TENA/JMETC:

Live-Virtual-Constructive Integration for Test and Training

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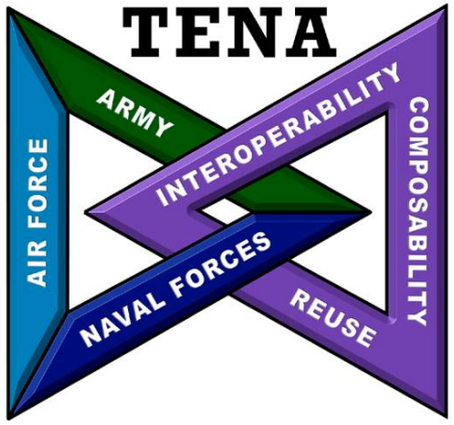
TENA Architect



Outline

- **Building and Using the Test and Training Enabling Architecture (TENA)**
  - TENA Mission and Benefits
- **The TENA Architecture**
  - Key Tenets
  - Architecture Overview and Key Concepts
  - Architecture Details
    - Meta-Model and Object Models
    - Repository
    - Middleware
    - Data Collection System
    - Performance
    - Tools and Utilities
    - Adapters
- **The Joint Mission Environment Test Capability (JMETC)**
- **Summary and Conclusions**

Learning Objectives

- **Identify the four major aspects of TENA and be able to explain their role in promoting interoperability.**
- **Identify at least three major differences between TENA and simulation architectures such as Distributed Interactive Simulation (DIS) and the High-Level Architecture for Modeling and Simulation (HLA).**
  - Each difference will be identified as TENA is described.
- **Identify the major purpose and use of the JMETC paradigm for distributed testing.**

TENA Mission

Currently, range systems tend to be non-interoperable, "stove-pipe" systems

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

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

- **Support the warfighter**
- **Enable simulation-based acquisition**
- **Foster test and training integration**
- **In the long term: SAVE MONEY!**

Lay the Foundation for Future Test and Training Range Instrumentation

Benefits of TENA

- **All TENA software and support is free to users**
- **Now supports C++, Java, and .Net**
- **TENA software is thoroughly tested and very reliable**
- **TENA Auto-Code Generation makes creating a TENA application as simple as possible**
  - Auto-generated starting points mean you never start with a blank page
  - Rapid development of real-time, distributed, Live-Virtual-Constructive 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!**

Test and Training Enabling Architecture (TENA) at a Glance

- **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 exchange models (object models) that standardize 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**

TENA is an Open Architecture

- **The Software Engineering Institute defines an Open System as "a collection of interacting software, hardware, and human components designed to satisfy stated needs with interface specifications of its components that are fully defined, available to the public, maintained according to group consensus, in which the implementations of the components conform to the interface specifications."**
- **TENA is maintained according to a consensus of its users assembled as the TENA Architecture Management Team (AMT)**
- **TENA exists and is being used to support real events**
  - Government owned, no proprietary software
- **TENA is freely releasable (Distribution A) to non-US entities**
  - We have many non-US users in Britain, France, Sweden, Denmark, etc.
- **There are no plans for standardizing TENA in the same way as DIS and HLA have been standardized (IEEE)**
  - However, we are looking into innovative mechanisms to get the same usability and confidence with TENA as we do with these standards
  - TENA's business model is not the same as the DIS and HLA business models

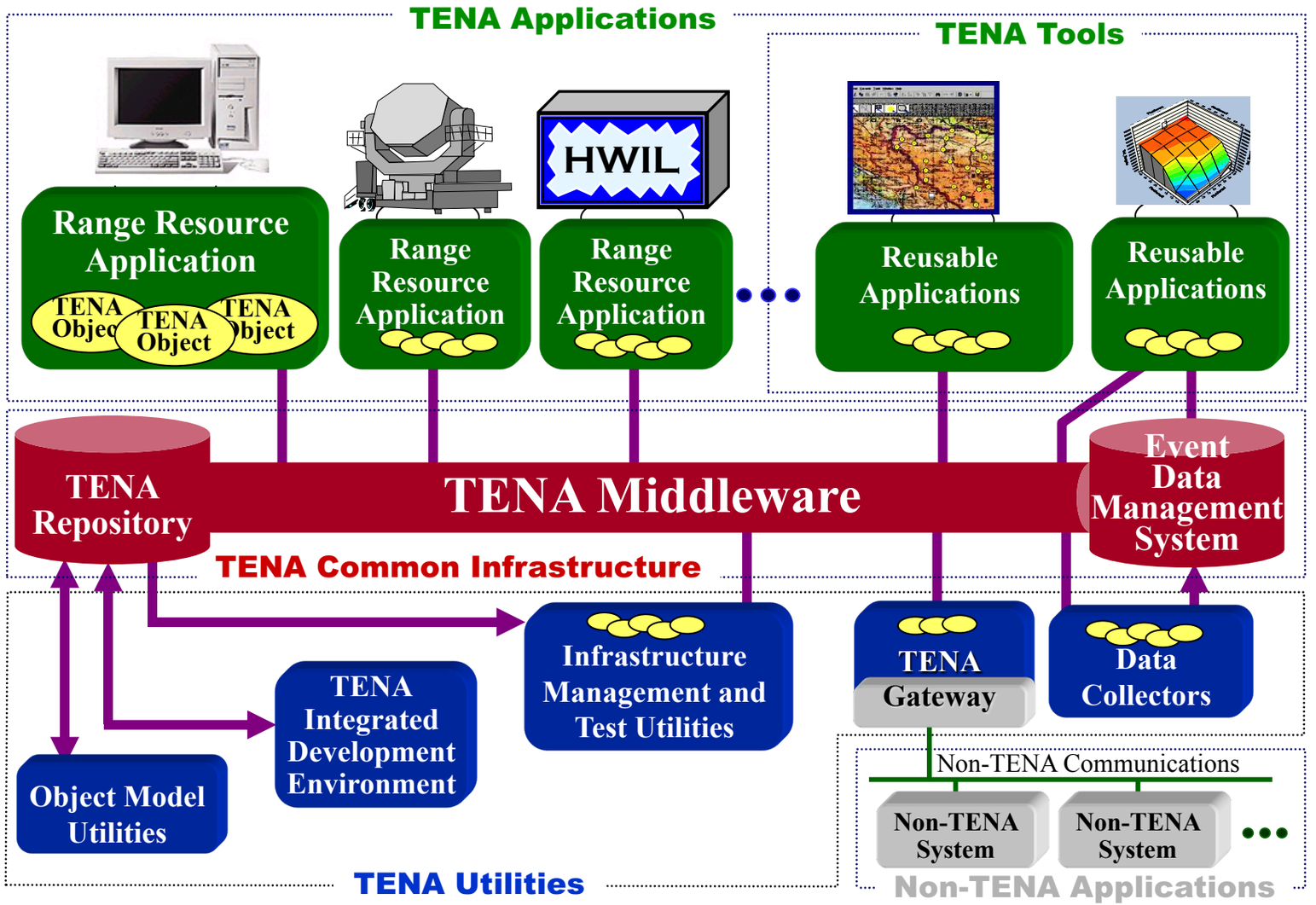
Test and Training Enabling Architecture

(TENA)

Core Architectural Tenets of TENA

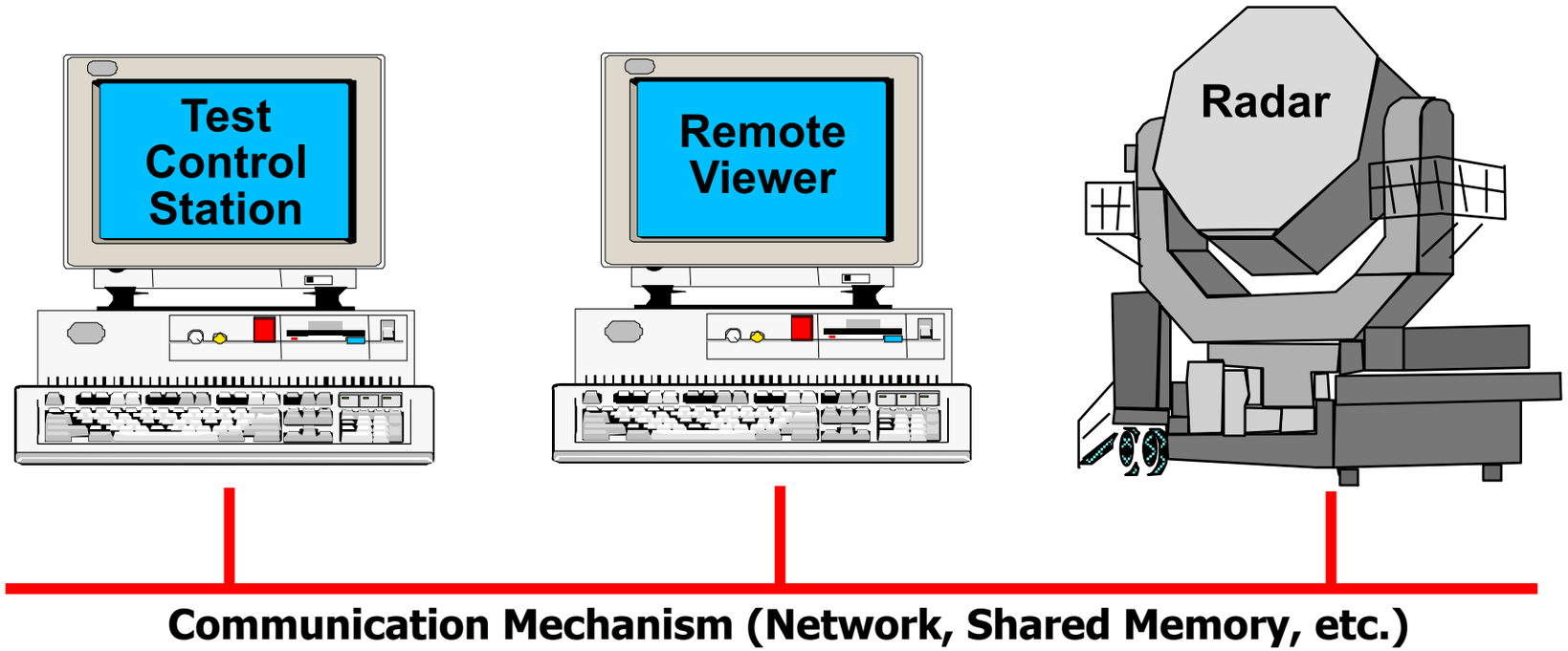
- **Promote Computer Enforceable System Interfaces**
- **Use Auto-Code Generation to Raise the Abstraction Level**
- **Let Computer Detect Interoperability Errors as Early as Possible**
- **Design the Middleware to Make it Hard to Use Wrong**
- **Anticipate Better Techniques and Technologies**
- **Emphasize Live-Virtual-Constructive Interoperability**

TENA Architecture Overview



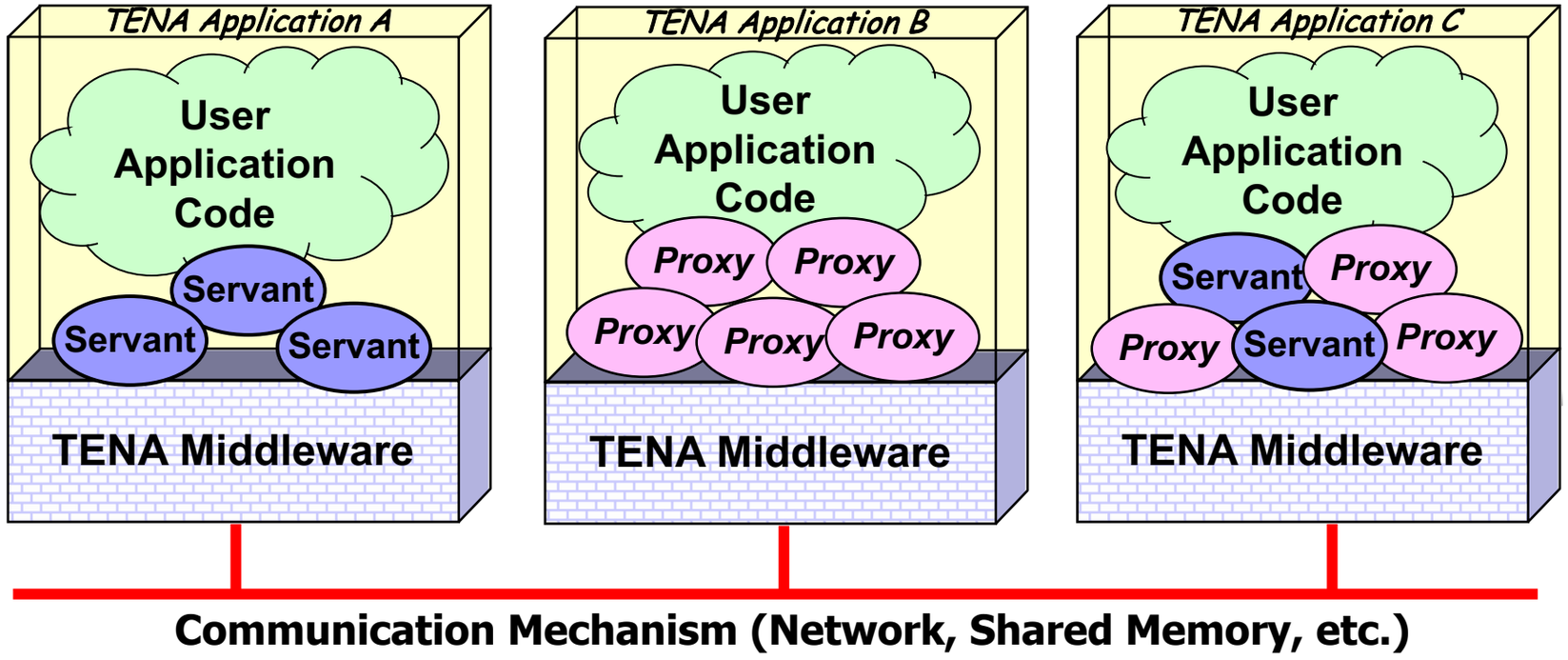
Logical Range
Simple Example

TENA specifies an architecture for range resources participating in logical ranges



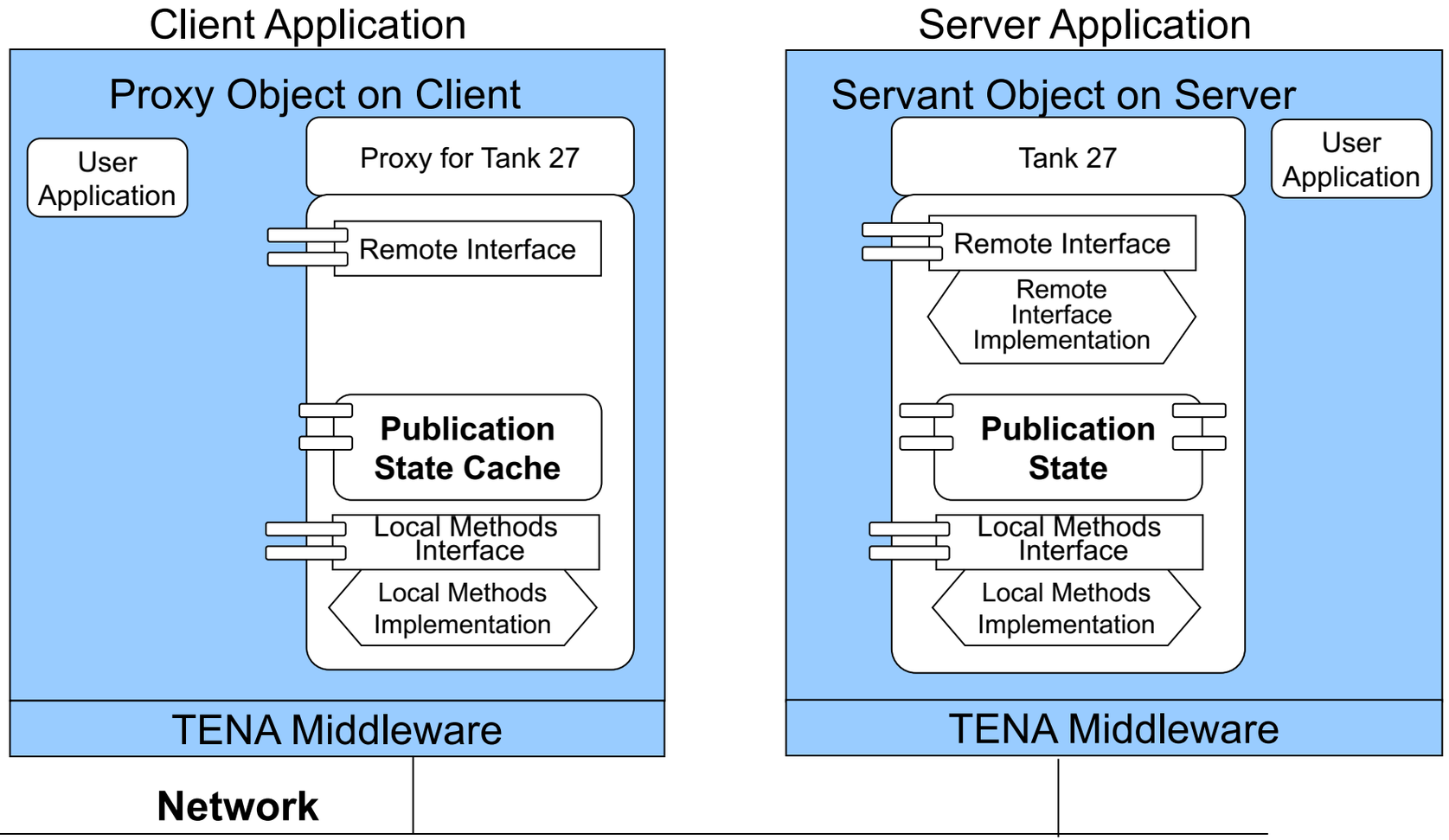
Logical Range
Simple Example

- TENA specifies a peer-to-peer architecture for logical ranges:
  - Applications can be both clients and servers simultaneously
  - In their role as servers, applications serve TENA objects called "servants"
  - In their role as clients, applications obtain "proxies," representing other applications' servants. Only servers can write to their servant objects' publication state
- The TENA Middleware, the TENA objects, and the user's application code are compiled and linked together



Clients and Proxies, Servers and Servants

- **A proxy is a read-only stand-in for a servant**
- **Proxies are obtained as a result of subscription**



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 the Interface Definition Language 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++

How hard is it to create a new TENA Object Model?

1. Name the object model, including the version

2. Define the message or object types needed by the application

3. Define the attributes that characterize the messages and objects

4. Determine if any attributes are constant or optional

5. Define any remote or local methods

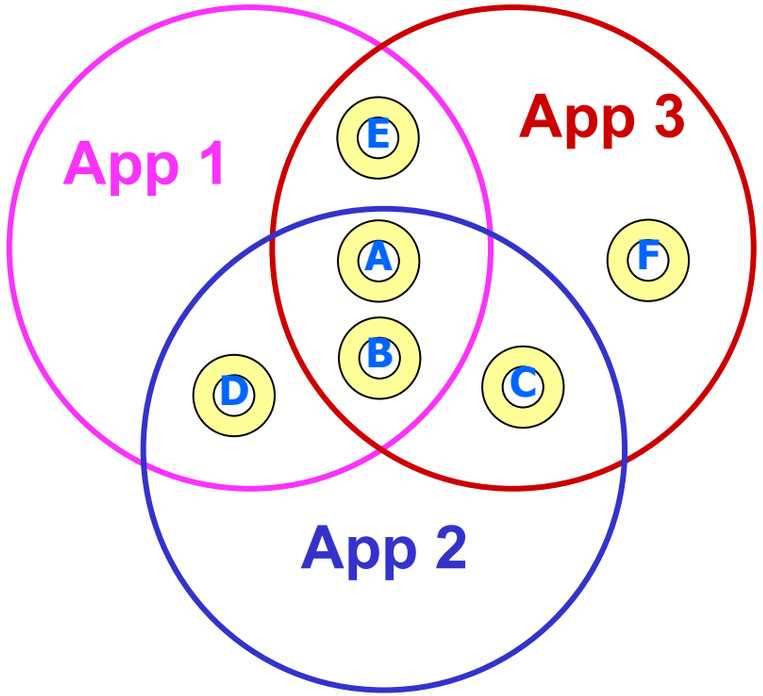
```
  file Example-Vehicle-v6.tdl
package Example {
  enum Team {
    Team_Red,
    Team_Blue,
    Team_Green };

  class Vehicle {
    optional string name;
    const Team team;
    float64 xInMeters;
    float64 yInMeters;
    driveTo (float64 xInMeters,
             float64 yInMeters);
  };
};
```

TENA has a powerful meta-model for defining expressive object models, yet descriptive models are easy to create

The Logical Range Object Model

- **Logical Range Object Model (LROM)**
  - Those object definitions, derived from whatever source, that are used in a given logical range execution to meet the immediate needs and requirements of a specific user for a specific range event
- **The LROM is the common object model shared by all TENA resource applications in a logical range**
- **Applications do not have to be linked against every object model in the LROM—only those the application cares about**



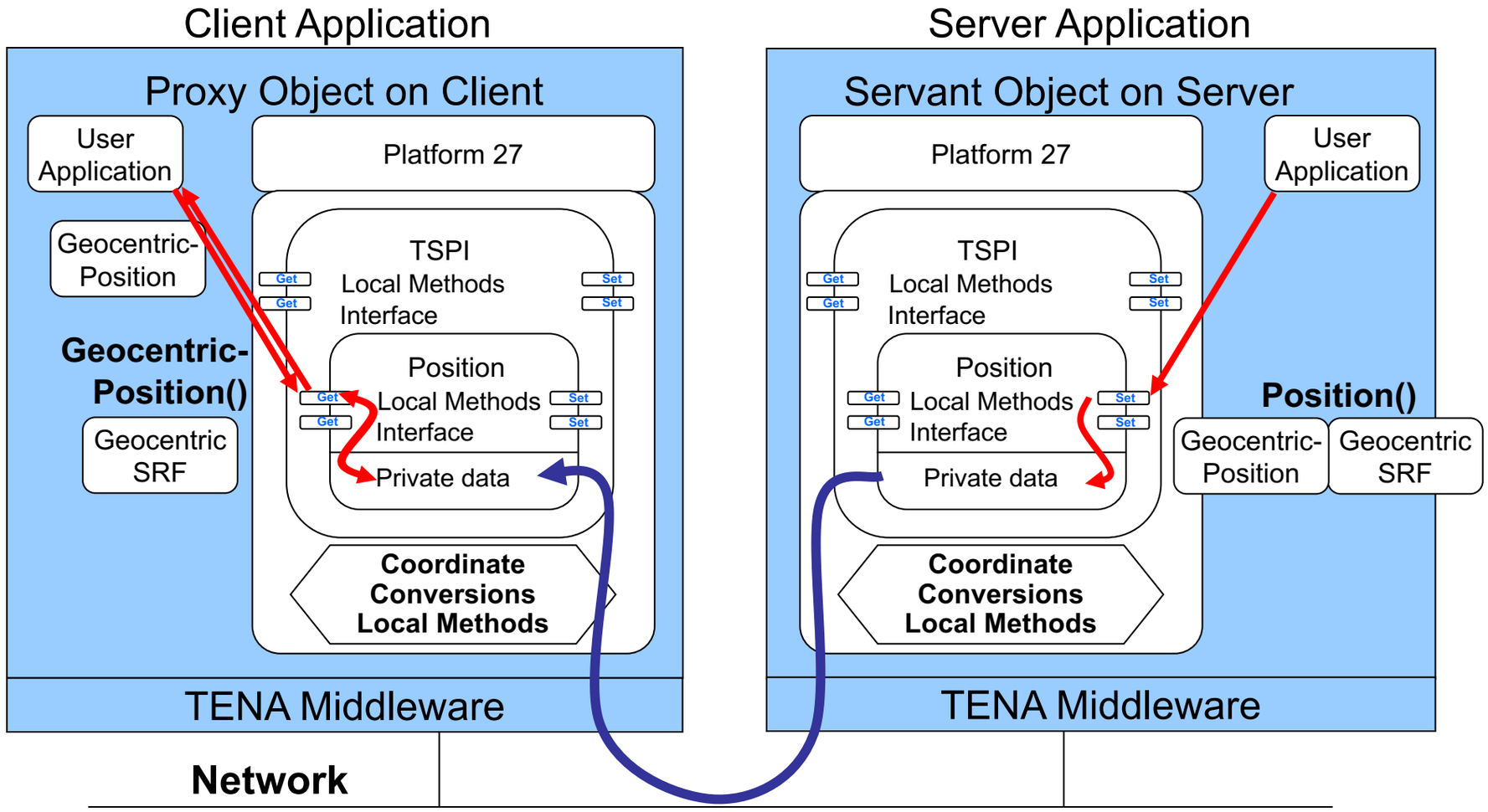
TENA Standard Object Models:

A Common Set of Data Definitions for the Entire Range Community

- **Platform Related**
  - TENA-Platform-v4
  - TENA-PlatformDetails-v4
  - TENA-PlatformType-v2
  - TENA-Embedded-v3
  - TENA-Munition-v3
  - TENA-SyncController-v1
  - TENA-UniqueID-v3
- **Time-Space Position Information (TSPI) Related**
  - TENA-TSPI-v5
  - TENA-Time-v2
  - TENA-SRFserver-v2
  - TENA-Pointing-v1
- **JNTC OMs (for Training)**
  - JNTC-AirRange-v2
  - JNTC-CounterMeasure-v2
  - JNTC-IndirectFire-v2
  - JNTC-Instrumentation-v2
  - JNTC-NBC-v2
  - JNTC-ObstacleMinefield-v2
  - JNTC-Threat-v2
- **Others**
  - TENA-AMO-v2
  - TENA-Engagement-v4
  - TENA-Exercise-v1
  - TENA-GPS-v3
  - TENA-Radar-v3
- **In Progress**
  - Range Instrumentation OM Suite
  - TENA-AVstream
  - TENA-LiftoffDetector
  - TENA-Link16
  - TENA-PowerController
  - TENA-SpectrumAnalyzer
  - TENA-Telemetry
  - TENA-Waypoint
  - TENA-Weather
  - TENA-LVC-Emitter
  - Additional JNTC OMs for training

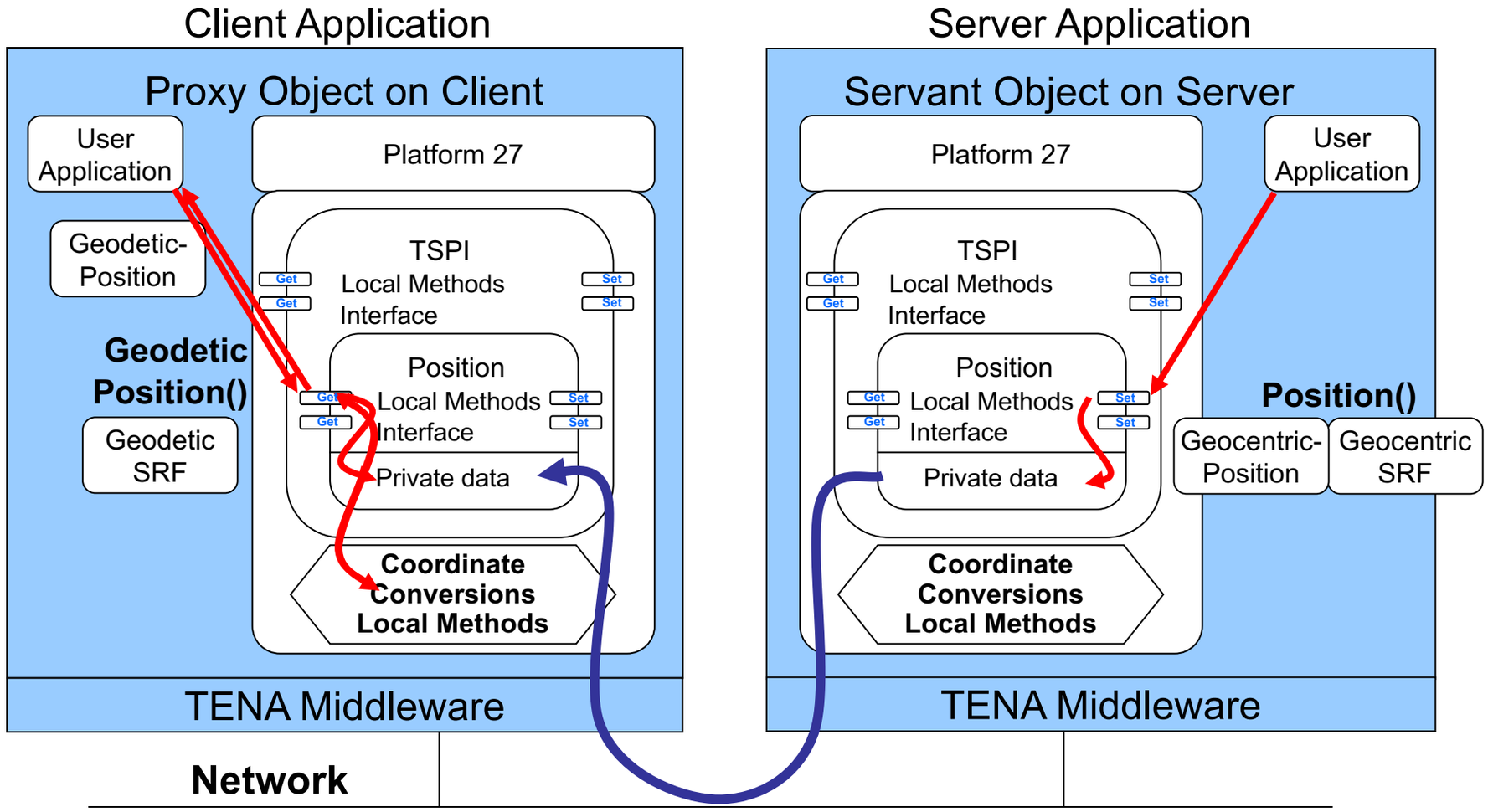
TSPI v4 with Coordinate Conversions

- **Case 1: Reading and writing in the same coordinate system**



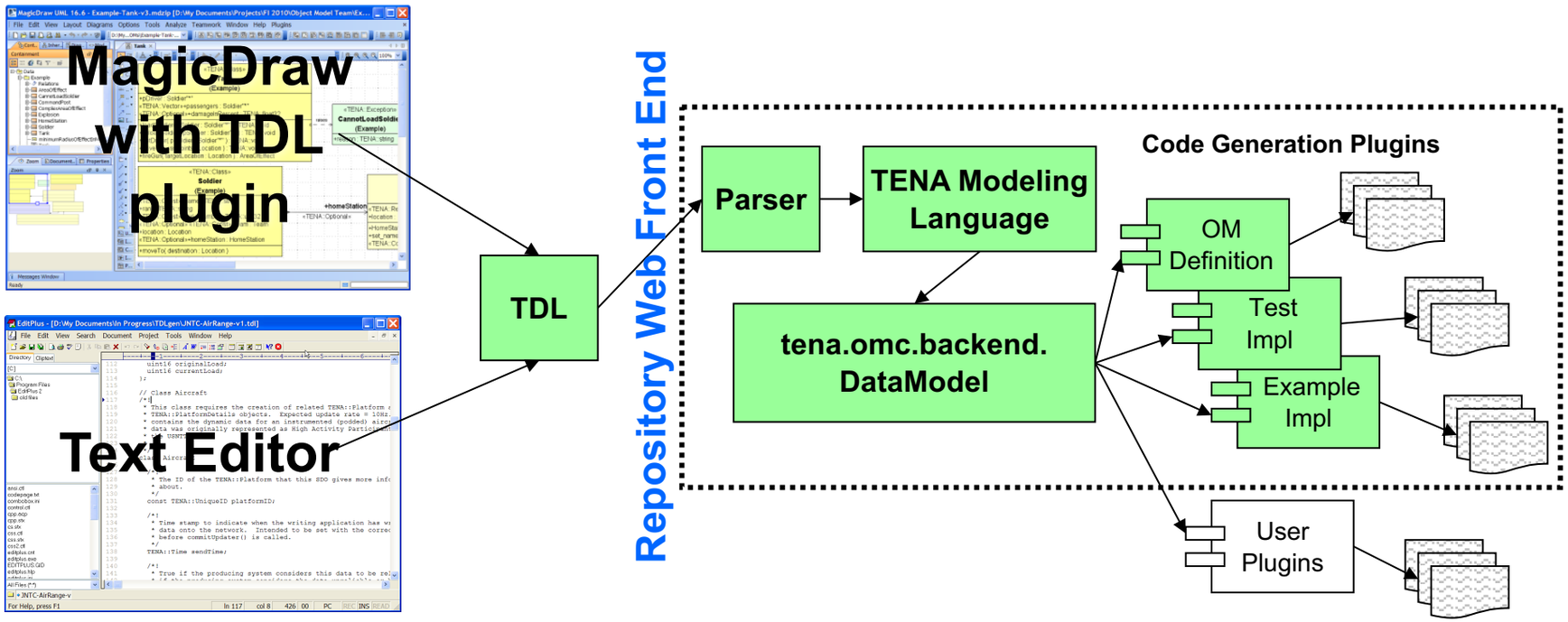
TSPI v4 with Coordinate Conversions

- **Case 2: Reading and writing in different coordinate systems**
  - Write in Geocentric (ECEF), read in Geodetic (latitude/longitude/altitude)



Auto-Code Generation With TENA

- **Input to the TENA auto-code generator is in a standard form (TDL generated from UML)**
  - Use MagicDraw plug-in to create TDL from UML
- **API and framework available to support various "code generation plugins" used to automatically create specialized code based on FreeMarker templates**



TENA Repository

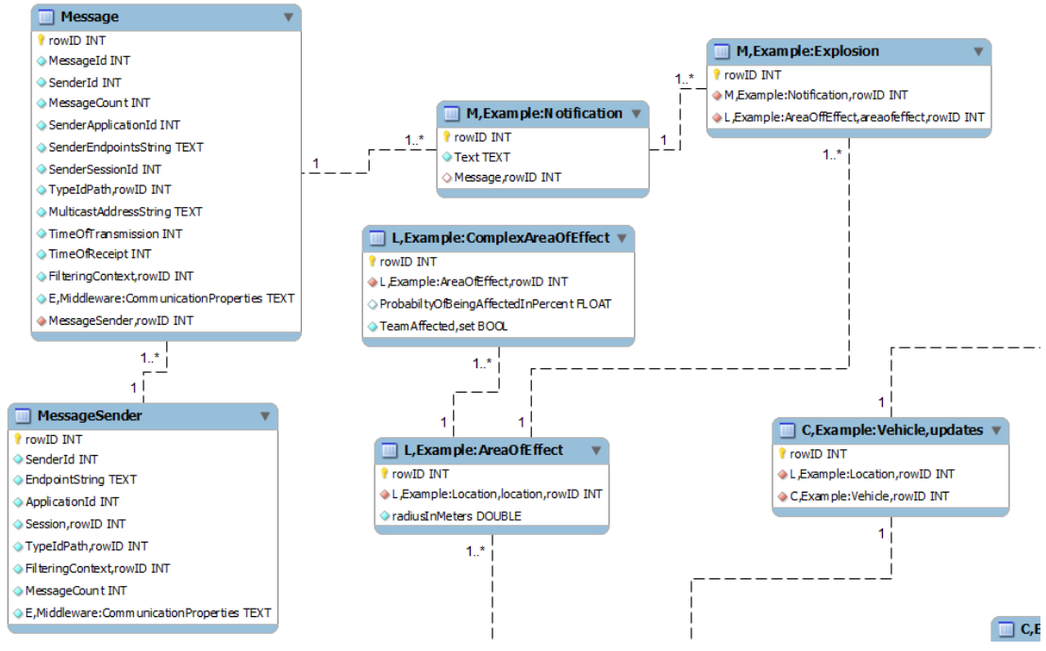
- **Purpose: to contain all the information relevant to TENA that is not specific to a given logical range**
- **Current Repository Contents:**
  - All TENA Object Models, both standard and user-designed
  - All TENA software (middleware, helpdesk cases, tools, gateways, reusable applications, and reusable components)
  - All TENA documentation
  - Lessons learned from previous uses of TENA
  - Provide an easy-to-use secure interface to all of this information
- **The Repository is a collection of technologies based around a wiki-like front end**

TENA Middleware Purpose and Requirements

- **Purpose: high-performance, real-time, low-latency communication infrastructure used by range resource applications and tools during execution**
- **Requirements:**
  - Support programming in C++, Java, .Net
  - Fully support TENA Meta-Model
  - Be easy to use and highly reliable
  - Many varied communication strategies and media
    - Including management of quality-of-service
    - Including object-level security services
  - Be high-performance, including
    - Support multiple information filtering strategies
    - Support user-defined filtering criteria
  - Support a wide variety of range-relevant platforms (HW/OS/compiler)
  - Be technology neutral

TENA Data Collection System Purpose and Requirements

- **Called TENA Data Collection System**
- **Supports**
  - Collecting arbitrary Object Model information
  - Contains data viewer
  - Contains playback capability
- **Currently works with MySQL and SQLite database systems**
  - Database schema follows the structure of the object model, with separate table for each object and message type
- **Separate Data Collector Application**
  - Export to Excel for viewing
- **Playback application**



Platforms Supported in Middleware Release 6.0.5.1

- Linux Fedora 24
- Red Hat Enterprise Linux 6.4
- Red Hat Enterprise Linux 7.2
- Linux Centos 6.8 32/64-bit
- Linux Centos 7.2 64-bit
- Ubuntu 16.04.1
- Mac OS X 10.11
- macOS 10.12
- Windows Vista (SP2)
- Windows 2008 Server 64-bit (R2 SP1)
- Windows Server 2012 R2, 64-bit
- Windows 7 SP1, 32/64-bit
- Windows 8.1 32/64-bit
- Windows 10, Visual Studio 2015, 64-bit
- Windows Server 2016

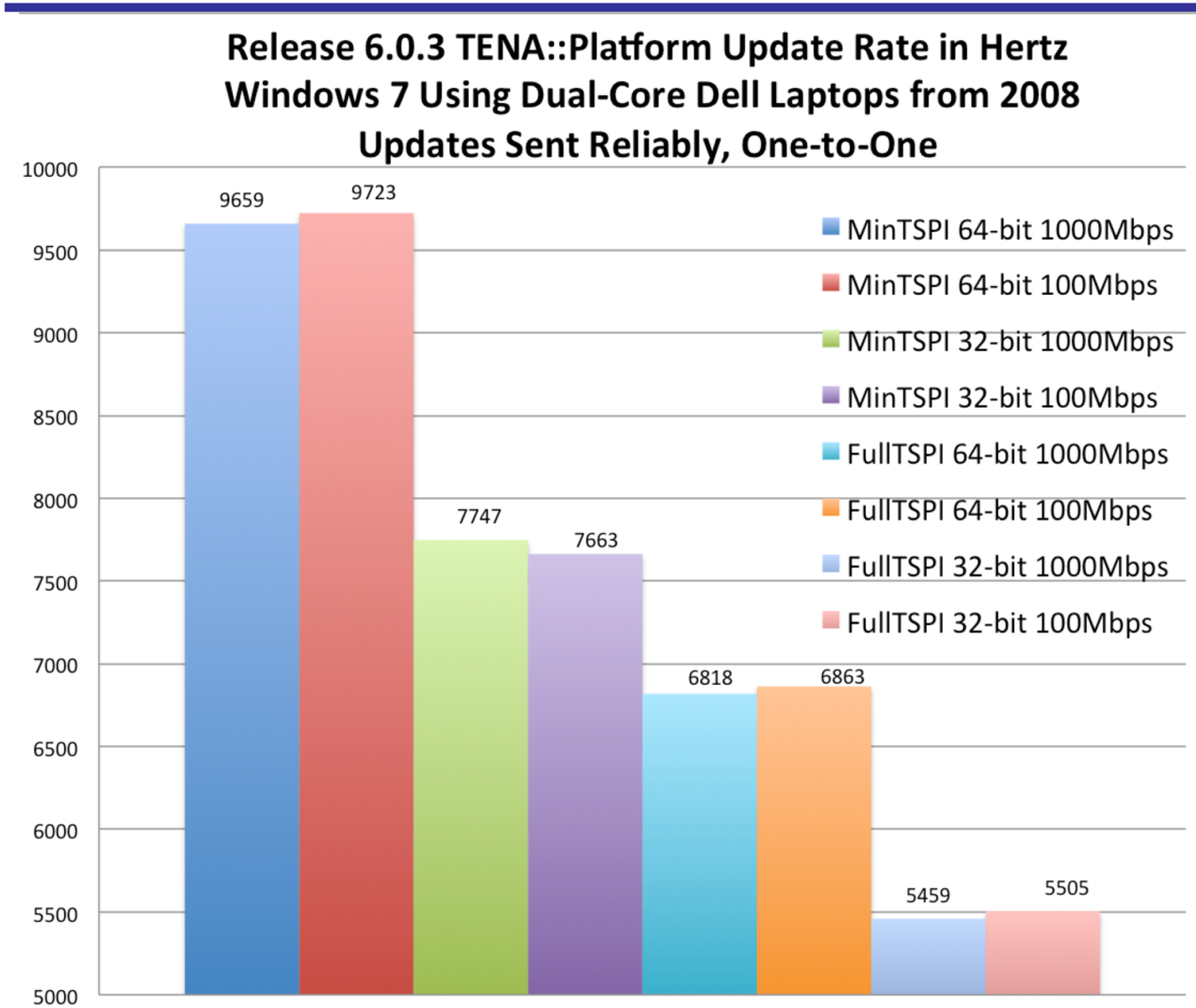
Will TENA meet my performance requirements?

- **Users are encouraged to conduct experiments by customizing the auto-generated example programs to be representative of actual systems**
  - Use actual object models, computers, and networks
- **Primary requirement for TENA is to support high performance, real-time distributed communication**
  - TENA uses compiled code to avoid interpretive marshalling/demarshalling
  - Minimizes data copies, utilize single thread to perform network write, etc.

TENA enables test & training solutions

that are cheaper to build, field, maintain, and improve

TENA Performance
Update Throughput



- **Network data rate has virtually no effect on throughput here**
  - **Data size "on-the-wire" has no effect on throughput in these tests**
  - **Memory operations are dominant factor**
  - **64-bit memory operations used in 64-bit OS yields dramatic speed-up compared to 32-bit OS**

Update Rate vs. “Wiresize” Trade-off

(As Demostrated by the TRCE Program)

	TENA 6.0.0 (Reliable)	TENA 6.0.0 (Best Effort)	TRCE LNC (No Compression)	TRCE LNC (Lossy Compression)
Total Update Size	543 bytes	511 bytes	147 bytes (3.5 x)	98 bytes
Update Rate with 1 Publisher and 1 Subscriber	6,187 Hz	7,540 Hz	2,352 Hz (3.2 x)	2,549 Hz
Update Rate with 5 Publishers and 5 Subscribers	4,351[1] Hz	8,305 Hz	1,673 Hz (5.0 x)	1,884 Hz

- **TRCE demonstrated a reduction in “wiresize” for TENA-Platform-v4 updates by a factor of 3.5 to 5.2**
- **TRCE simultaneously demonstrated a reduction in throughput for TENA-Platform-v4 updates by a factor of 3.2 to 5.0**
- **Reducing the update “wiresize” reduced the update throughput**
  - All update rates are stated as the average over all subscribers
  - Tests performed with 100 Mbps link & switch

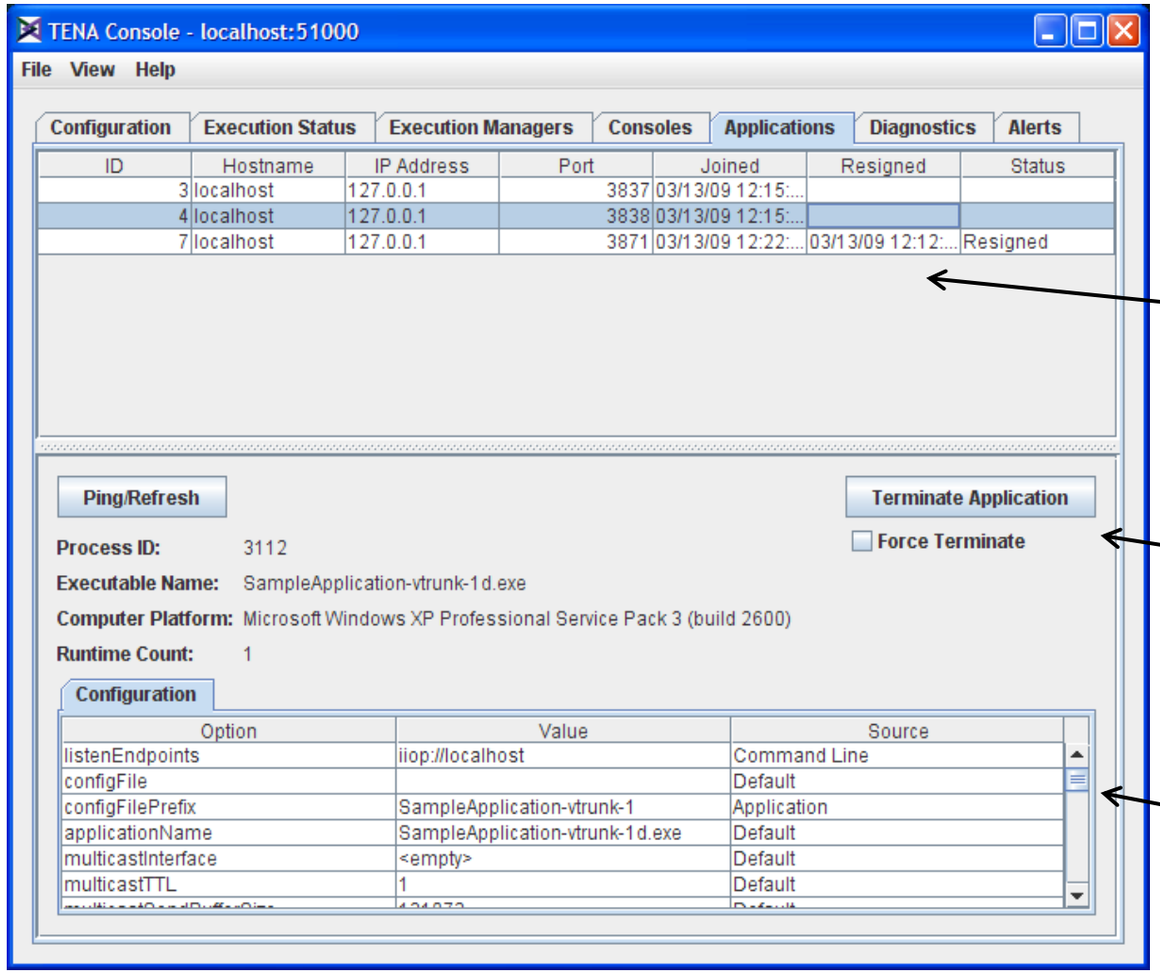
[1] TCP flow control taking place during test

TENA Means Free GOTS LVC Tools (Partial List)

- **TENA Utilities—Making TENA easier to use**
  - TENA Repository (automated software building, community source code collaboration)
  - TENA Wiki (website collaboration for user groups)
  - TENA Issue Tracking System (task tracking system for user groups)
  - TENA Installer (cross platform software installation)
  - MagicDraw Plugin (converts UML diagrams in object model TDL syntax)
- **TENA Tools—Helping you conduct and manage your event**
  - TENA Middleware (C++, Java, .NET support for ~50 computer platforms)
  - TENA Console and Canary (event management and network monitoring)
  - ClearPath (multicast network testing)
  - TENA Data Collection System (collector, database export, and playback tools)
  - Interface Verification Tool (Platform generator to support testing activities)
  - Web Binding (provides JSON/REST http interface to TENA systems)
  - RelayNode (bridges different communication domains)
  - SIMDIS TENA Plugin (3D visualization and analysis support for TENA object models)
  - TENA Video Distribution System (various tools related to video/audio stream support)
  - Mission Information Resource Controller (automated configuration for distributed systems)
  - Network Communication Tools (chat, file transfer, etc.)
  - SimShield Trusted Guard (Cross Domain Solution supporting many object models)

TENA Console
Application Status Screenshot

- **TENA Console is a GUI-based event management tool used to evaluate and monitor applications and network**



- **Application Diagnostics**
- **Network Monitoring**
- **Application Alerts**

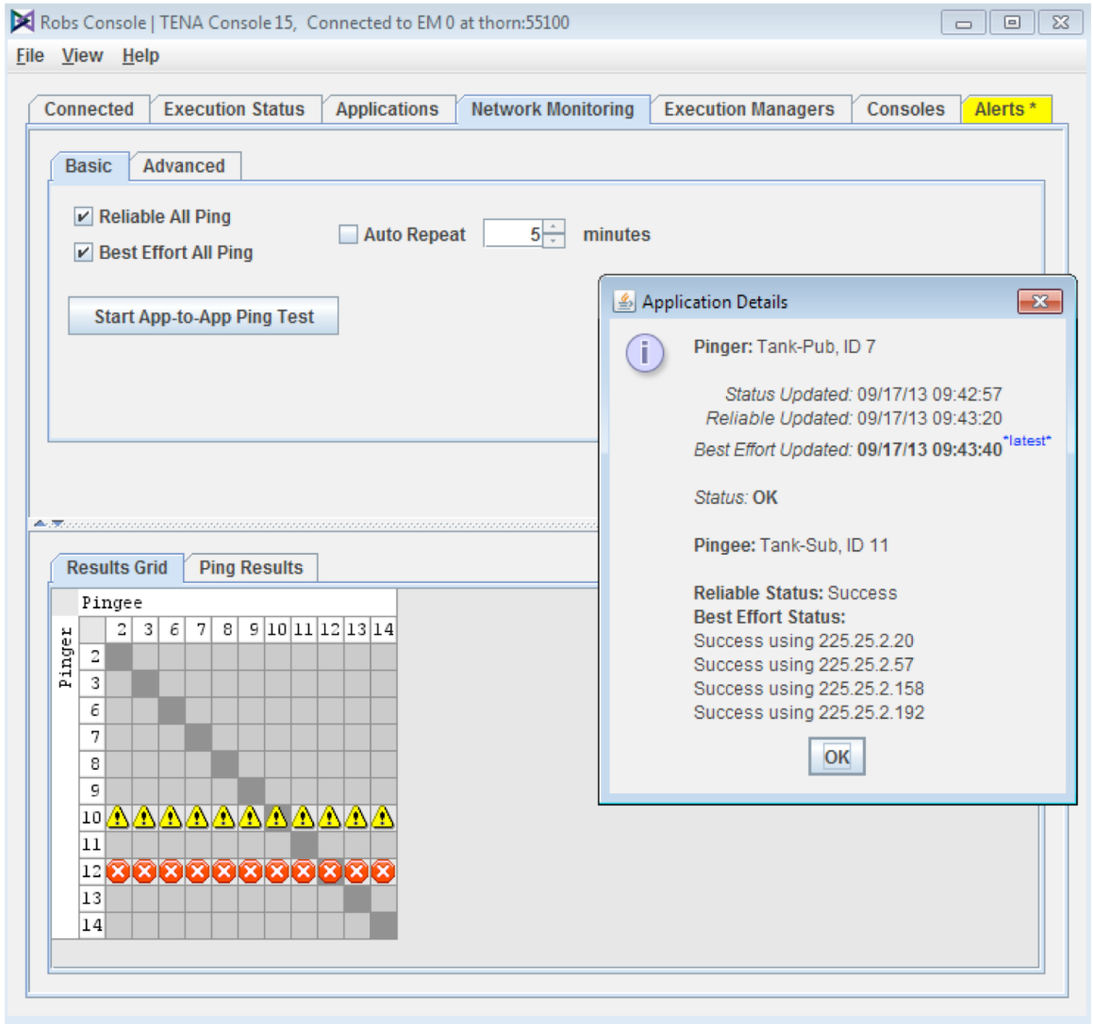
Basic application information provided in table

"unresponsive" applications can be removed from the execution

Application configuration parameters listed to indicate use of non-default values

TENA Console
Network Monitoring

- **Network Monitoring**
  - Perform continuous TCP and UDP multicast communication monitoring
  - Obtain system alerts regarding the operation of the distributed event over the network

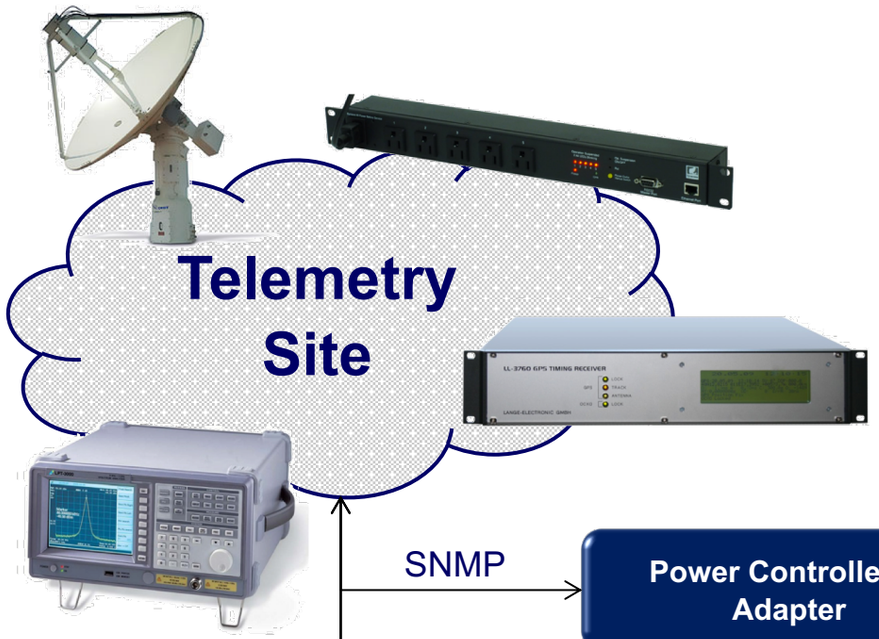


How do we integrate TENA into an existing environment?

- **Gradual and Overlapping Deployment**
  - TENA can be introduced into an existing environment in a gradual manner
  - Existing systems will typically require Adapters
- **Adapters for Existing Protocols and Systems**
  - TENA Adapters are built in a collaborative manner following a common software framework (with code generation) to create a library.
  - Adapters allow the range system information and services to be available using common system interfaces and distributed communication infrastructure without changing the code to the existing systems
- **Redundancy during Testing**
  - Since existing range systems are not modified, the use of adapters permits side-by-side initial testing and operational deployment to minimize risk

TENA can be introduced to a range gradually and unobtrusively using Protocol and System Adapters

Adapter Illustration



SNMP → Power Controller Adapter

VISA → Spectrum Analyzer Adapter

TCP proprietary → Telemetry Antenna Controller Adapter

VISA → Telemetry Receiver Adapter

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Range Instrumentation Network

- Event Management Tools
- Remote Configuration Control
- Remote Operator Station(s)
- Range Supervisor Station(s)
- Data Collection, Analysis, & Playback
- Data Visualization Tools

Where Do Adapters Make Sense?

- **Purpose of Adapters**
  - Enable an existing range system to use TENA without modification
  - Permit side-by-side testing/operation of Adapters with existing range protocols
- **Typical Range System Use Cases that Benefit from Adapters**
  - Legacy range systems that can't be updated
  - Commercial system with proprietary interface
  - Systems without network communication
- **Needed Capabilities obtained with Adapters**
  - Remote Monitoring and Control that can support multiple operators and supervisors
  - Operator efficiency improvements with ability to support multiple systems
  - Integrate a non-networked system into a common communication environment
  - Bring a legacy system into compliance with Information Assurance (IA) requirements
  - Support coordinated data collection in support of Range Characterization activities

More info here: https://www.tena-sda.org/display/Adapters

TENA Adapters

- **Adapter Configurations**
  - Adapters have a single purpose (i.e., convert protocols), intended to operate as a computer service
  - Nominally configured as a stand-alone process capable of running on separate computer
- **Adapter Benefits**
  - Promotes common interfaces for range systems to increase interoperability and reuse
  - Avoids having every range system develop and maintain duplicate protocol communication mechanisms
  - Developing Adapters using common blueprints reduces development and maintenance costs
- **Adapter Library**
  - TRMC is performing collaborative development with multiple test ranges to develop Adapters that convert existing range system protocols into common Object Models
  - A Library of Adapters is maintained in a central repository with backend infrastructure
  - Adapters have been used to facilitate distributed communication change with WSMR RTDPS and FPS-16 radars through multiple tests that have compared performance (latency, latency jitter) and data integrity

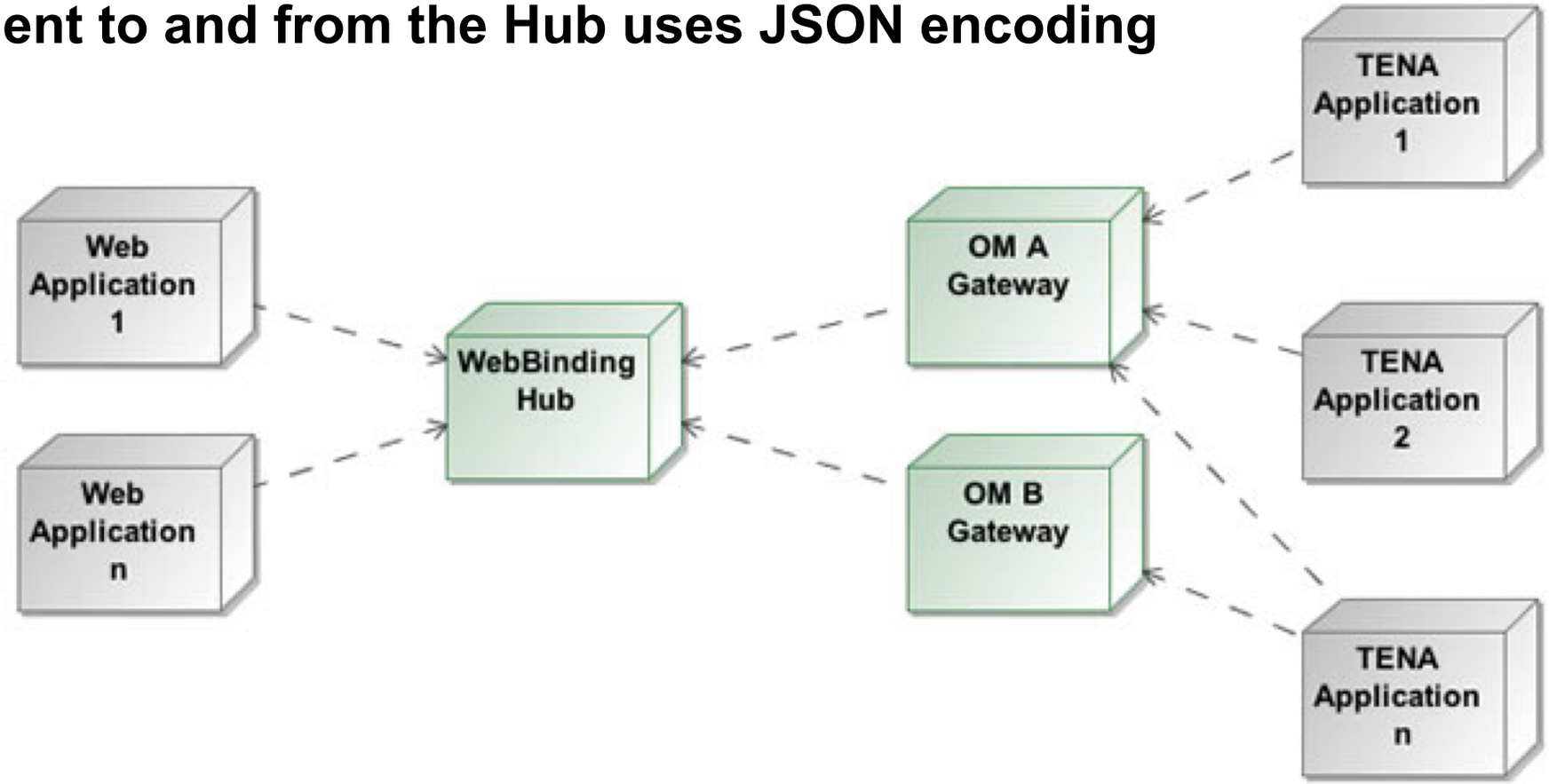
Current
Range System Adapters

- FPS-16 Radar (WSMR network protocols)
- iBootBar Power Strip Controller
- IRTS (Yuma real-time data processing system)
- IVTS (Yuma GPS System)
- LPT Spectrum Analyzer (LP Technologies 3000, 6000)
- MPS-25 Radar (Yuma network protocols)
- MRTE (WSMR real-time data processing system)
- Multiple Object Tracking Radar (WSMR network protocols)
- RDDS (Pax. River message protocol) Common TSPI
- RTDPS (WSMR real-time data processing system)
- SEMCO R600A Telemetry Receiver
- Smartronix 5000 Decommutator
- TCS 600 Telemetry Antenna Control Unit
- TCS M1L Telemetry Antenna Control Unit

Collaborating with vendors on developing Range System Adapters for their products is important

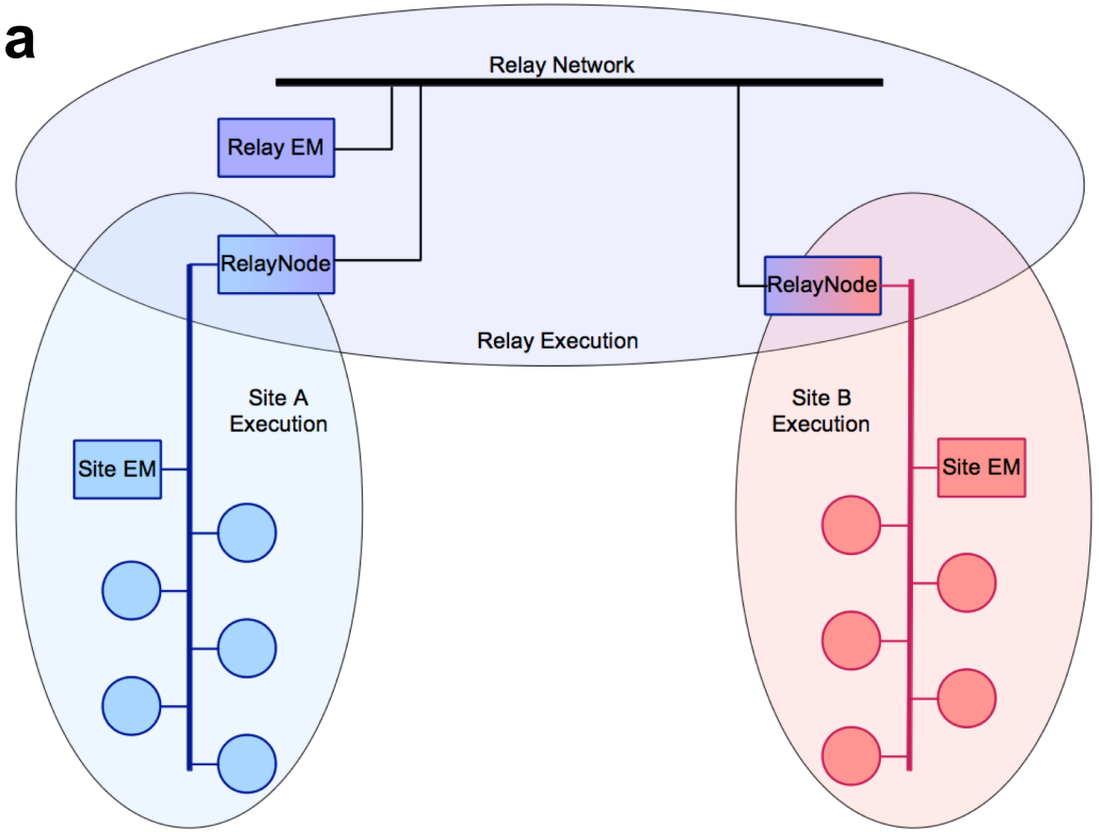
Other TENA Integration Methods: Web Binding

- **Web Binding is automatically generated based on object model**
- **Hub provides REST API to web clients to perform middleware operations (e.g., subscribe to type Vehicle and obtain updates)**
- **TENA data sent to and from the Hub uses JSON encoding**



Other TENA Integration Methods: Relay Node

- **RelayNode is used to bridge two executions that may have different communication characteristics**
  - For example, one network segment may be for a low data rate link and an update would only need to traverse that link once, and then be replicated by the RelayNode to multiple subscribers
- **Illustration shows a typical scenario with a single WAN execution and multiple LAN executions**



TENA Information Assurance (IA) Activities

- **Air Force Evaluated/Approved Product List (E/APL) – approved 11/18/10**
- **Navy Application & Database Management System (DADMS) – approved 6/27/11**
- **Army Certificate of Networthiness (CoN) – approved 5/22/12**
- **S/DREN (Secret/Defense Research and Engineering Network) – approved**
- **NIPRnet – obtained ATO 12/27/12**
- **DIACAP – approved**
- **Cross Domain Solutions**
  - TENA is used with Radiant Mercury cross domain guard for bridging information associated with certain Common Training Instrumentation Architecture (CTIA) events
  - TENA-enabled Cross Domain trusted guard SimShield v2.2.0.1 on baseline list
  - Currently working with J7 with the GOTS DTNG (Distributed Training Network Guard) product to integrate TENA and is planned to be certified and accredited in the FY2014/15 timeframe

The TENA project is working with IA organizations to reduce cost and delays with ability to operate TENA applications

The Joint Mission Environment Test Capability

(JMETC)

The JMETC Mission

JMETC provides the robust distributed infrastructure (network, enterprise resources, integration software, tools, reuse repository) and technical expertise to integrate Live, Virtual, and Constructive (LVC) systems for test and evaluation in Joint Systems-of-Systems and Cyber environments.

You Worry About Your Test…
JMETC Worries About the Infrastructure

JMETC Benefits Acquisition Programs, Testers, & Evaluators

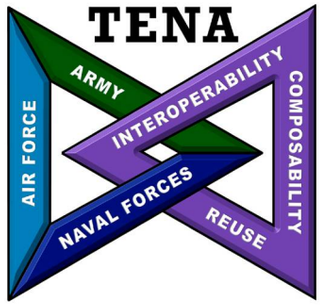
- **Enables early verification that systems work in Joint and Cyber contested environments**
- Provides access to **high-demand, low availability systems**
- **Provides access to cyber ranges**
  - Ability to conduct unconstrained but nondestructive cyber activities in representative environments
- **Provides a collaborative engineering environment**
- **Supports all aspects of testing across the acquisition lifecycle**
  - Interoperability, cybersecurity, rapid fielding, DT, OT, etc.

Reduces Acquisition Cost, Schedule, and Risk

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

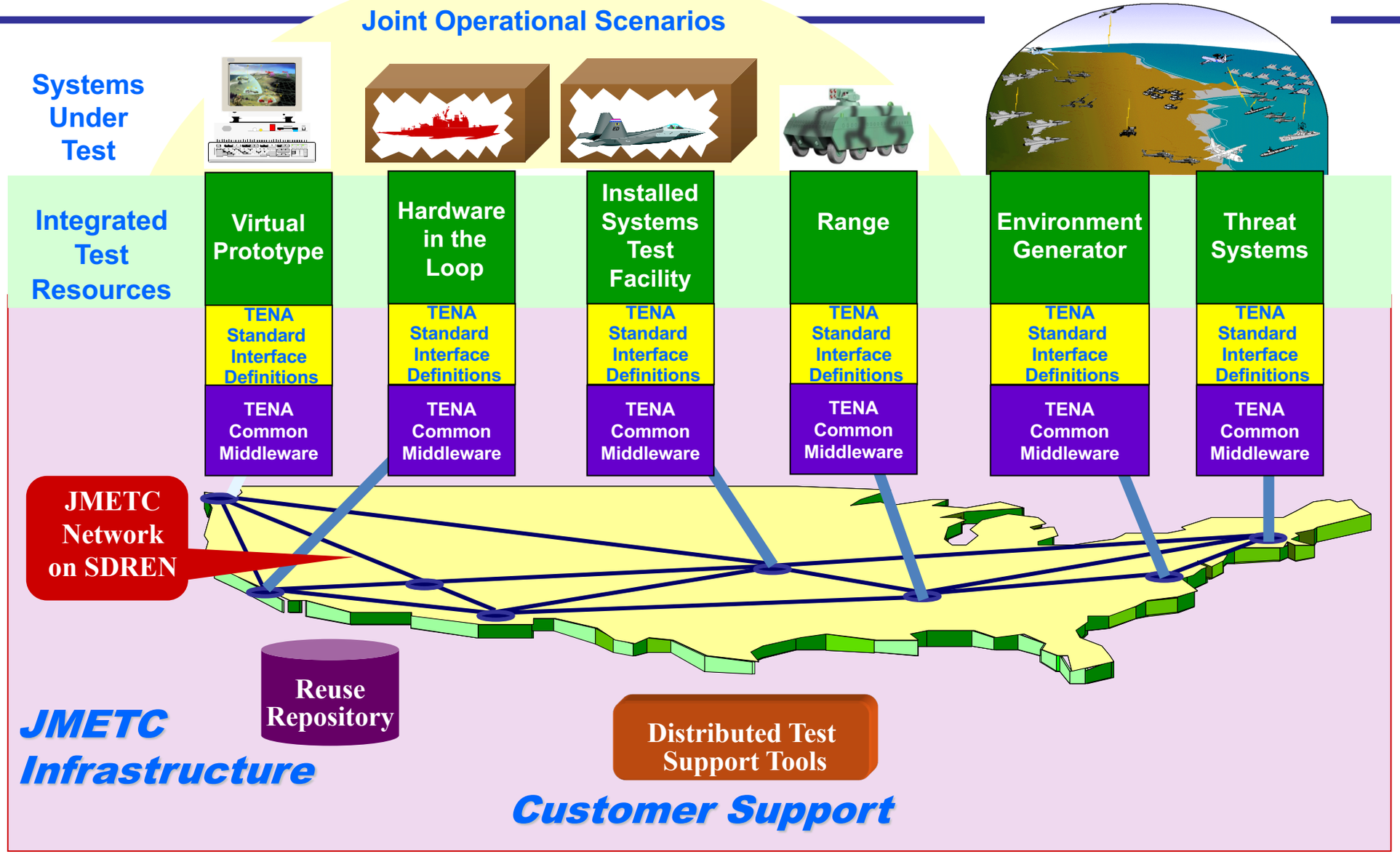
JMETC Networks Using DREN and SDREN



TENA Software, Object Models, Tools, Repository

- **Provides common joint testing process and customer support team for JMETC products and distributed testing**

JMETC Enables Distributed Testing



JMETC SECRET Network (JSN)

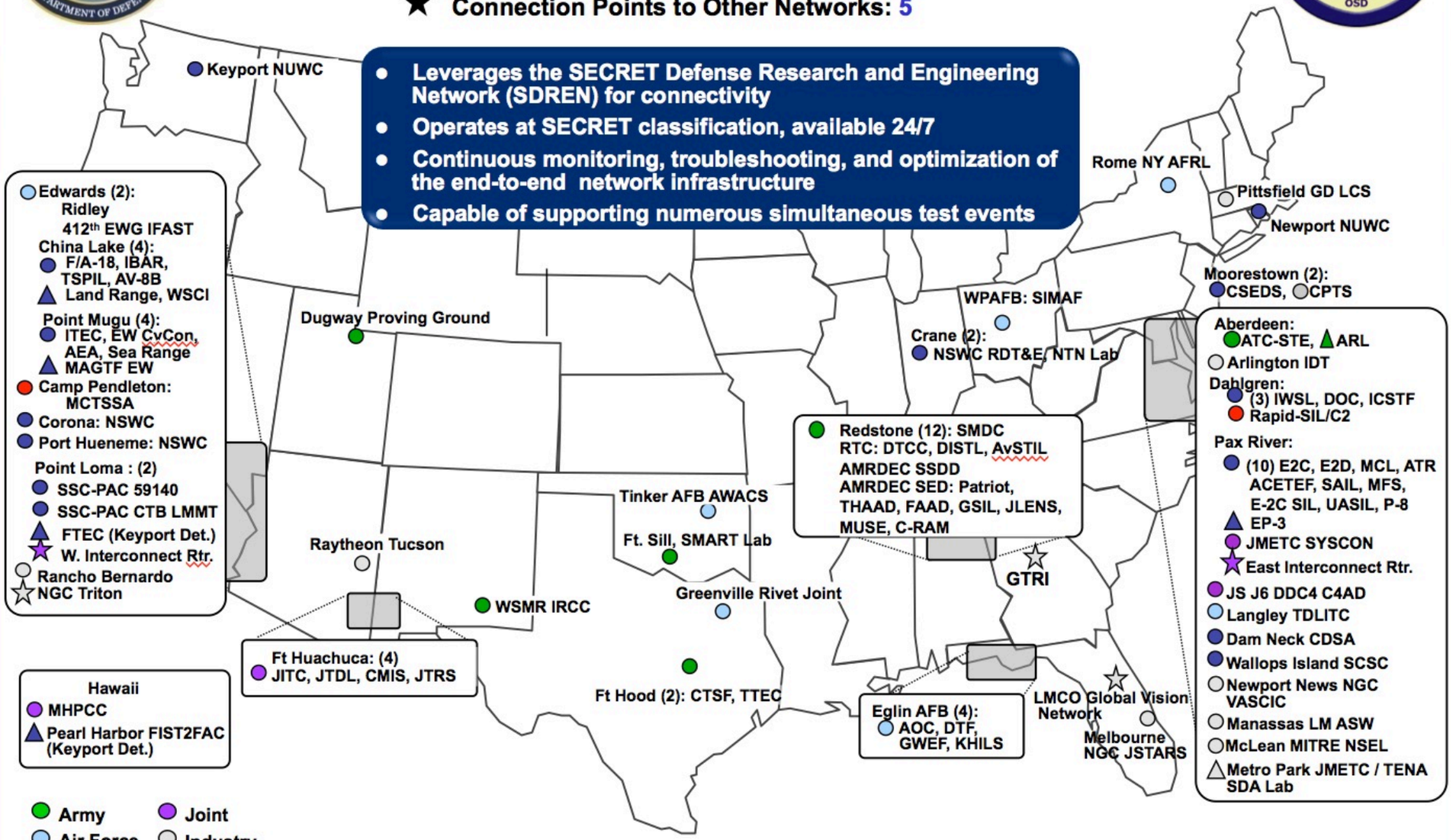
- **Focus is on persistent connectivity**
  - Standing Agreements
    - All sites have valid Authority to Operate (ATO) and Authority to Connect (ATC)
  - Daily full mesh, end-to-end network characterization ensure optimized performance
  - On demand usage with little to no coordination necessary
    - 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

Customers save time and money on infrastructure by leveraging JMETC

JMETC SECRET Network (JSN) Site Map

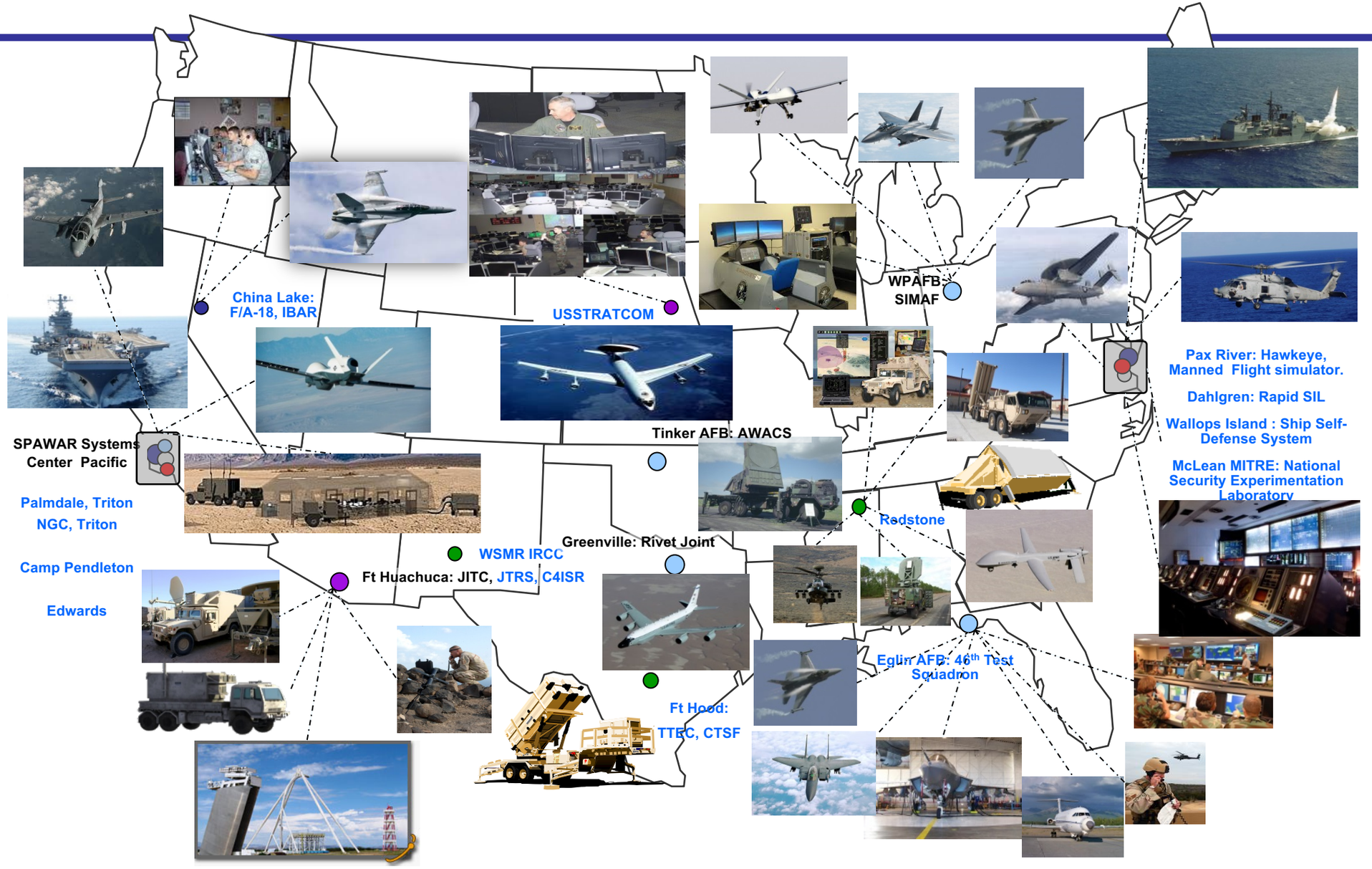
- Functional JSN Locations: 46 (access to 78 labs/facilities)
- Planned JSN Locations: 8
- Connection Points to Other Networks: 5

- Leverages the SECRET Defense Research and Engineering Network (SDREN) for connectivity
- Operates at SECRET classification, available 24/7
- Continuous monitoring, troubleshooting, and optimization of the end-to-end network infrastructure
- Capable of supporting numerous simultaneous test events

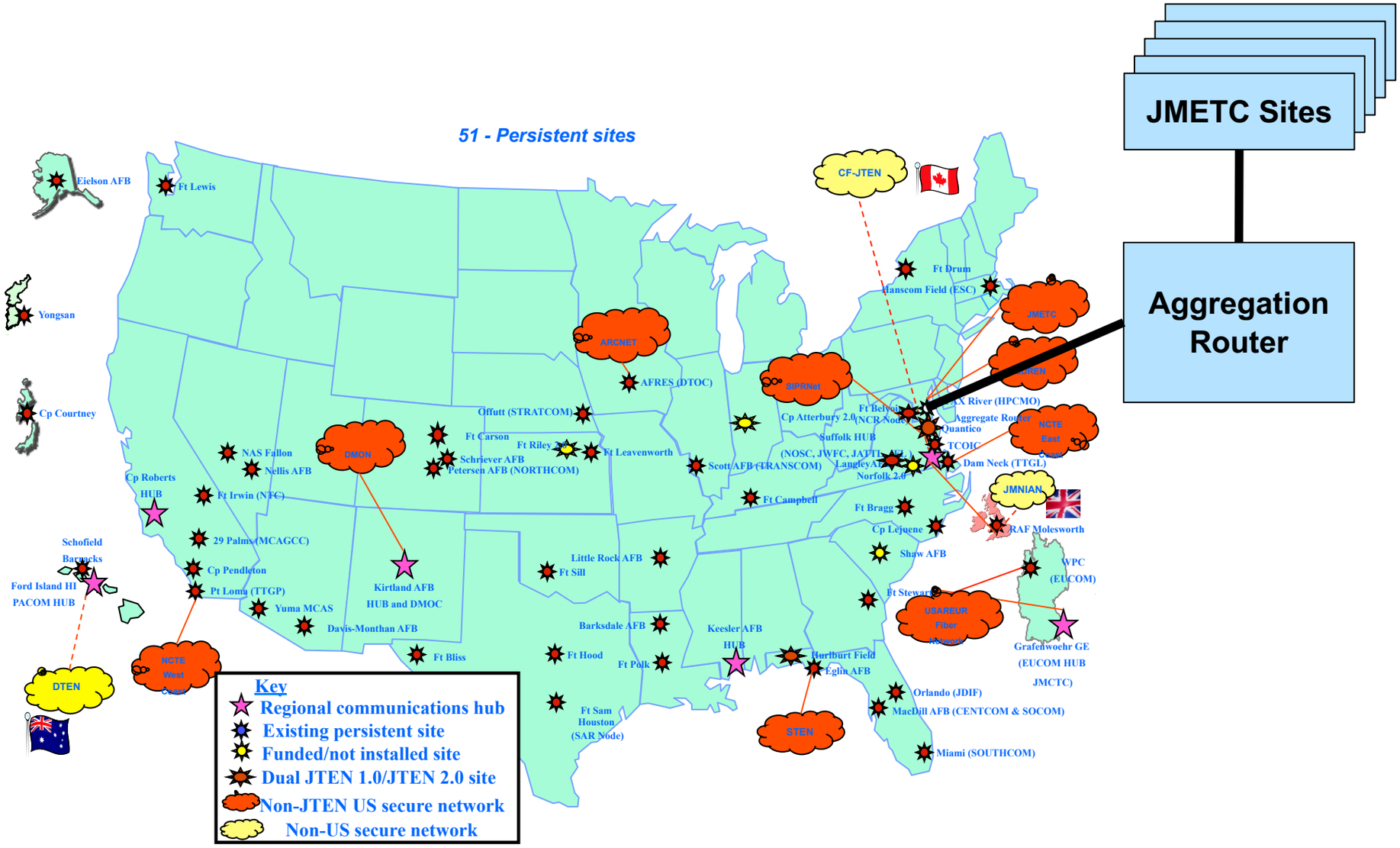


As of 12 May 2017

Sampling of Test and Training Assets Available on JSN



Current JTEN Sites Can Be Reached Through an Aggregation Router



Major JSN Events Supported

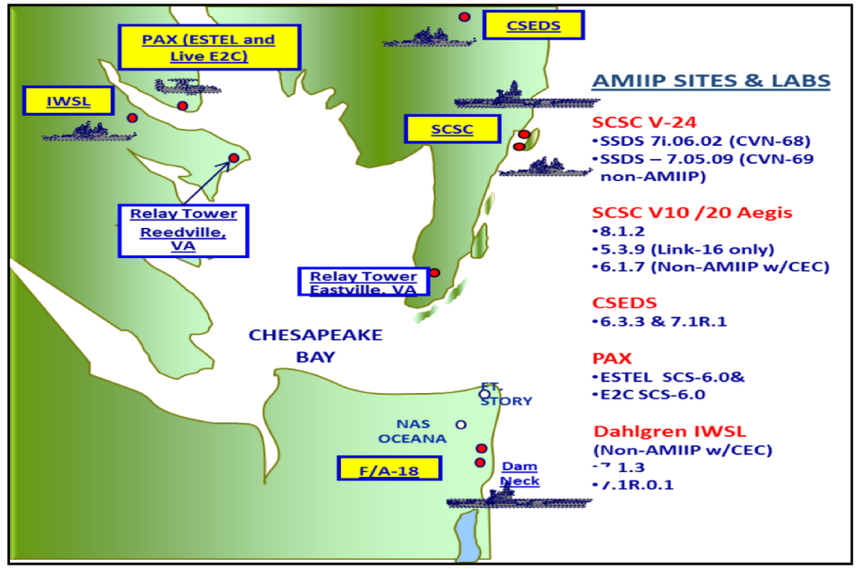
(June 2016 – May 2017)

Customer	Event	Execution Dates	Onsite Support
Navy	MQ-4C Triton	Ongoing	-
Air Force	Small Diameter Bombs II (SDB) Live Fly Testing	Sep-14 – Aug-16	-
Air Force	Air Force System Interoperability Test (AFSIT)	Jul-16 Feb-17 Apr-17	-
Joint	Joint Interoperability Test Command (JITC) Joint Interoperability Tests (JIT)	Jul-16 Oct-16 Jan-17 Mar-17	**Yes**
Navy	Distributed Integration & Interoperability Assessment Capability (DIIAC) V&V	Jun-16 Sep-16 Jan-17	**Yes**
Navy	Interoperability Development and Certification Testing (IDCT)	Aug-16 Nov-16 Apr-17	**Yes**
Joint	Air Ground Integrated Layer Exploration (AGILE) Fire IX	Jun-16 Aug-16	**Yes**
Joint	Joint Distributed IRCM Ground-test System (JDIGS)	Jun-16 Apr-17	-
Joint	Navy Integrated Fires	Jun-16 Nov-16	**Yes**
Joint	F-35 Joint Strike Fighter Record & Playback	Aug-16	**Yes**
Navy	Alpha Omega Live Virtual Constructive (LVC) Event	Sep-16	-
Joint	Undersea Communication	Jan-17	**Yes**
Navy	Digital Integrated Defense System (DIADS) Demo	Feb-17	-
Navy	Amethyst	Feb-17	**Yes**
Joint	Joint Integrated Air and Missile Defense Office (JIAMDO) Joint Distributed Engineering Plant (JDEP) Black Dart	Mar-17 May-17	**Yes**

JSN Event Example

Aegis "Accelerated Mid-Term Interoperability Improvement Project" (AMIIP)

- Assessment of interoperability improvements between Aegis and cooperative platforms
- Aegis Ship Self Defense Ship (SSDS) and Hawkeye E-2C Live Hardware-In-the-Loop systems in a full Cooperative Engagement Capability (CEC) net for a representative Battle Group environment.
- Addresses 4 of the "Big 6" Fleet interoperability issues
    1. Track ID / IFF
    2. Link Track Correlation
    3. TDL Filtering
    4. Link 16 / Link 11 Pairings
    5. Digital Air Control
    6. IFF Mode 5 Fielding
- 5 Sites, 9 Labs, 10 HWILs, Live Fly includes E-2C and F/A-18s
- JMETC supported distributed testing of systems is verified in follow-on live Sea Tests.

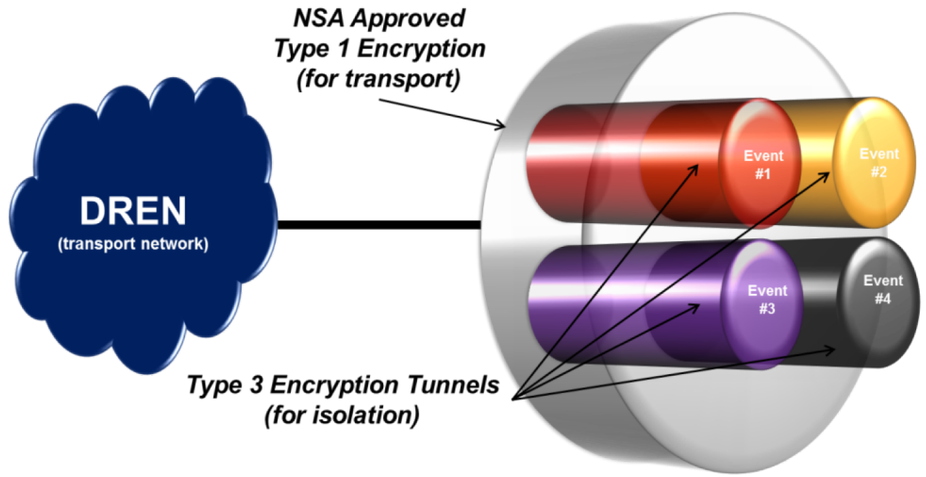


IMPACT

- Provided "unprecedented environment for Strike Group like testing"
- Testing efficiency, reduced risk & minimized costs to find/fix problems
- True "Test-Build-Test" rapid turnaround
- Moved data to the analyst versus moving analyst to the data

JMETC MILS Network (JMN)

- **Focus is on providing secure distributed testbeds to support unconstrained cyber activities and users access to enterprise resources at multiple classifications**
- **Employs Multiple Independent Levels of Security (MILS) architecture**
  - Allows for segregation of data streams by protocol, system, event, COI, etc.
    - Capable of supporting multiple simultaneous events at multiple classifications concurrently
    - Ability to create isolated "sandboxes"
  - Accredited by Defense Intelligence Agency (DIA) to operate from Unclassified up to TS//SCI
    - Included NSA Red Team assessment



Primarily Used for Cyber Testing

JMETC Network Options

Key Attributes		JMETC Secret Network (JSN)	JMETC MILS Network (JMN)
Access to Non-DoD Assets	Industry	X	X
	Academia	X	X
Bridge Kinetic and non-Kinetic Environments	Kinetic Assets	X	X
	Non-Kinetic Assets		X
Classifications Supported	SECRET NOFORN	X	X
	Up to & including TS/SCI		X
	Enterprise Coalition Capability		X
Non-Standard Configurations	Tactical IPs		X
	Non-Routable IPs		X
Performance	Full Mesh Network Architecture	X	X
	High BW/ Low Latency	X	X
Cloud Services	Access to Regional Service Delivery Points (RSDP's)		X
Non-Destructive Cyber Test Environments	National Cyber Range		X

JMETC Customers

Venues (Multiple Programs/Events)
JITC Joint Interoperability Test (JIT)
Air to Ground Integrated Layer Exploration (AGILE)
Accelerated Mid-Term Interoperability Improvement Program (AMIIP)
Air Force Systems Integration Test (AFSIT)
Joint Integrated Air & Missile Defense Organization (JIAMDO)
Network Integration Event (NIE)
Virtual Rapid Prototyping Lab (VRPL)

**Navy COTF OT Support

- **IDECM:** Integrated Defensive Electronic Countermeasures
- **AIM-9X:** Air Intercept Missile – 9X
- **AARGM:** Advanced Anti-Radiation Guided Missile

Acquisition Programs/PEOs	
Active	**Potential**
B-52 CONECT	F-35 Data Link
JSTARS	SDB-II
TRITON	AC-130J
P-8A INC III	JMS
AIM-9X**	3DELRR
IDECM**	DDR
AARGM**	CANES
APACHE w/ AMF RADIO	UCLASS
JTNC*	Tomahawk
CAC2S	PM-UAS
G/ATOR	AIAMD
	PEO-IEW&S*
	IFPC INC II

* Multiple Programs

Significant Past Support
B1 Fully Integrated Data Link (FIDL)
Battlefield Airborne Communication Node (BACN)
B-52 Combat Communications Technology (B-52 CONECT)

AIAMD: Army Integrated Air & Missile Defense
CANES: Consolidated Afloat Network Enterprise Services
CAC2S: Common Aviation C2 System
CONECT: Communications Networking Technology
DDR: Dismount Detection Radar
G/ATOR: Ground/Air Task Oriented Radar
IEW&S: Intelligence, Electronic Warfare, and Sensors
IFPC: Indirect Fire Protection Capability
JMS: Joint Space Operations Center (JSpOC) Mission System
JTNC: Joint Tactical Networking Center
SDB: Small Diameter Bomb
UCLASS: Unmanned Carrier Launched Strike & Surveillance
3DELRR: Three Dimensional Expeditionary Long Range Radar

JMETC Summary

- **JMETC is here and proven!**
- **Many sites and systems already connected**
- **Demonstrated efficiencies for interoperability and cyber test**
- **Robust capability – ability to execute multiple events simultaneously, across the spectrum of T&E and acquisition life cycle**
- **Multiple examples of JMETC value added for customers**
- **Provides Acquisition T&E programs flexible and efficient T&E at lower cost and technical risk**
- **JMETC offers support to develop our customer's distributed test requirements**

JMETC enables both Acquisition and T&E Communities to partner for a better product, faster, and at a lower cost

Summary of TENA/JMETC Capabilities

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

- **A Working Implementation of the Architecture**
  - TENA Middleware currently works on Windows, Linux, and Mac
  - TENA Repository filled with information, tools, and object models
- **A Process to Develop and Expand the Architecture**
  - JMETC Users Group and AMT Meetings
- **A Technical Strategy to Deploy the Architecture**
  - JMETC process brings interoperability and reuse to test ranges
- **A Persistent Network to permanently connect test sites**
  - JMETC network enabled with TENA allows new tests to be performed with much less lead time and expense compared to the past

Learning Objectives Revisited

- **Four major aspects of TENA:**
  - Middleware – real time interoperability transport mechanism
  - Data Collection System – collect event data
  - Repository – place for reusable software/documentation
  - Object Models – common language for interoperability
- **Difference between TENA and DIS/HLA**
  - TENA is a government standard and is provided for free to all users
  - TENA is focused on live ranges and LVC, rather than just simulations
  - TENA uses auto-code generation to provide rapid reliable development
- **JMETC**
  - Purpose is to provide a persistent interoperable suite of tools for testing and training that can be composed rapidly into a Joint Mission Environment

Important Contact Information

- **Both TENA and JMETC provide free technical assistance and training for any interested users.**
  - TENA Questions, Feedback, and Requests: feedback@tena-sda.org
- **All references can be found at the websites below:**
  - TENA Website: **http://www.tena-sda.org**
  - JMETC Website: **http://www.jmetc.org**