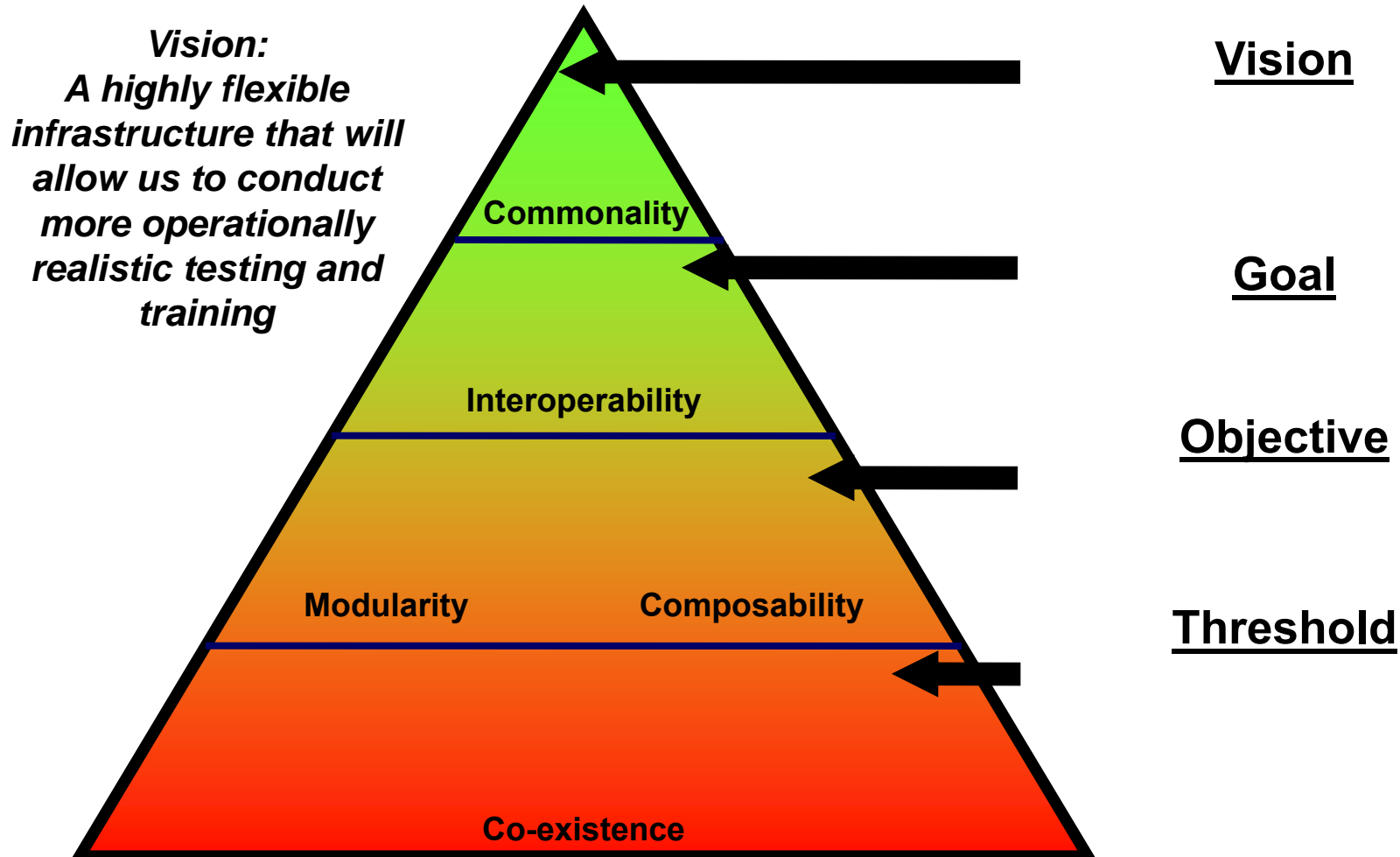
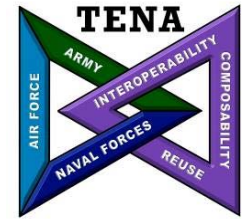
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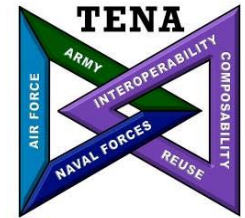
The TRMC Vision: An Agile T&E Infrastructure to Support Rapid Acquisition





A TRMC Perspective: Vision for a Common Test and Training Infrastructure





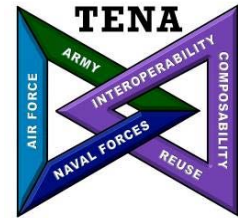
What is an Architecture?

- An architecture is a **segmentation** of a system (or system of systems) such that the primary pieces are identified, as well as their purpose, function, interfaces, and inter-relatedness, along with guidelines for their evolution over time
- Architectures put constraints on developers. These constraints make possible the achievement of higher level goals.
- These higher-level goals are called the system's driving requirements
- An architecture is a **bridge** from requirements to design





TENA at a Glance



TENA is the DoD GOTS range integration architecture

● What does TENA enable?

- Interoperability between inter- and intra-range assets
- Elimination of proprietary interfaces to range instrumentation
- Efficient incremental upgrades to test and training capabilities
- Integration of Live, Virtual, and Constructive assets (locally or distributed)
- Sharing and reuse of common capabilities across existing and new investments

● What is included in the TENA architecture?

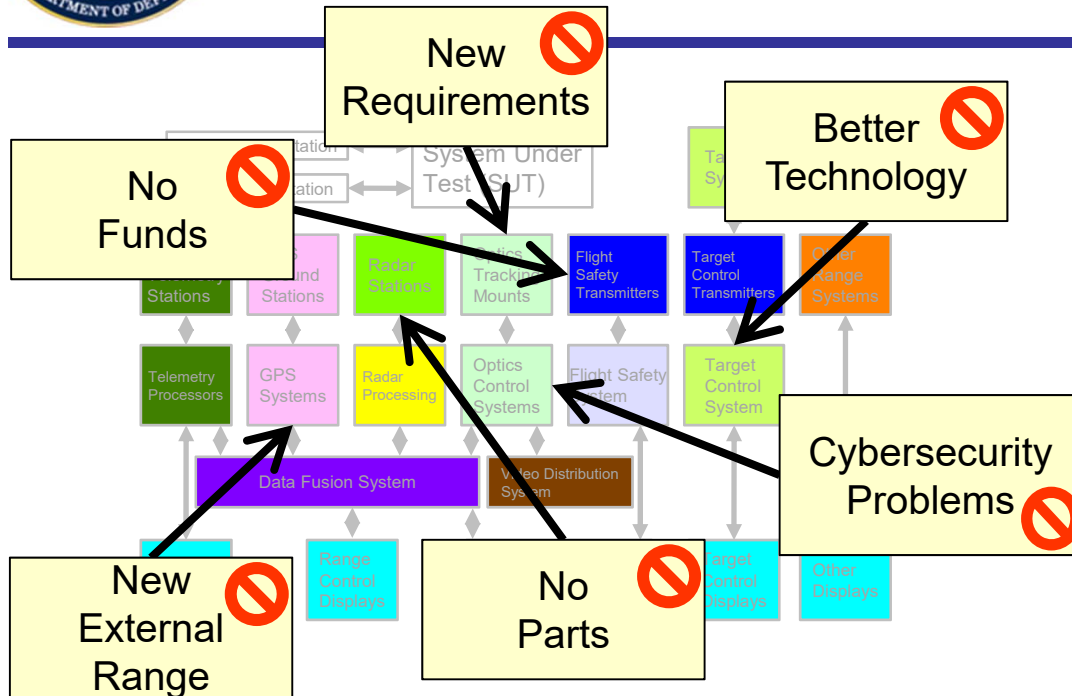
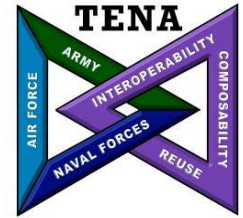
- Customizable “data contracts” that standardize repeatable information exchange
- Interoperability-enabling, auto-code generated software libraries
- A core set of tools that address common test and training requirements
- Collaboration mechanisms that facilitate sharing and reuse

● TENA has a plan for continued evolution and funding to execute this plan





Range System and Infrastructure Development Challenges



• General Development Challenges

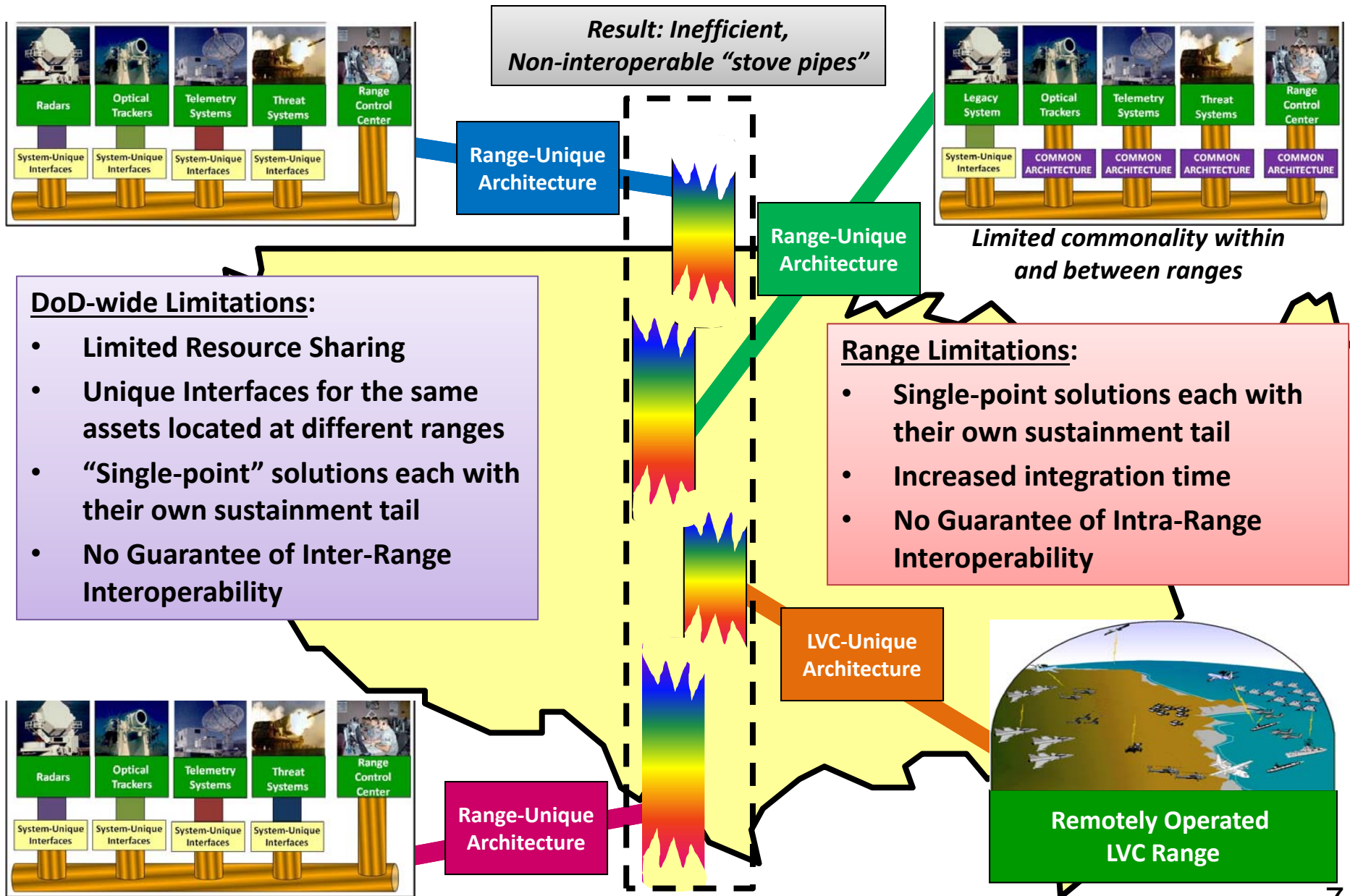
- Multiple Developers and Development Groups
- Different Timelines and Delivery Dates
- New Computing and Communication Technologies

• Range Specific Development Challenges

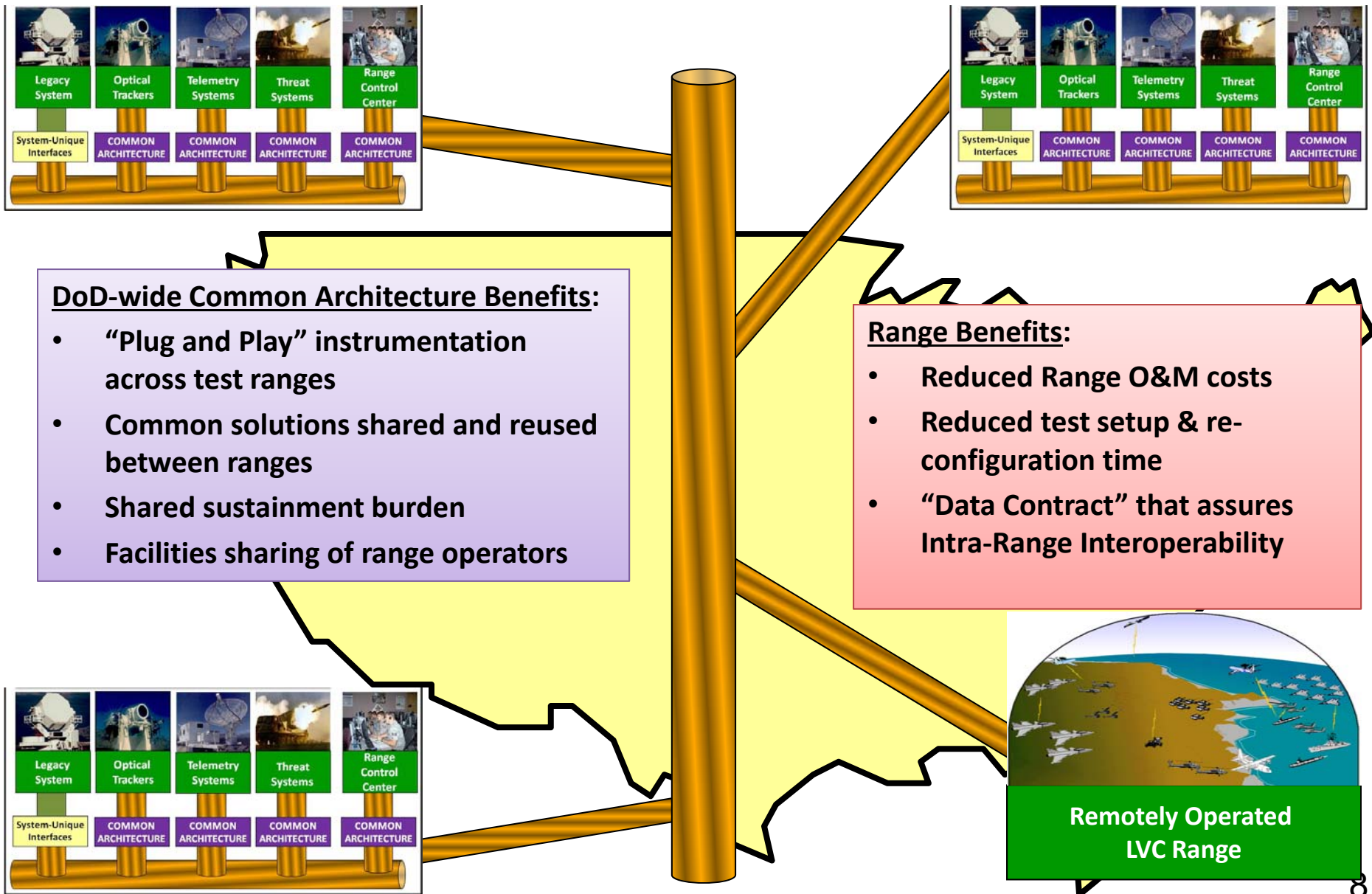
- Multiple Sponsors and Funding Sources
- Evolving Test and Training Requirements
- Expansion of Inter-Range Connectivity
- Cybersecurity Policies and Procedures
- Range Modernization Must Be Gradual

TENA has helped the community address these challenges

Notional "Current State" of T&E Operations

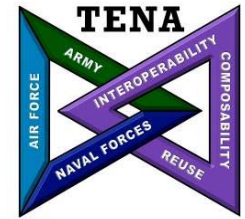


Notional “Efficient State” of T&E Operations



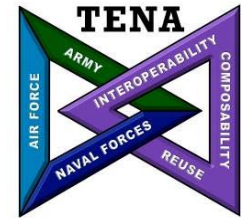


How TENA is currently Used In Test and Training Facilities



- Common specifications for test and training data
 - Data Dissemination across variable applications, platforms, programming languages, networks, and classification levels
 - Data Collection and Playback
 - Local and Remote Command and Control
 - Health & Status Monitoring
 - Real-Time simulations
 - Stimulation of live sensors and instrumentation
 - Connecting non-interoperable inter- and intra-range systems
 - Eliminating proprietary interfaces to range instrumentation
 - Sharing and reuse of common range tools and capabilities
 - Online Collaboration and File Sharing
- Data Management**
- Event Management**
- LVC Integration**
- Sharing & Reuse**

These activities are all relevant to cyber experiments



TENA by the Numbers

9,000+ user accounts

250+ separate activity groups

20+ million page hits in 2017

3,104 helpdesk cases resolved in 2017

84 supported computer platforms

56 supported test / training tools

1,724 different object models

94,841 downloads in 2017

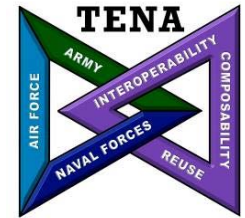
100% Government-off-the-Shelf (GOTS)

TENA Software Repository

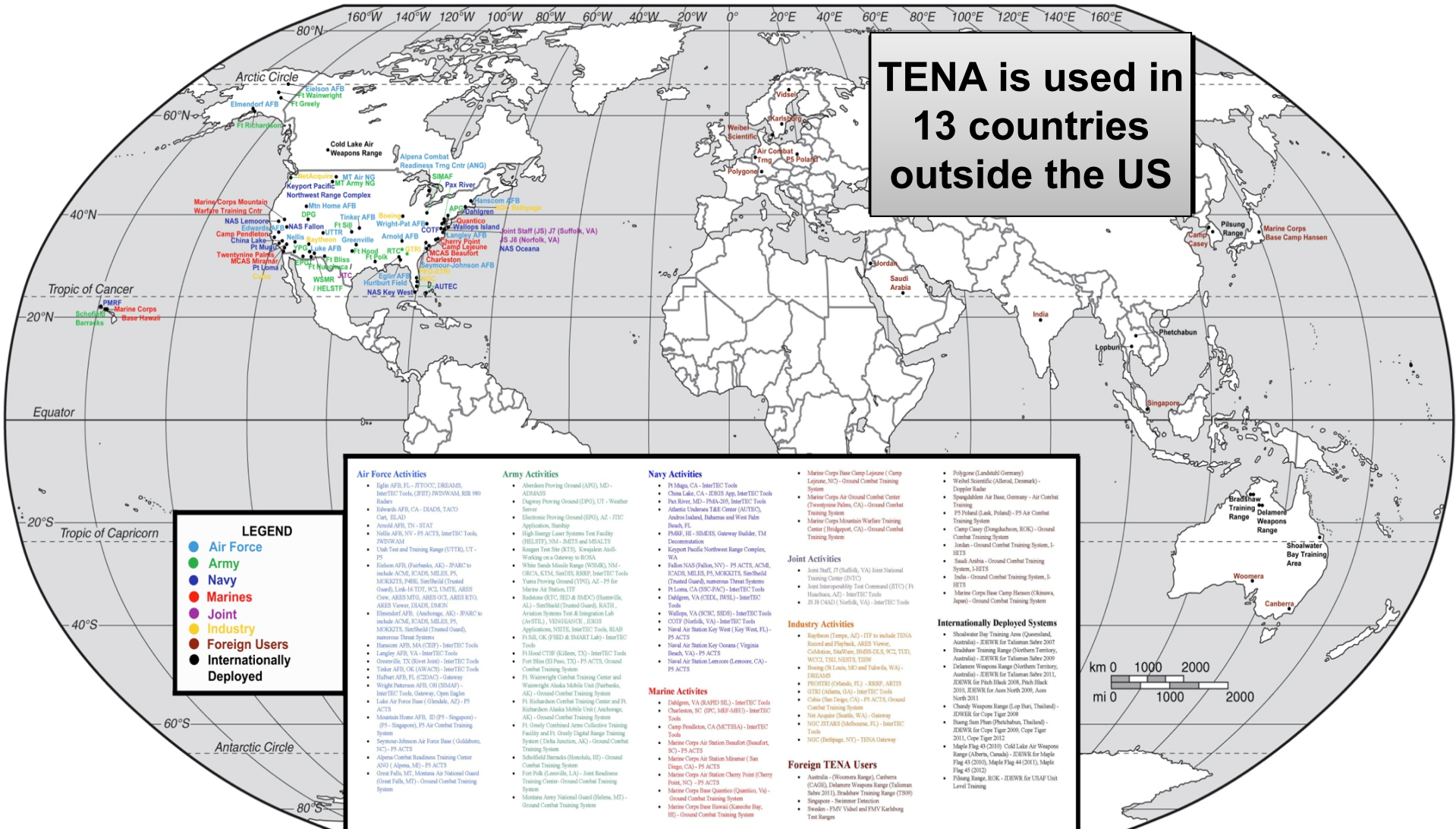
TENA
Repository

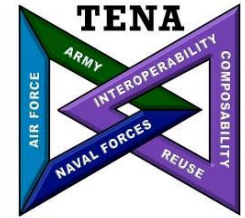
Discover, reuse and share
TENA components

TENA Website (wiki and helpdesk)

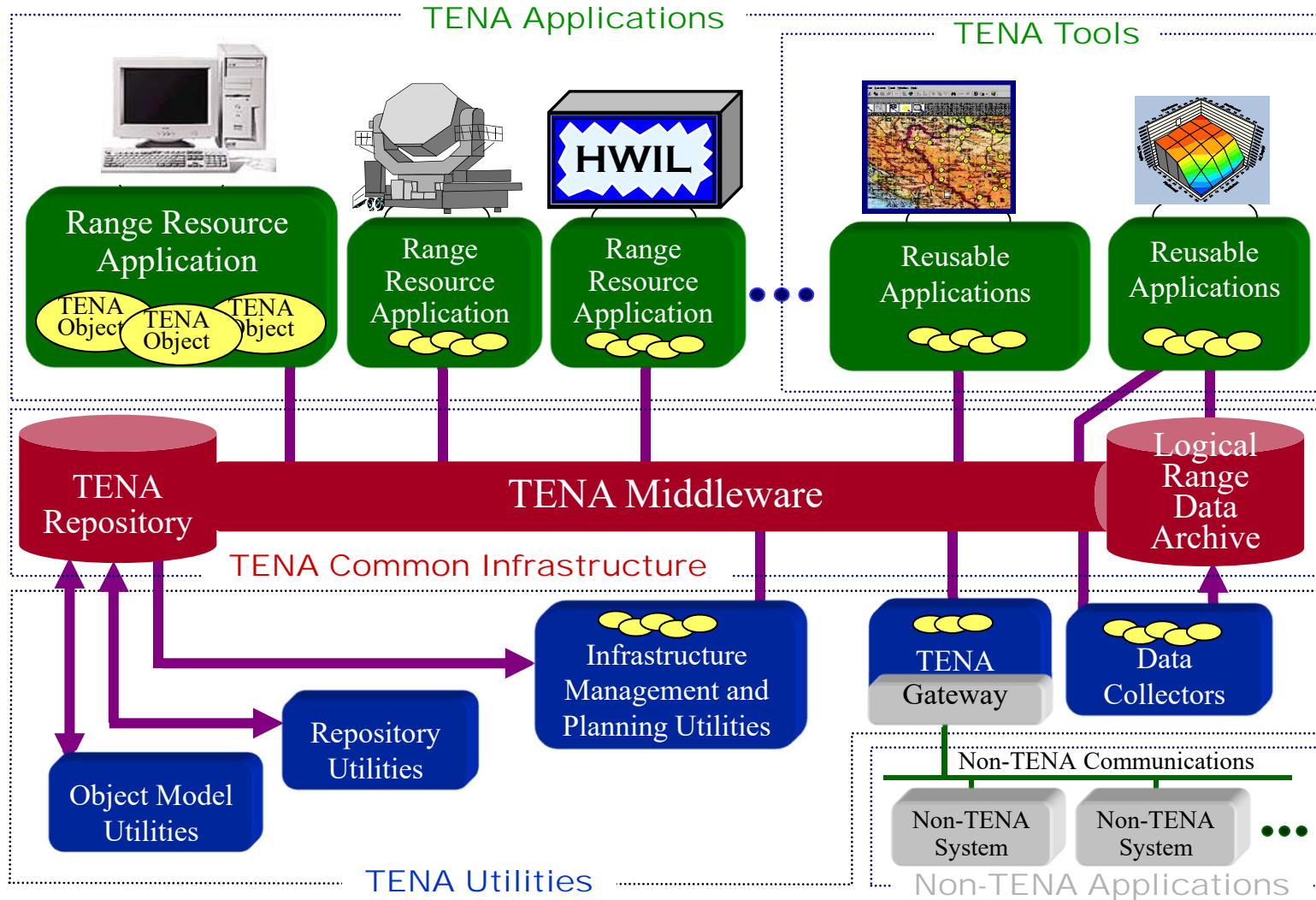


Worldwide Use of TENA



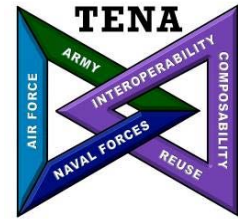


TENA Architecture Overview





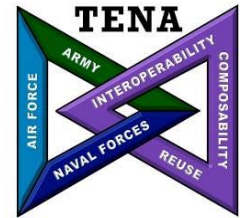
What Makes TENA Unique? Core Architectural Tenets



- **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**
 - 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



The Ways in Which TENA Applications Can Communicate



TENA provides to the application developer a unification of several powerful inter-application communication paradigms:

● Publish/Subscribe

- Each application publishes certain types of information to which any other application can subscribe
- Similar in effect to HLA, DIS, CORBA Event Service, DDS, etc.

● Remote Method Invocation (RMI)

- Each object that is published may have methods that can be remotely invoked by other applications
- Similar to CORBA RMI or Java RMI

● Distributed Shared Memory (DSM)

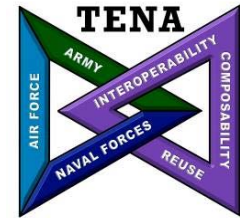
- Applications read and write the state of objects as if they were local objects, even though they are remote objects
- A very natural, easy to understand programming paradigm that projects the illusion of working on a shared memory multi-processor machine onto a distributed computing system

● Messages

- Individual messages that can be sent from one application to other applications



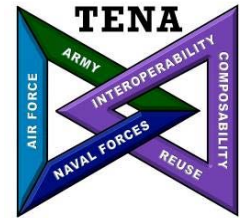
TENA is an Open Architecture



- **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) now JMETC Configuration Review Board (JCRB)**
- **TENA Middleware exists and is being used to support real events**
 - Government owned, without 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 as DIS and HLA (IEEE)**
 - However, we are looking into innovative mechanisms to get the same usability and confidence with TENA as we do with open standards
 - TENA’s business model is not the same as the DIS and HLA business models



TENA Cybersecurity Activities

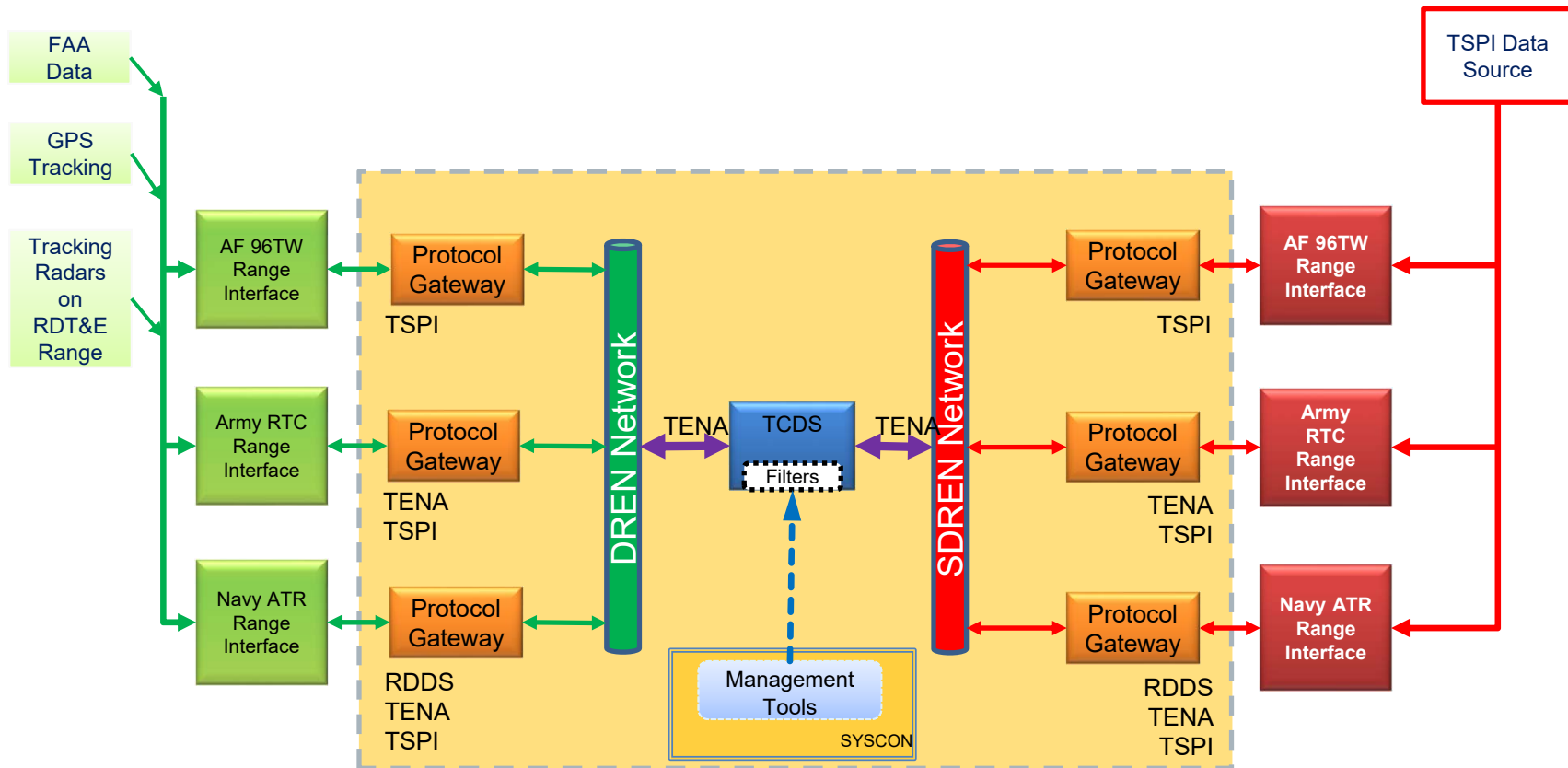


- **Air Force Evaluated/Approved Product List (E/APL)**
 - Software Certification for TENA Middleware Version 6.x
- **Navy Application & Database Management System (DADMS)**
- **Army RMF Assess Only Process**
- **SDREN (Secret Defense Research and Engineering Network)**
 - TENA protocol, ports, and TENA-based applications approved for DREN / SDREN sites
- **NIPRNet**
 - Eglin AFB JTTOCC (which includes TENA Middleware) obtained ATO on NIPRnet
- **DoD PPSMO Category Assurance List (CAL)**
 - TENA ports approved for use on classified and unclassified network enclaves
- **Unified Cross Domain Management Office (UCDMO)**
 - TENA-enabled Cross Domain trusted guard SimShield on baseline list
- **Joint RDT&E Reciprocity Overlay Team (JRROT)**
 - Foundational set of controls for basing reciprocity determinations for RDT&E

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



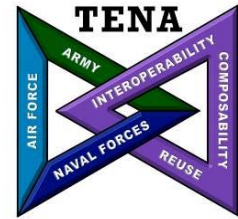
Test Design Example: JMETC CDS System



The MLS-JCNE CTEIP project implementation provided the RDT&E community with a persistent, interoperable, and reusable capability to exchange unclassified data between unclassified and classified enclaves (DREN and SDREN)



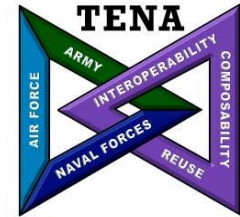
Test Construction / Setup: TENA Tools



- **Tools are applications, components, or utilities required to support a successful test execution**
- **The TENA SDA maintains a library of tools that address common test requirements**
 - Common tools enable a consistent depiction of the test environment
 - All tools and supporting documentation available through the TENA Repository
- **Some example tools include:**
 - Collaboration and Sharing: TENA Repository
 - Help Desk and Troubleshooting: TENA Issue Tracking System
 - OM Design Support: MagicDraw UML-to-TDL Plugin
 - Legacy Test Asset Integration: TENA Adaptor
 - Test Event Management: TENA Console
 - 3D Visualization: SIMDIS TENA Plug-in
 - Video Sharing: TENA Video Distribution System
 - Data Logging: TENA Data Collection System



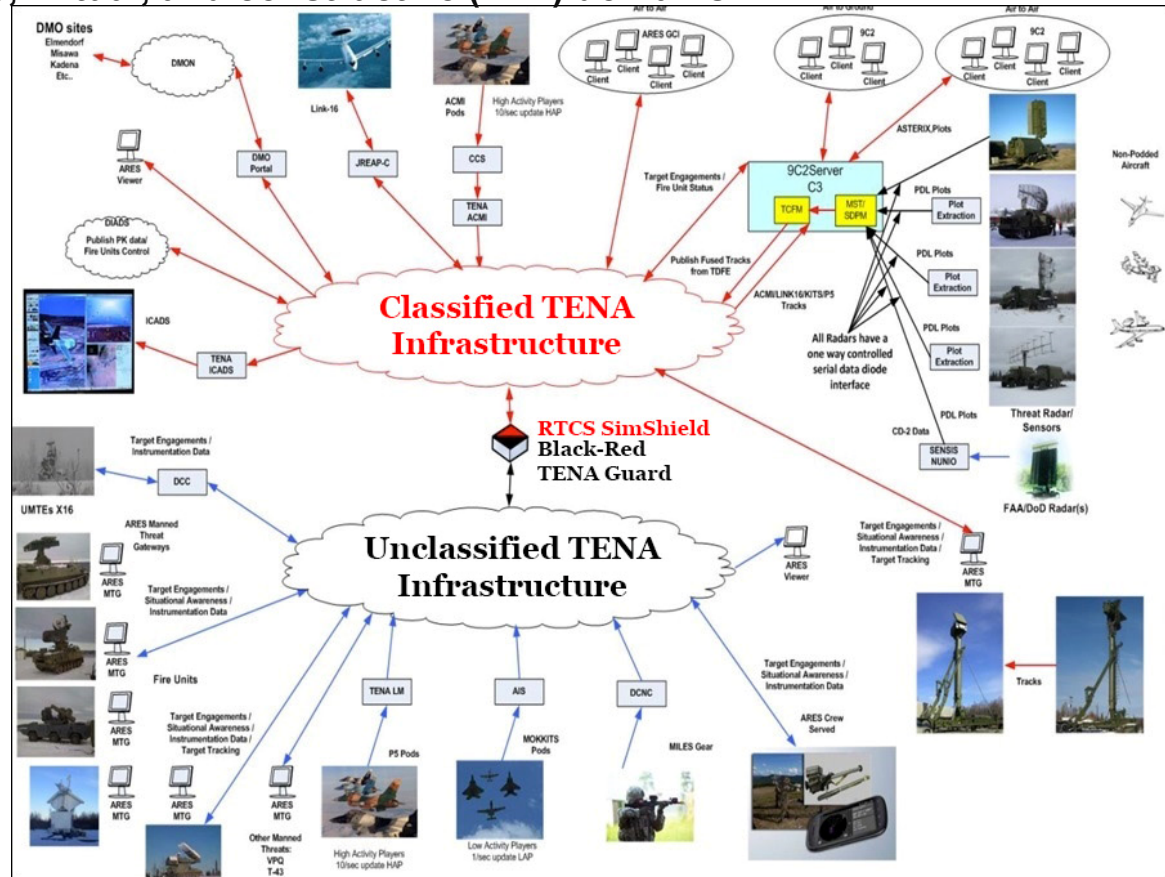
TENA at Joint Pacific Alaska Range Complex (JPARC)



TENA enables the Pacific Air Force (PACAF) JPARC to provide 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

A few of the systems currently using TENA at JPARC include:

- Individual Combat Aircrew Debriefing Subsystem (ICADS)
- Air Combat Maneuver Instrumentation (ACMI)
- 9C2 (tactical data fusion system)
- Digital Integrated Air Defense System (DIADS)
- Integrated Threat Force (ITF)
- SimShield (Cross Domain System)
- Misawa-Osan-Kusan-Kadena Instrumentation Training System (MOKKITS)
- Multiple Integrated Laser Engagement System (MILES) 2000 (tactical engagement simulation)
- Initial Homestation Instrumentation Training (I-HITS)
- Un-manned Threat Emitter (UMTE)
- Adaptable Range Exercise System (ARES)

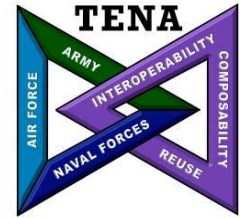


“TENA is the greatest thing that ever happened to us. We couldn’t be doing today with all these systems—and we couldn’t have all the participants that we do—if it weren’t for TENA” Billy D. Smith (PACAF Chief of electronic combat training requirements for Red Flag at JPARC)



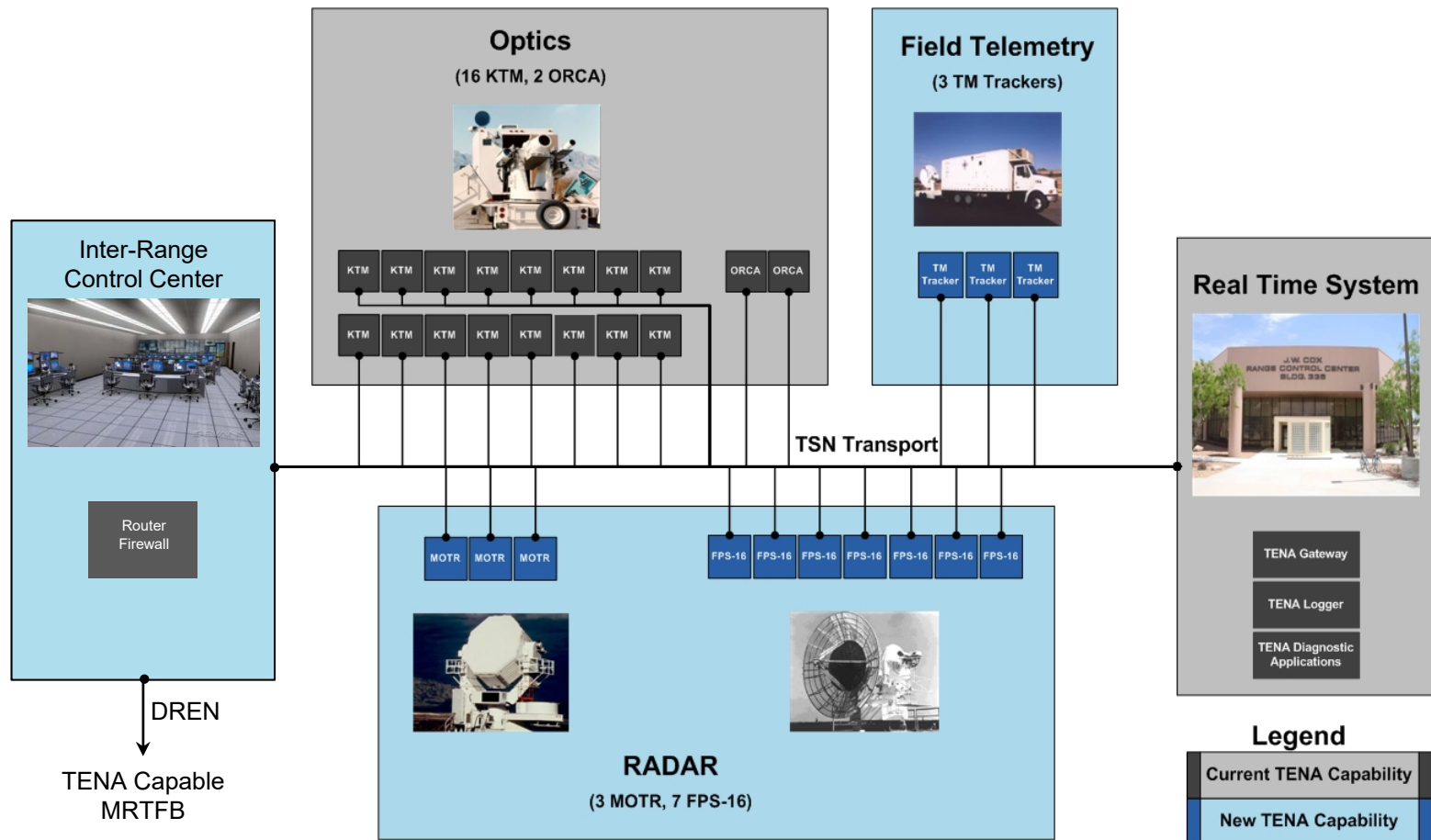
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WSMR Distributed Instrumentation Control Enterprise (DICE)



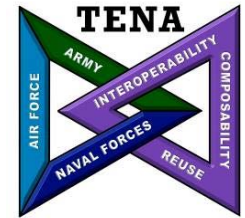
Establishing common communication architecture that operates in parallel with the different functional group protocols

WSMR TENA SENSORS

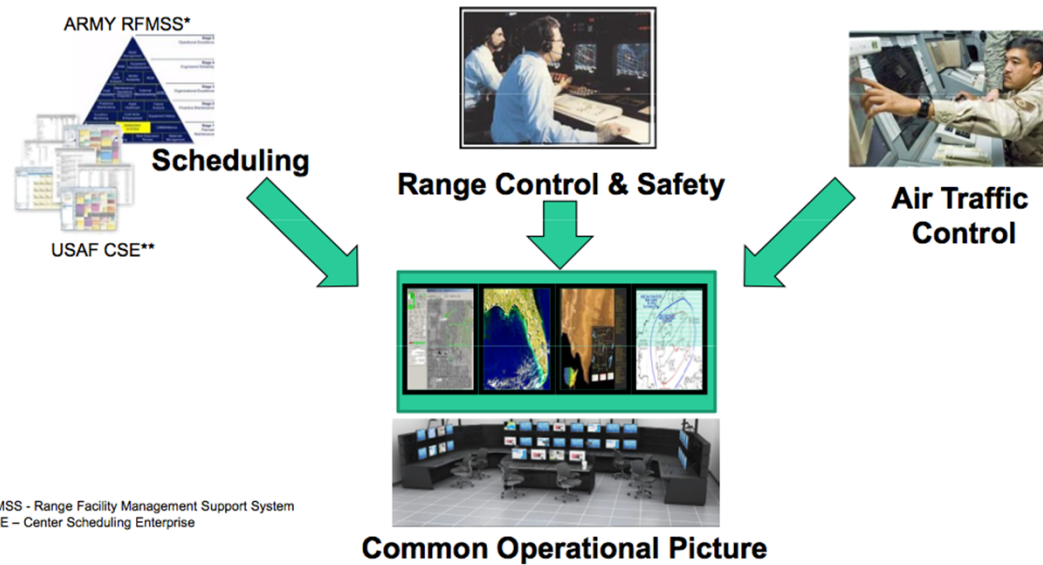




TENA at Eglin AFB

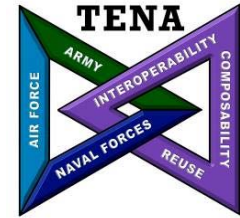


TENA supports Eglin's Joint Test and Training Operations Control Center (JTTOCC) in providing efficient, flexible real-time control of all resources required for safe air, land, and sea test and training 24x7 operations



“TENA gave us a common environment that greatly simplified the efforts of our two non-co-located software development contractors. It also significantly aided in our ability to meet information assurance criteria, allowing us to move from requirements to fielding on the NIPRNet in under 18 months. ”

Chris Short
JTTOCC Lead Systems Integration Engineer



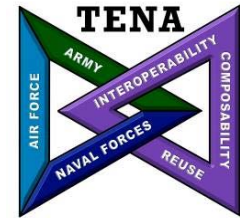
TENA Enabled TM Control at YUMA

- TCS Antenna Control Unit (ACU) model M1 completing TENA interface
- Remote monitoring and control of telemetry antenna system using TENA is undergoing operational testing
- To be used on Yuma TM pedestals
- Updated controller to be procured this year with Red Hat 6 Operating System





Test Analysis / Reporting: Data Collection and Analysis Framework



● Data Collector

- Using TENA object models, data collection software is automatically generated to record object and message attribute values in a persistent data store (currently SQLite and MySQL database representations)
- Plan to provide add-on collection capability to allow publisher side collection, as well as subscriber side collection – which requires collection management capabilities

● Data Analysis Support

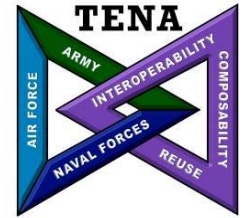
- Extractor tool provided to convert data into format that can be used by Microsoft Excel
- Analysis capabilities and tools are often highly specialized, and the intent of TENA is to provide a framework for user community to extend to support their unique data storage and analysis needs

● Data Playback

- Automatically generated playback tool can be used to re-play collected data for various forms of testing and analysis



TENA Upgrade Support Offer



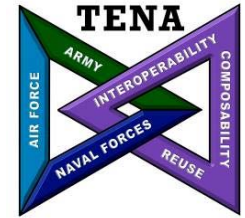
- **The TENA team is available to offer advice and assist any organization looking to use TENA**
 - Advice on overall design approach and trade-offs to consider
 - Recommended Object Models to reuse
 - Recommendations on how to design new Object Models
 - Implementation / Code Designs Reviews
 - Awareness of similar systems and lessons learned
 - Hands-on training classes on TENA capabilities
 - Hands-on training classes
 - Developing TENA interfaces
 - Incorporating different Object Models
 - Upgrading for HLA/DIS applications migrating to TENA

Opportunity to Get Assistance in Using TENA

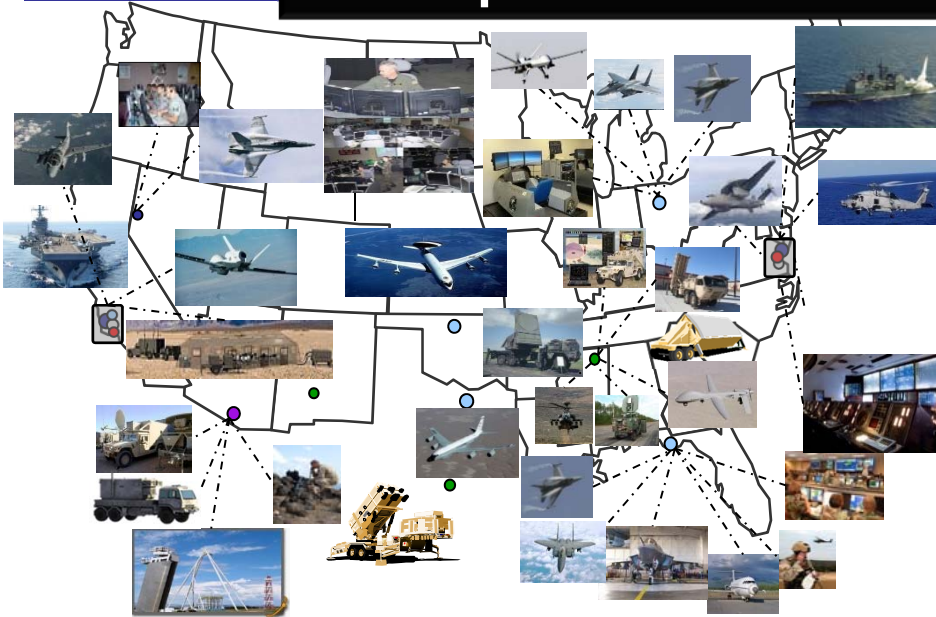
E-mail request to: tena-feedback@trmc.osd.mil



Joint Mission Environment Test Capability (JMETC)



Enterprise Infrastructure for testing like we fight



JMETC Summary:	
System of Systems Infrastructure	147 Govt. & Industry Sites
	272 JSN Test Events FY07-FY18
	92% Enterprise Reusability
Common Integration Software (Test & Training Enabling Architecture)	Suite of 56 Integration Tools
	Runs on all DoD-approved Operating System environments (84 different variants)
	Used in 13 partner nations
Customer Collaboration (Enables RDT&E Problem-Solving)	9,000+ website user accounts
	20 million+ webpage views in FY18
	94,841 downloads in FY18
Subject Matter Expertise	11,325 Help Tickets Resolved FY12-FY18
	341 Lessons Learned & Shared

JMETC Mission:

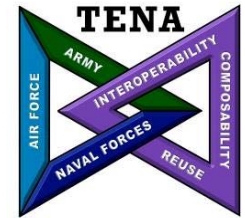
- Optimize the DoD's distributed system of systems test infrastructure
- Develop & maintain common software that eliminates stove-pipes
- Promote Inter-Service RDT&E collaboration through website services
- Provide expertise to rapidly design, setup, & execute tests



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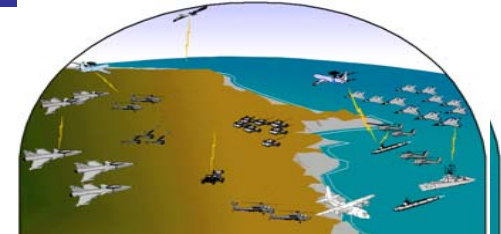
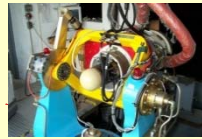
JMETC Distributed Test Architecture

JMETC depends on TENA to support distributed testing



Joint Operational Scenarios

Systems Under Test



Integrated Test Resources

Virtual Prototype

Hardware in the Loop

Installed Systems Test Facility

Range

Environment Generator

Threat Systems

TENA Standard Interface Definitions

TENA Standard Interface Definitions

TENA Standard Interface Definitions

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TENA Standard Interface Definitions

TENA Standard Interface Definitions

TENA Common Middleware

TENA Common Middleware

TENA Common Middleware

TENA Common Middleware

TENA Common Middleware

TENA Common Middleware

JMETC Infrastructure on DREN

Reuse Repository

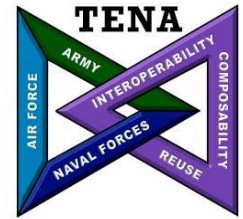
Distributed Test Support Tools

* TENA: Test and Training Enabling Architecture



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Joint Mission Environment Test Capability (JMETC) Program Investment Areas

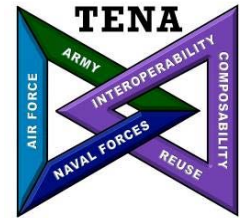


- **Distributed Testing Support**
 - Event Planning and Execution Support
 - Help Desk Troubleshooting and Subject Matter Expertise
- **Distributed Testing Networks**
 - JMETC SECRET Network (JSN): Always connected
 - JMETC MILS Network (JMN): Event-specific links
- **TRMC Cybersecurity Services**
 - Risk Management Framework Support
 - RDT&E Cybersecurity Standards: Overlay, SW Certification
- **Test & Training Enabling Architecture (TENA)**
 - TENA Software Repository
 - TENA Object Models
 - TENA Web Services
- **Big Data / Knowledge Management Initiative**
 - Enterprise Architecture Framework
 - Proofs of Concept Support
- **National Cyber Range Complex (NCRC)**
 - Cyber Range Infrastructure, Tools, Instrumentation
 - Offensive & Defensive Cyber Tests & Events (OCO/DCO)
 - Cyber SMEs & Support Team (including skilled OPFOR)



TRMC Available Enterprise Services

Hardware, Software, & Subject Matter Expertise

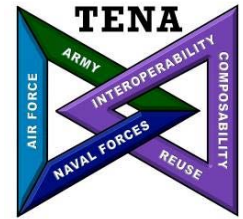


- **JSN-SYSCON Services**
 - Active JSN Monitoring & Troubleshooting
 - VoIP including Conferencing
 - Adobe Connect Collaboration
 - XMPP Chat
 - Secure JSN File Transfer
 - YUM Server CentOS Updates
 - Domain Name Service (DNS)
 - DREN / SDREN RDT&E Cross Domain Solution
- **Cybersecurity**
 - Risk Management Framework Implementation Support
 - RDT&E Overlays
 - RDT&E SW Certification (*future*)
- **TRMC Support Services**
 - TRMC Use Case Archive
 - Test Capabilities Database
- **Enterprise Software Services**
 - Software Repository incl. 50+ common tools
 - JIRA Helpdesk Projects
 - Wiki Collaboration Spaces
 - Email Reflectors
 - TENA Auto-Code Generation
 - Bitbucket Source Code Management
- **NCRC Services**
 - Cyber Event Planning / Design / Execution Tools & Expertise
 - MILS Network connecting Govt, Industry, and Academia at multiple classifications
 - Representative blue / red / gray environments
 - Traffic generation and instrumentation
 - IaaS & System Virtualization
 - Cooperative Vulnerability and Penetration Assessment expertise
 - Data reduction, analysis and customized reporting

TRMC wants to help turn your capabilities into enterprise services



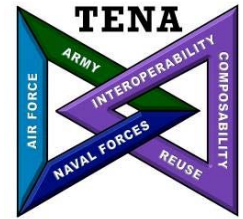
JMETC Network Architecture



- **JMETC has a hybrid network architecture**
 - **The JMETC Secret Network (JSN), based on the Secret Defense Research and Engineering Network (SDREN), is the T&E enterprise network solution for Secret testing**
 - **The JMETC Multiple Independent Levels of Security (MILS) Network (JMN) is the T&E enterprise network solution for all classifications and cyber testing**



JMETC SECRET Network (JSN)



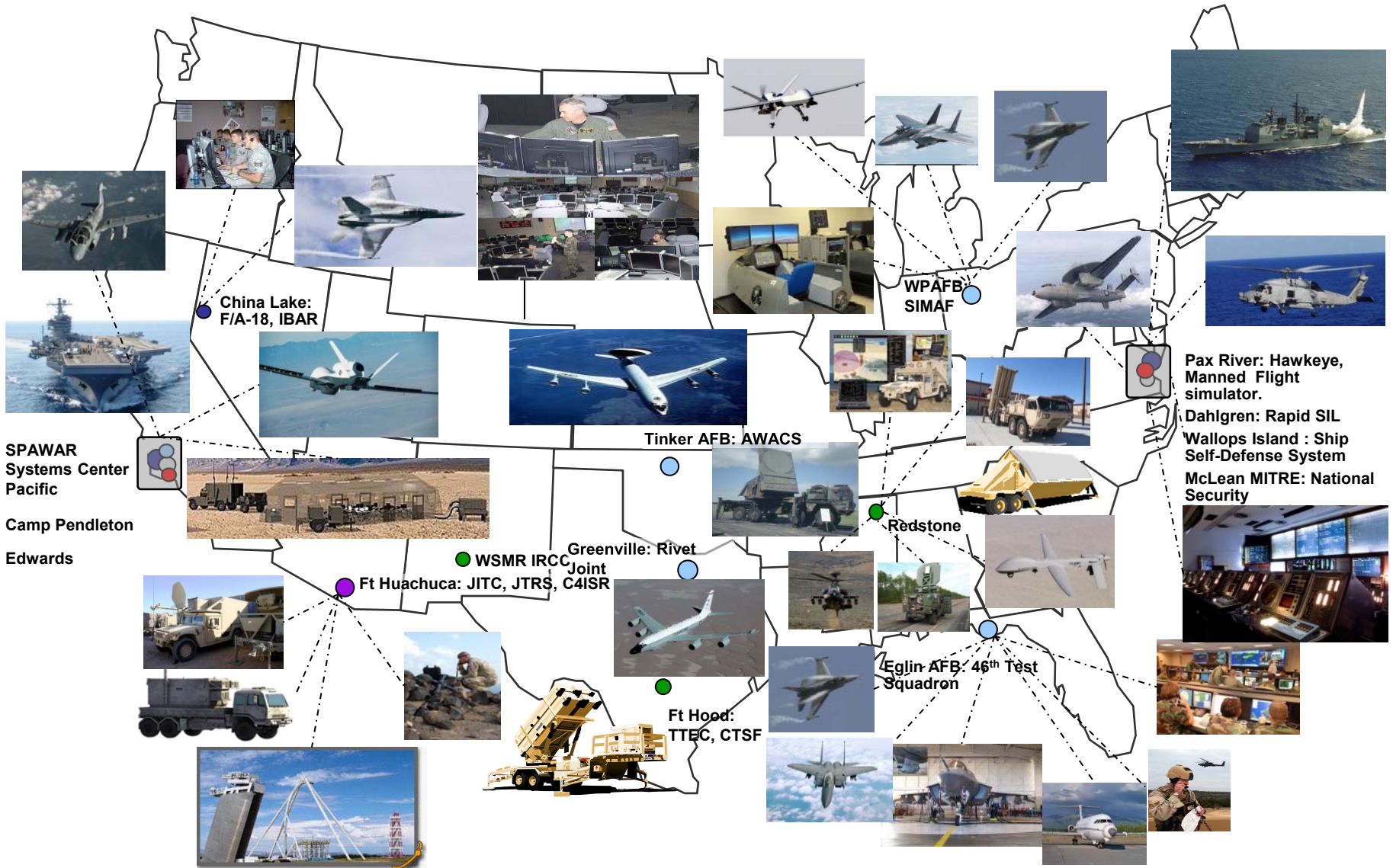
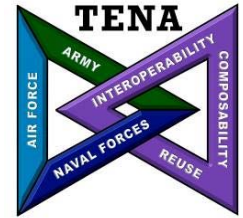
- Focus is on **persistent connectivity**
 - Standing Agreements
 - All sites have valid Authority to Operate (ATO) and Authority to Connect (ATC)
 - Daily full mesh, end-to-end network characterization ensure optimized performance
 - On demand usage with little to no coordination necessary
 - MOAs in place to authorize connections between all sites
- Persistency enables user to...
 - Test capabilities early and often
 - Execute unscheduled/unplanned testing whenever needed
 - Focus on the test rather than the network
- Operates at **SECRET Collateral**
 - Leverages SECRET Defense Research & Engineering Network (SDREN) for connectivity
 - Functional and growing since 2007

Customer time and dollars not spent on infrastructure by leveraging JMETC



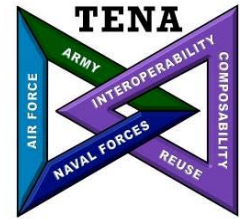
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Sampling of Assets Available on JSN

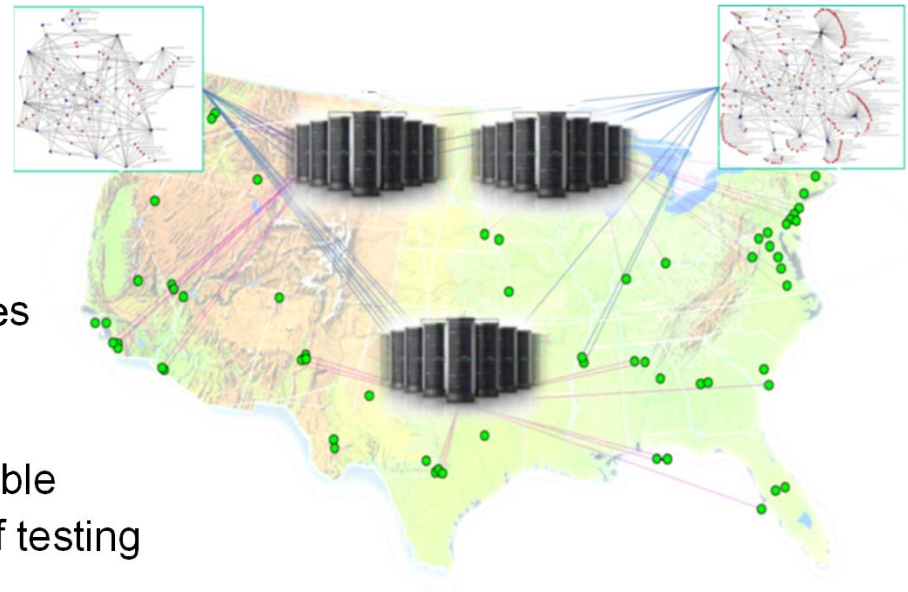




National Cyber Range Complex (NCRC) Facilities

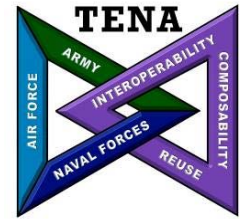


- Provide enterprise resources to rapidly generate virtualized representative cyber environments
 - Comprised of computational and storage resources to host 1000s of high fidelity virtual representations
 - Large, integrated Red-Blue-Gray environments
 - Platform specific high-fidelity representations
 - Tailored, independent student classrooms
 - Automated provisioning to minimize deployment time
 - Each is capable of supporting numerous events and varying classifications concurrently
 - Serves as a platform for tools and services
 - Geographically dispersed to minimize latency and maximize usability
 - Designed to be cost-effective and adaptable
 - Also supports more conventional types of testing





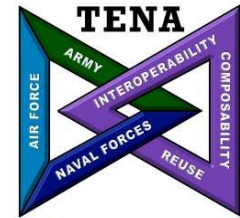
Summary



- **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



Architecture Management Team (TENA AMT) replaced by JTEX/JCRB



• JMETC Technical Exchange (JTEX) / JMETC Configuration Review Board (JCRB)

Participating Organizations:

- 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
 - Alaska Training Range Evolution Plan (ATREP)
 - Army Operational Test Command (OTC), Fort Hood, TX
 - Common Training Instrumentation Architecture (CTIA)
 - Common Range Integrated Instrumentation System (CRIIS)
 - 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 Mission Environment Test Capability (JMETC)
 - 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 Test Center (RTC)
 - T&E/S&T Non-Intrusive & Advanced Instrumentation
 - White Sands Missile Range (WSMR)
 - Yuma Proving Ground (YPG)
- **Design Decisions / Trade-offs / Status / Technical Exchanges of Lessons Learned / Use Cases / Testing / Issues & Concerns Identification, Investigation, & Resolution**

Industry Advising Members

- Boeing
- Cubic Defense
- DRS
- Embedded Planet
- EMC
- General Dynamics – C4 Systems
- Kenetics
- MAK Technologies
- NetAcquire
- Raytheon
- Science Applications International Corp (SAIC)
- Scientific Research Corporation (SRC)
- Scientific Solutions, Inc. (SSI)
- Trusted Computer Solutions

International Participation

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



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Linking Sites

Cyber Events

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Secret Only

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Connected Only During Event

Above / Below Secret

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For TENA questions: tena-feedback@trmc.osd.mil

For NCRC questions: ncrc-feedback@trmc.osd.mil

Websites

Unclassified, FOUO, DoD-Restricted (CAC required): <https://www.trmc.osd.mil>

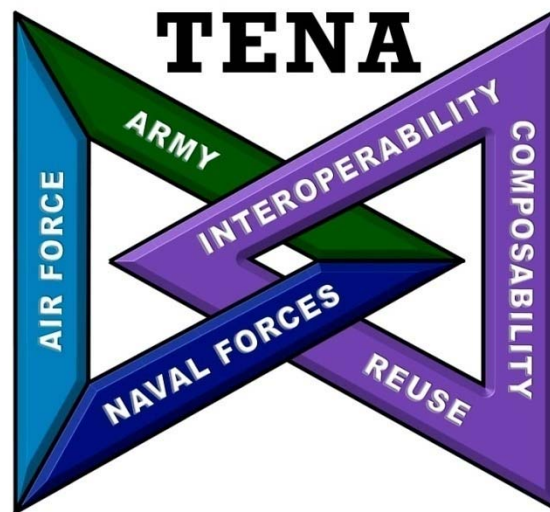
Distribution A, Industry, non-DoD (username/password required): <https://www.tena-sda.org>

Help Desk

Action Items, Questions, Tasks, Software Needs, Bug Reports: <https://www.trmc.osd.mil/helpdesk>

JTEX-05: December 9-12, 2019; Charlotte, NC

Backup Slides



Additional Examples



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Some Examples of TENA Usage



- 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)
- 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



Partial Listing of Recent Testing, Training, and Experiments Using TENA-Compliant Capabilities



● Test Events

- MQ-4C Triton, Ongoing
- Air Force Systems Interoperability Tests (AFSIT), Feb – Apr 18
- Navy Gemstone Event Series, Feb 17 – Aug 18
- Joint Interoperability Test Command (JITC) Joint Interoperability Tests (JIT), Ongoing (4/yr)
- Distributed Integration & Interoperability Assessment Capability (DIIAC) Verification & Validation, Nov 17 – Aug 18
- Decisive Sting, Jan – Sep 18
- Apollo Captive Carry (CC) for Integrated Test Events (ITE), Jul 18
- Interoperability Development and Certification Testing (IDCT), Ongoing (4/yr)
- Tactical (TAC)-to-TAC Testing, Oct 17 – Apr 18
- Automatic Test Case-Generator (ATC-Gen) Net-Enabled Weapons Interface Test, Aug 17
- Net-Centric Weapons Test and Evaluation Environment (NCWTEE), Jul 17 – Jun 18
- Cross Domain Maritime Surveillance and Targeting (CDMaST), Sep 17 – Feb 18
- Small Diameter Bomb (SDB) II Testing, Mar 18
- P-8A Harpoon Block 2+ Testing, Apr 18
- Fleet Support, Oct 17 – Ongoing
- Fenceless Ranges, Aug 17 – Ongoing

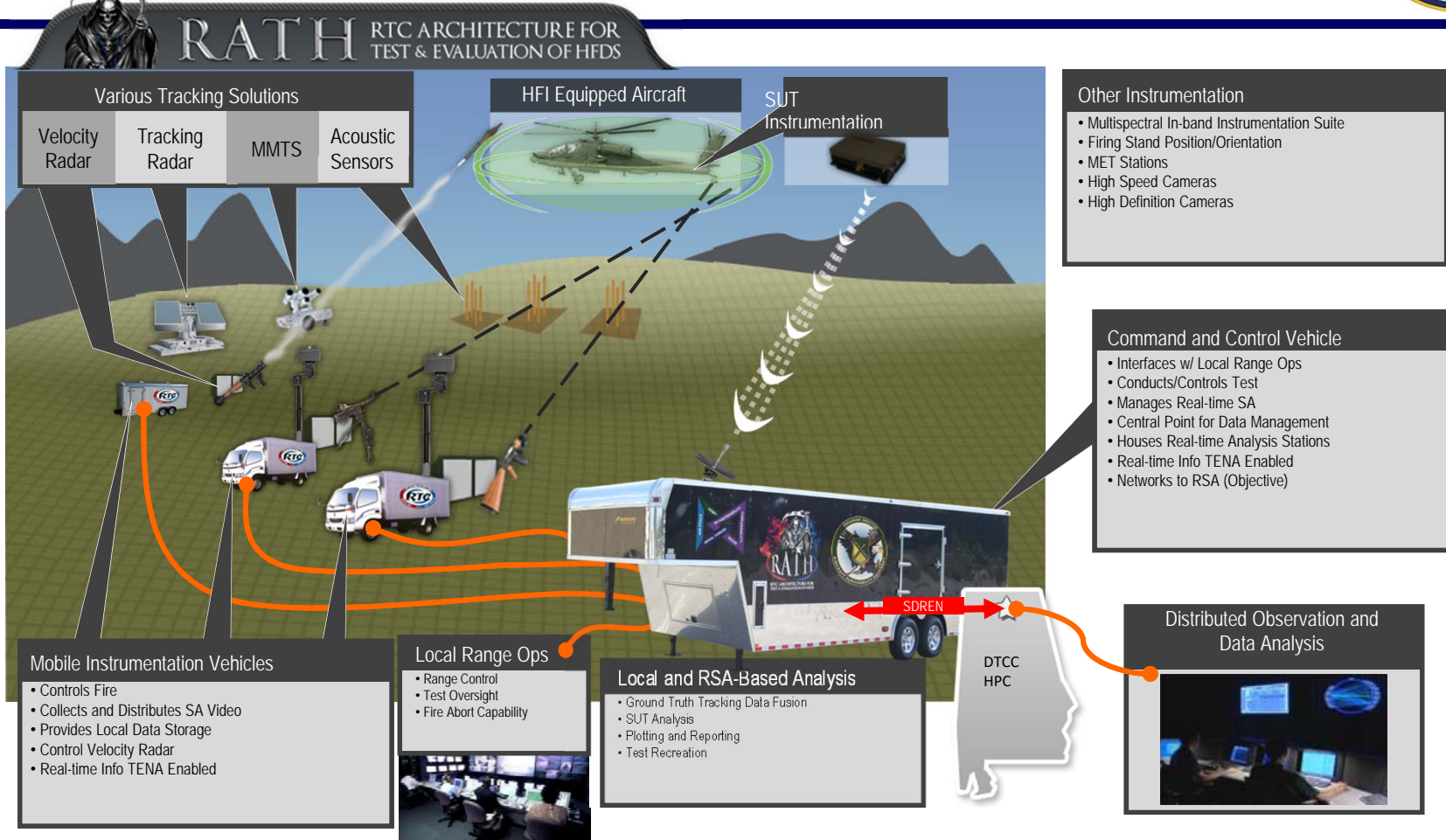
● Training Exercises

- Daily Training, Eielson AFB
- Daily Training, Kadena AB
- Daily Training, Kunsan AB
- Daily Training, Misawa AB
- Daily Training, NAS Fallon
- Daily Training, Multinational Aircrew Electronic Warfare Tactics Facility, Polygone, Germany
- Joint Deployable Electronic Warfare Range (JDEWR) Max Thunder 2017, JPARC
- JDEWR Vigilant Ace 2018, JPARC
- Northern Edge, May 2019, JPARC
- Red Flag Alaska (RFA), three to four times a year since 2008, Joint Pacific Alaska Range Complex (JPARC)
- RFA 18-1, Apr 30 – May 11, 2018
- RFA 18-2, Jun 11 – 22, 2018
- RFA 18-3, Aug 11 – 24, 2018
- RFA 19-1, Oct 8 – 19, 2018

● Experiments



RTC/ASE Architecture for Test & Evaluation of Hostile Fire (RATH)



“Applying TENA has been a leading contributor to making disparate efforts (M&S, Lab, Hangar, Range) leverage duplicate capabilities to form an overall better test capability”

Mac Lowry

Advanced Technology Office Chief, Redstone Test Center



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Mobile Multi-Sensor TSPI System (MMTS) Project



- U.S. Army Program Executive Office (PEO) for Simulation, Training, and Instrumentation (STRI) awarded Photo-Sonics, Inc. a contract to build the Mobile Multi-Sensor Time-Space-Position-Information-System (MMTS)
- The MMTS consists of two high-performance optical tracking pedestals connected via fiber optics to a control van equipped with two remote control consoles, the system was designed to track and provide high accuracy Time-Space-Position-Information (TSPI) of high-speed weapons including hyper-velocity projectiles
- Functional testing and Final Site Acceptance Test completed at White Sands Missile Range (WSMR)
- Final system has been delivered and integrated via TENA Interface into Redstone Arsenal

System Characteristics

- Fully Integrated Pedestal and Sensor Control Software
- Radar provides a Single Station Solution
- High-Speed Auto Tracker (250 FPS)
- High Accuracy
- High Dynamics
- Automated Stellar and Turn & Dump Calibration
- Simulation System
- Range Interface Computer to calculate real-time 3D data
- Integrated Data-Reduction Software (six degrees of freedom)
- TENA Integration into RTC



“TENA architecture was instrumental in the development of the interoperability between the MMTS and the Integrated Test Range. Implementing the various TENA modules was simple, smooth, and straightforward with no major effort needed.”

Philip Kiel
President, Photo-Sonics

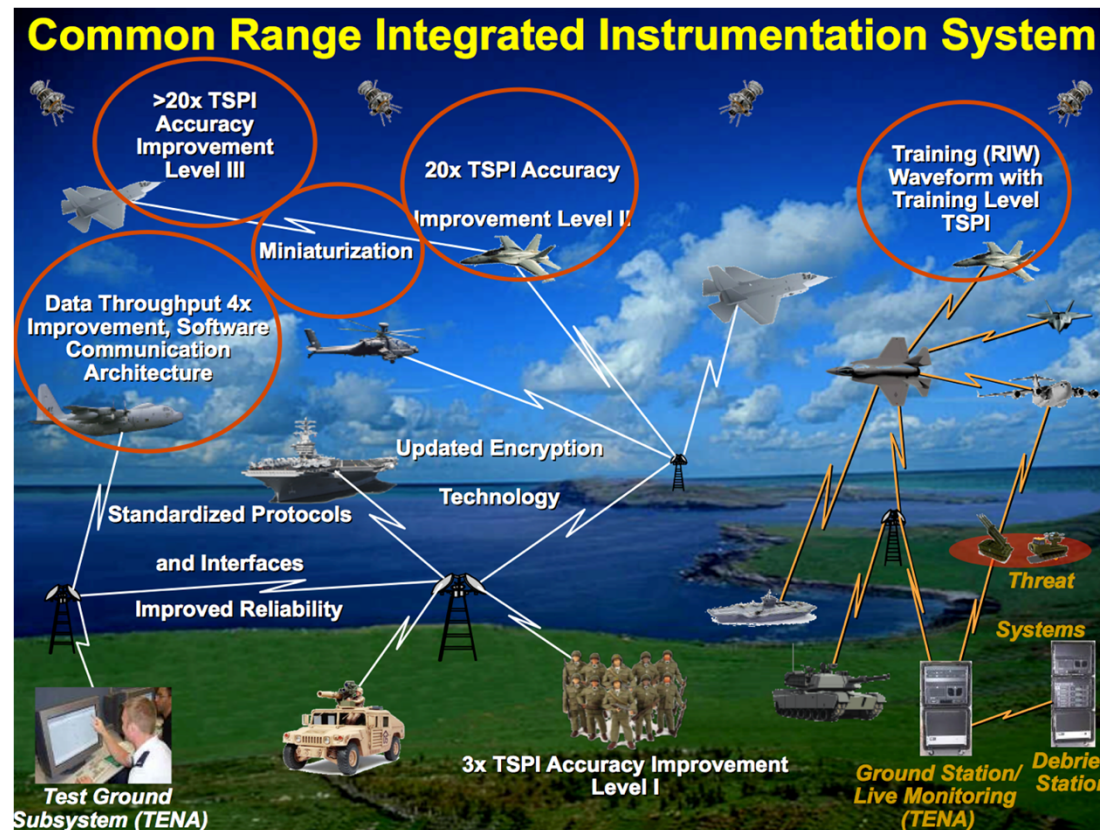


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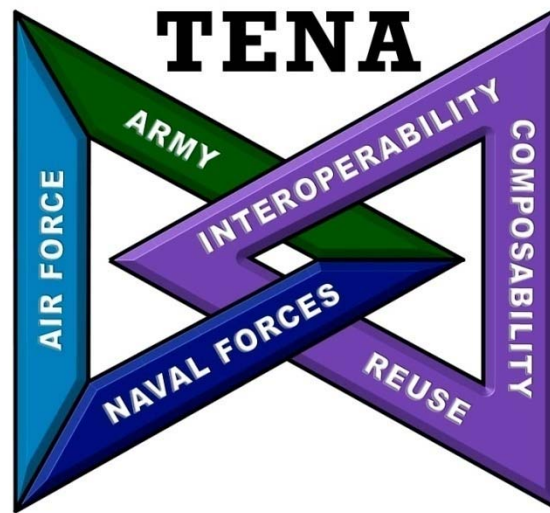
Common Range Integrated Instrumentation System (CRIIS)



- 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



Backup Slides



For Reference Only



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



TENA is...

- **An implemented architecture that many government organizations & vendors use to build interoperable systems**
- **A highly robust GOTS network data transport architecture**
- **A collection of developed systems that address common needs**
- **Fully controlled by the community of its users**
- **Built for “performance, performance, and performance”**
- **Available for a wide range of computer platforms and programming languages**
- **Streamlined for practical application via auto-code generation**
- **A mechanism used to promote range data standards**
- **Backwards Compatible (from Release 6 onwards)**
- **Revised and Improved based on user feedback and lessons learned from working software implementations**
- **100% resourced for improvements and sustainment by U.S. DoD**



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TENA Objects are Compiled In

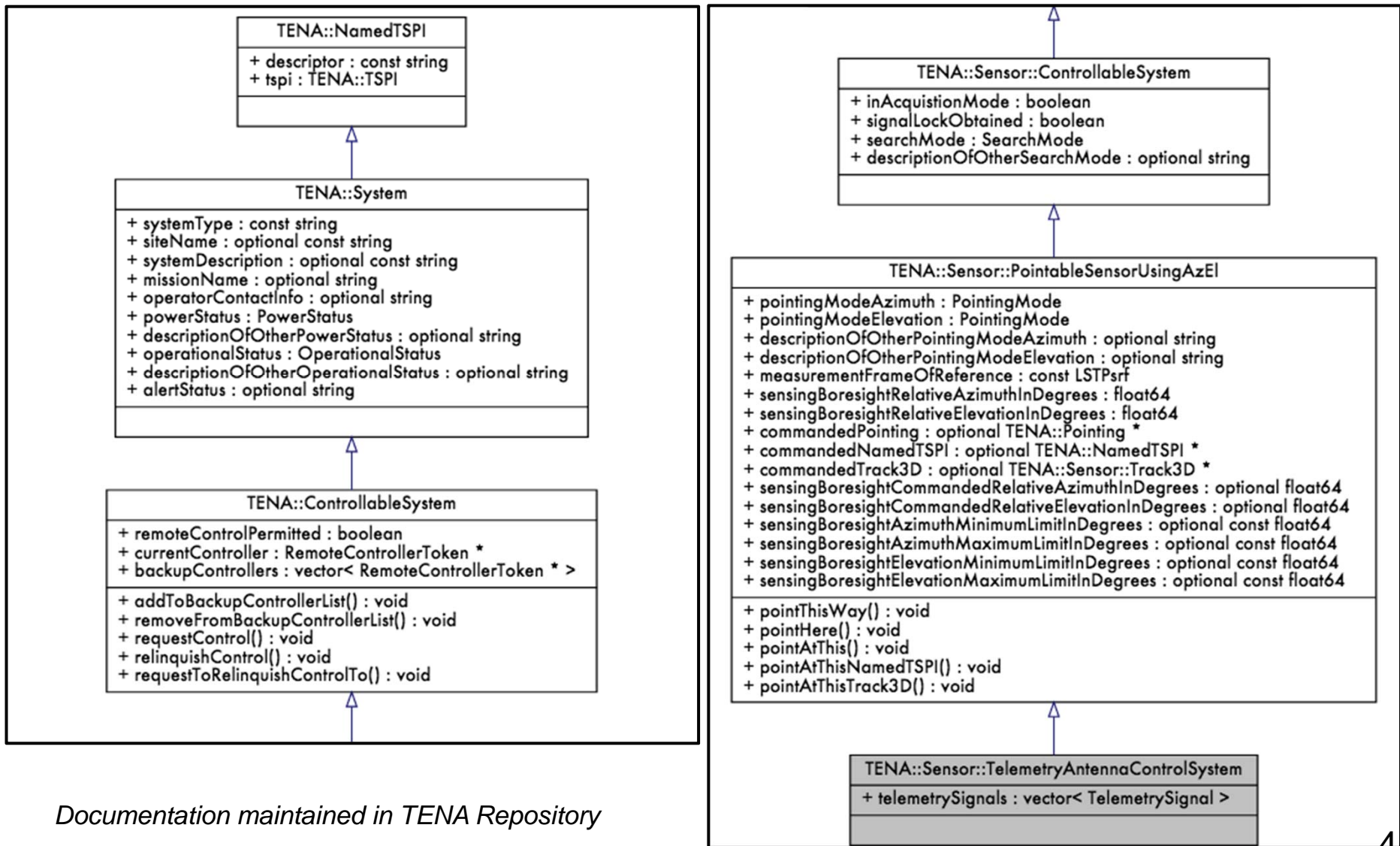


- **Why use compiled-in object definitions?**
 - **Strong type-checking**
 - Don't wait until runtime to find errors that a compiler could detect
 - **Performance**
 - Interpretation of methods/attributes has significant impact
 - Ability to easily handle complex object relationships
 - Conforms to current best software engineering practices
- **How do you support compiled-in object definitions?**
 - Use a language like CORBA Interface Definition Language (IDL) to define object interface and object state structure
 - Use **code generation** to implement the required functionality
- **Thus the concept of the TENA Definition Language (TDL) was created**
 - Very similar to IDL and C++



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TelemetryAntennaControlSystem Class Hierarchy Illustration



Documentation maintained in TENA Repository



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!