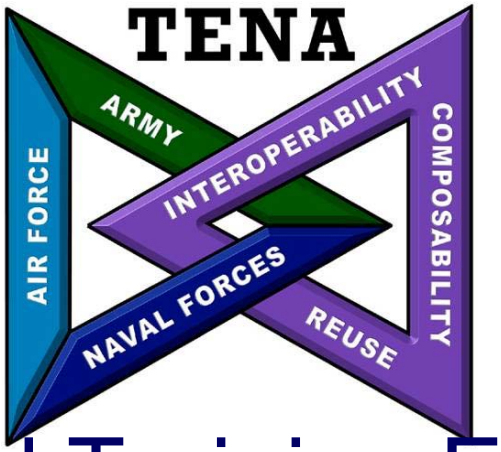

Test and Training Enabling Architecture (TENA) in Telemetry Applications

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TENA and JMETC

User Support Lead

TENA Mission

- **Historically, range systems tend to be developed in isolation, focused on specific requirements, and constrained by aging techniques/technologies**
- **Range infrastructures have grown organically with minimal coordination or sharing, resulting in duplicated effort and many "stove-pipe" systems**

The purpose of TENA is to provide the necessary enterprise-wide architecture and the common software infrastructure to:

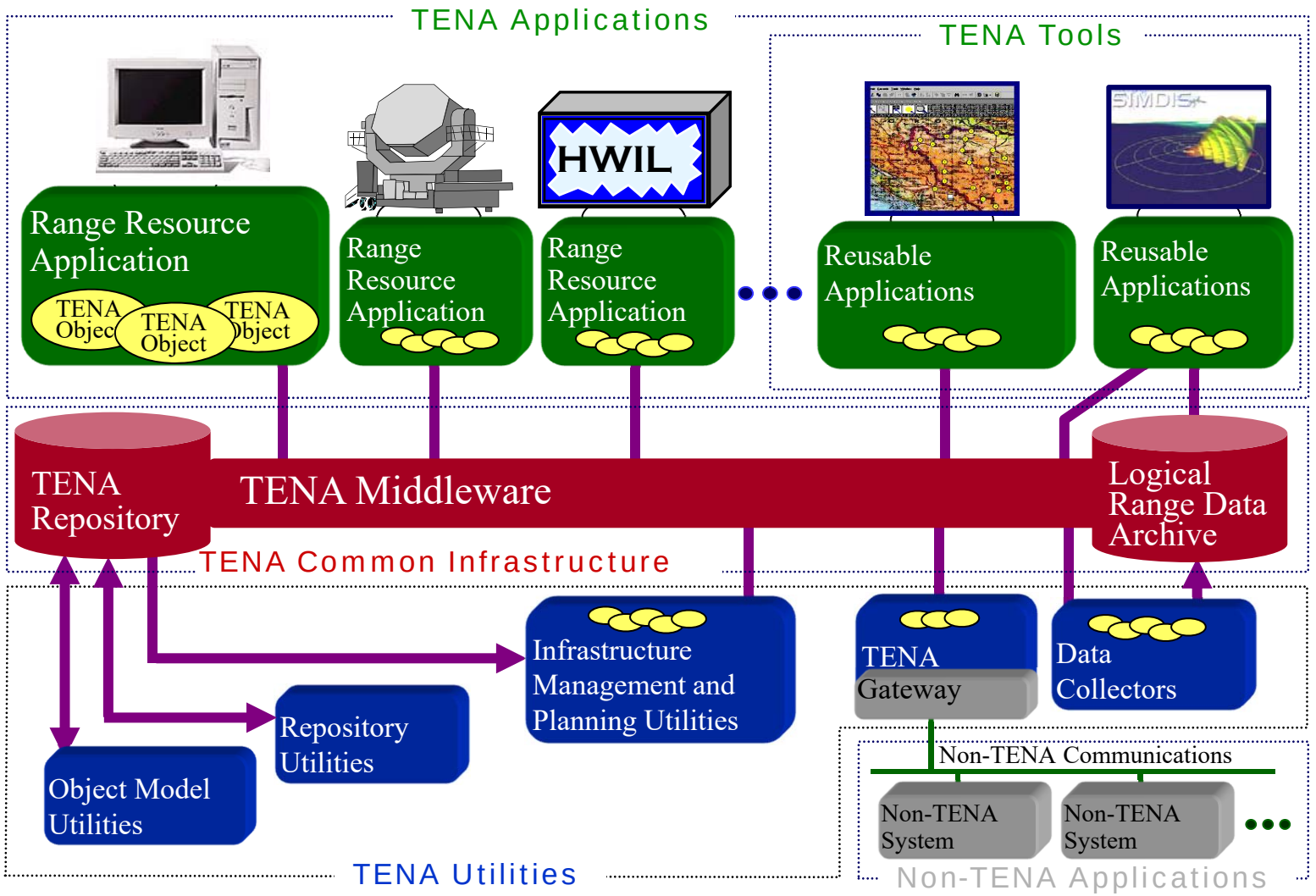
- Enable interoperability among range, C4ISR, and simulation systems used across ranges, HWIL facilities, and development laboratories
- Leverage range infrastructure investments across the DoD to keep pace with test and training range requirements
- Foster reuse of range assets and reduce cost of future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

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

Benefits of TENA

- **All TENA software and support is free to users**
- **TENA is the most capable and sophisticated interoperability solution**
- **TENA software is thoroughly tested and very reliable**
- **TENA Auto-Code Generation makes creating a TENA application as simple as possible**
  - TIDE Tool manages installation and configuration, upgrading and maintenance
  - Auto-generated starting points mean you never start with a blank page
  - **Rapid development** of real-time, distributed, LVC applications
  - Auto-generated test programs make integration a snap
- **TENA's technical approach emphasizes cost savings and reliability**
  - The TENA software is hard to use wrong
  - TENA catches many user errors at compile time rather than run time
  - TENA Tools provide unprecedented understanding of an event
- **TENA has a standard object model enhancing interoperability**
- **The TENA web site/repository has extensive documentation, training, and collaboration capabilities**
- **TENA has a plan for evolution and funding to execute this plan!**

TENA Architecture Overview



Architecture Management Team (TENA AMT)

- **Current AMT Members:**
  - 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)

Industry Advising Members

- Boeing
- Cubic Defense
- DRS
- Embedded Planet
- EMC
- General Dynamics – C4 Systems
- Kenetics
- KBRWyle
- Leidos
- 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

- **Design Decisions / Trade-offs / Status / Technical Exchanges of Lessons Learned / Use Cases / Testing / Issues & Concerns Identification, Investigation & Resolution**

TENA Information Assurance (IA) Activities

- **Air Force Evaluated/Approved Product List (E/APL)**
  - Software Certification for TENA Middleware Version 6.x
- **Navy Application & Database Management System (DADMS)**
  - Approved 6/27/2011
- **Army Certificate of Networthiness (CoN)**
  - Covers TENA Middleware, TENA Utilities, and TENA-enabled applications
- **S/DREN (Secret/Defense Research and Engineering Network)**
  - TENA protocol and TENA-based applications approved for DREN and SDREN sites
- **NIPRnet**
  - JTTOCC (which includes TENA Middleware) obtained ATO on NIPRnet
- **Air Force 46th Test Wing DIACAP**
  - InterTEC tool suite (includes TENA Middleware) completed DIACAP testing, ATO submission in process
- **DoD PPSMO Category Assurance List (CAL)**
  - Conditional approval for TENA use on classified and unclassified network enclave, awaiting final approval
- **Unified Cross Domain Management Office (UCDMO)**
  - TENA-enabled Cross Domain trusted guard SimShield v2.2.0.1 on baseline list
- **Joint RDT&E Reciprocity Overlay Team (JRROT)**
  - Foundational set of controls for basing reciprocity determinations for RDT&E

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

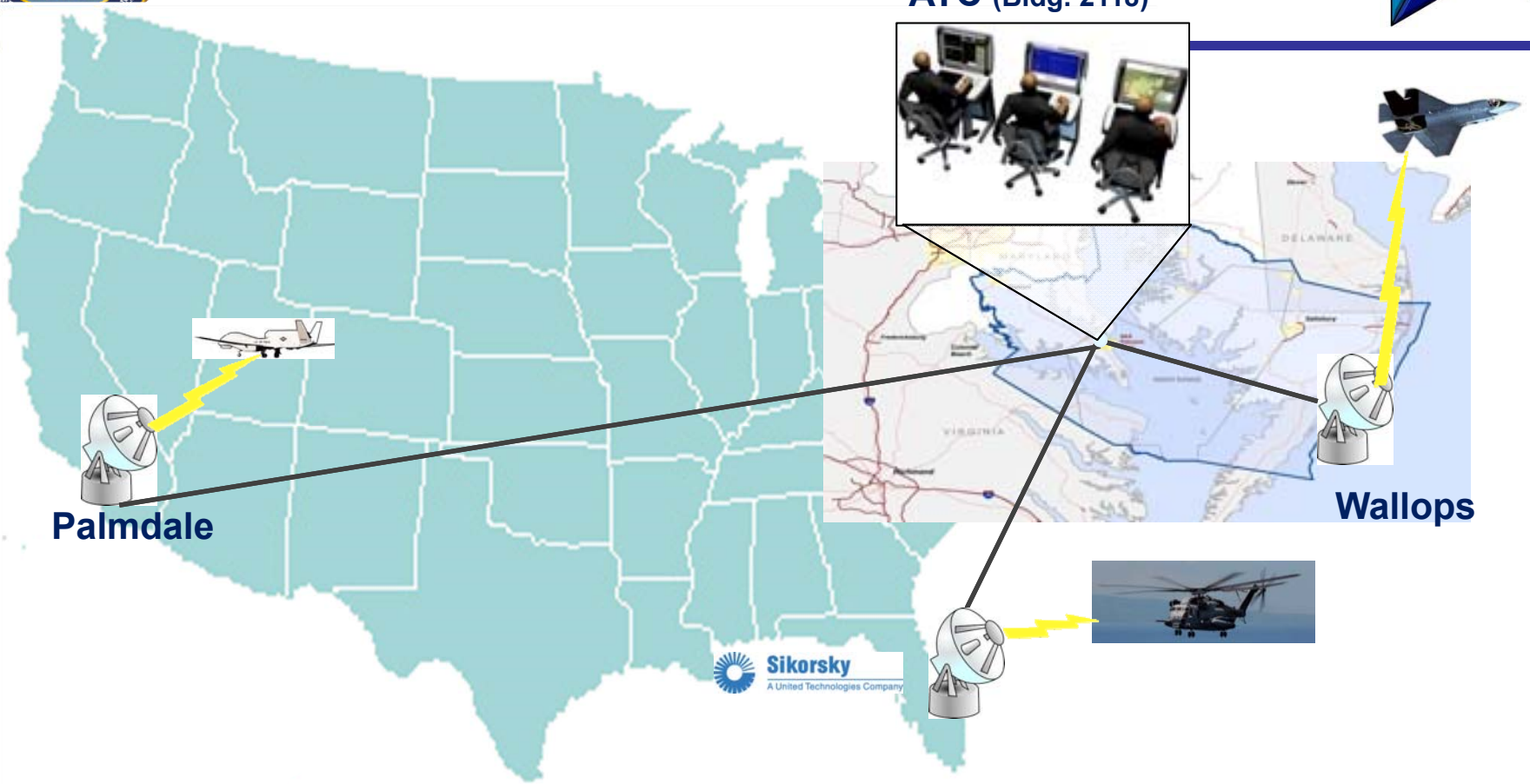
Patuxent NAS ATR TM Control

Objective: Develop and field an enterprise approach to remotely manage and operate all components of remote ATR ground telemetry systems. Approach should provide common interfacing to system components regardless of system manufacturer. Provide for single operator control of several remote TM systems which reduces travel and manning requirements at remote sites.

Current TM Approach:

- **Operator Proximity:** Current systems require TM Operator to be at location of TM Antenna Control Unit (ACU) during missions
  - Any near term remote operations concepts require a one-to-one correlation between remote ACU and remote TM Antenna, but no sub systems supported
- **Lights Out Operations:** No ability to fully power-on, configure, operate, and obtain status from remote Auto-Tracking Telemetry System (ATAS) and Mobile Telemetry Acquisition System (MTAS) systems. Requires personnel on-site to perform power-on and configure all systems. No distributed status available from TM system components.
- **Generalized Interface:** Vendor specific interfaces and data models are used
  - Operators must gain proficiency on each system component
  - Prohibits uniform operator consoles
  - Limited ability to easily access and share relevant metrics and engineering data
- **Information Assurance:** Limited ability to meet evolving Information Assurance (IA) requirements and Security Technical Implementation Guides (STIG) on system components

Operational View (OV-1)

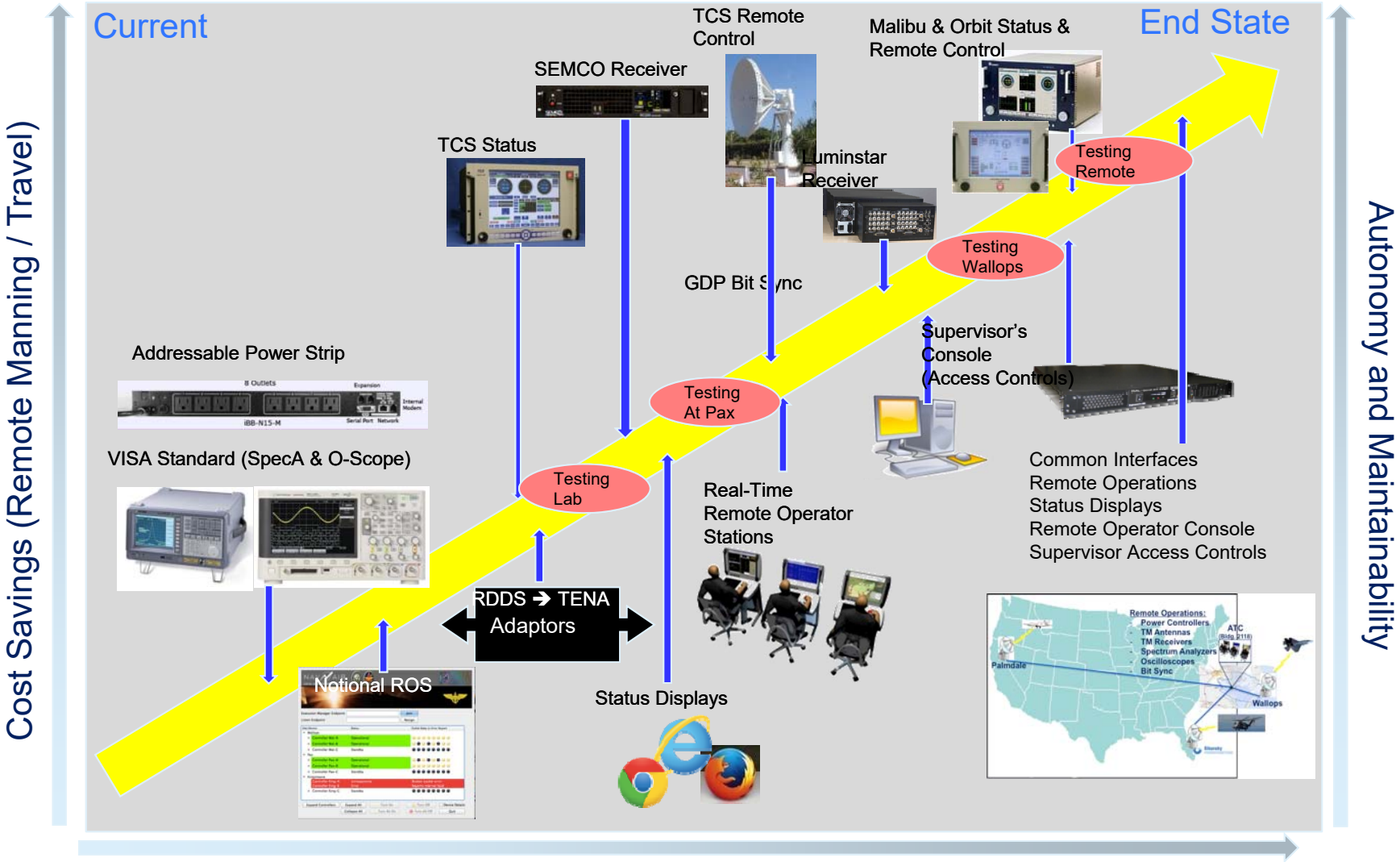


Remote Operations:
- TM Antennas
- TM Receivers
- Spectrum Analyzers
- Oscilloscopes
- Power Distribution

Real Time Displays:
- Antenna Position
- Signal strength
- Decommutator Status
- Airplane Position

Data Collection
- Enable post mission analysis
- Enable cross mission analysis for range characterization and optimization

ARC-TS Roadmap Overview



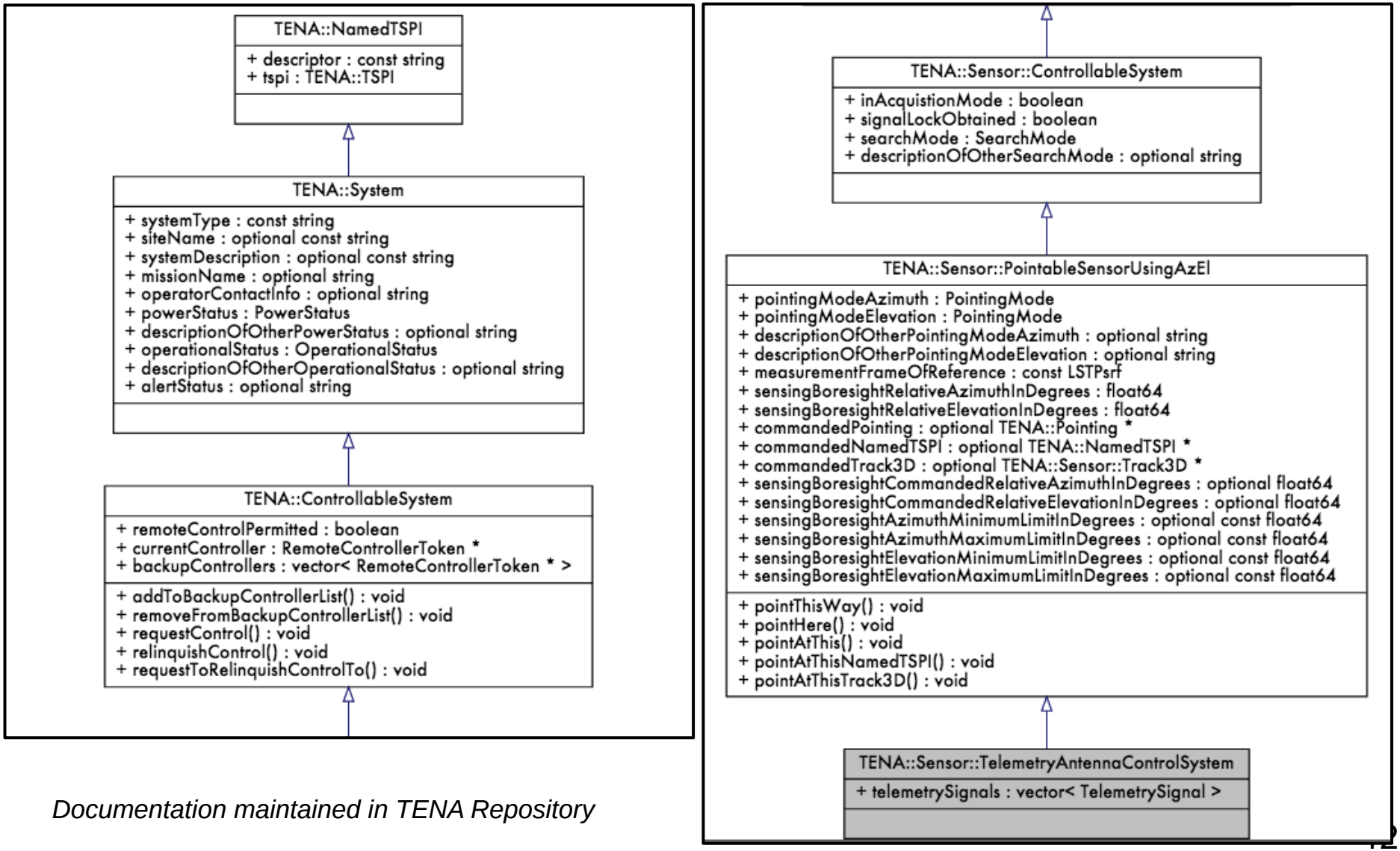
Implementation Strategy

- **Develop vendor agnostic object models and interfaces for the functional systems**
  - Consider ability to support multiple vendors in the design, e.g., use inheritance, make attributes optional
- **Develop TENA Adapters for the required functional systems**
  - TENA Adapters will be vendor specific, although sharing implementation code for typical system interfaces (e.g., SNMP, VISA) will be performed when feasible
- **Develop Remote Operator Station (ROS)**
  - We would like Range developers to assist in this area to ensure look and feel meet operator needs and help with broad acceptance within user community
  - Web Browser based user interface approach for status and quick-look information
- **Avoid using proprietary protocols for remote operations**
  - Utilize open architecture with common object models to achieve enterprise solution
  - Utilize common API for all systems
- **Incremental functionality demonstrations through development sprints will be conducted to integrate lessons learned and mitigate overall program risk**

Object Models (OMs)

- **Object Models**
  - Object Models formally define system information and services with support for automatic code generation
  - Users are permitted to derive extensions to TENA standard OMs, or users can establish their own OMs
  - TENA SDA collects requirements and implementation considerations from user community and candidate TENA standard OMs published for community review and testing purposes
- **Range Instrumentation System Classes (e.g., telemetry, radar, optics)**
  - Class inheritance hierarchy (16 separate classes with a total of ~120 attributes and ~25 remote methods)
  - Intended to be used by range instrumentation system vendors and range organizations, with unique derived class with proprietary and legacy attributes when necessary
  - Abstract base classes can be used by subscribing systems that just need basic information common to all range instrumentation systems (e.g., senior operator needs view of the operating status value for all antenna control units independent of any organization/vendor specialized derived classes)
- **Range Instrumentation Pointing and Track Representations**
  - A Pointing object is used for instructing an instrumentation system to look at a particular position, potentially at a future time (e.g., predicted missile impact position)
  - Range systems can use Pointing objects for multiple operational use cases (e.g., system operator can select a particular Pointing, system can automatically select the best Pointing, a remote operator can instruct the system which Pointing to use)
  - Tracks are based on instrumentation system measurements indicating what was sensed (e.g., azimuth and elevation angles to a test article's beacon signal at a particular time)
- **Range Instrumentation Sub-System Classes**
  - Definition of remote operation interfaces for instrumentation sub-systems, e.g., receiver, spectrum analyzer, controllable power strip, antenna control unit (similar to System class structure where derived classes permitted)
  - Designed for effective, multi-operator, remote monitoring and control of instrumentation sub-systems

TelemetryAntennaControlSystem Class Hierarchy Illustration



Documentation maintained in TENA Repository

Example Object Model PowerController
(aka networked power strip)

```
package TENA {
  local class PowerOutlet {
    string outletName;
    int16 outletNumber;
    boolean isPoweredOn;
    optional float32 currentLoadInAmps;
  };
  class PowerController {
    const string deviceName;
    const string siteName;
    PowerControllerState  status;
    optional string errorState;
    vector <PowerOutlet> outlets;
    void turnOutletOn (in string outletName);
    void turnOutletOff (in string outletName);
    const boolean isEventLogMaintained;
    vector<string> getEventLog ();
  };
};
```

Package TENA used for community approved standards, but other groups can create extensions or new OMs as necessary.

Attributes used to characterize the individual power strip outlets.

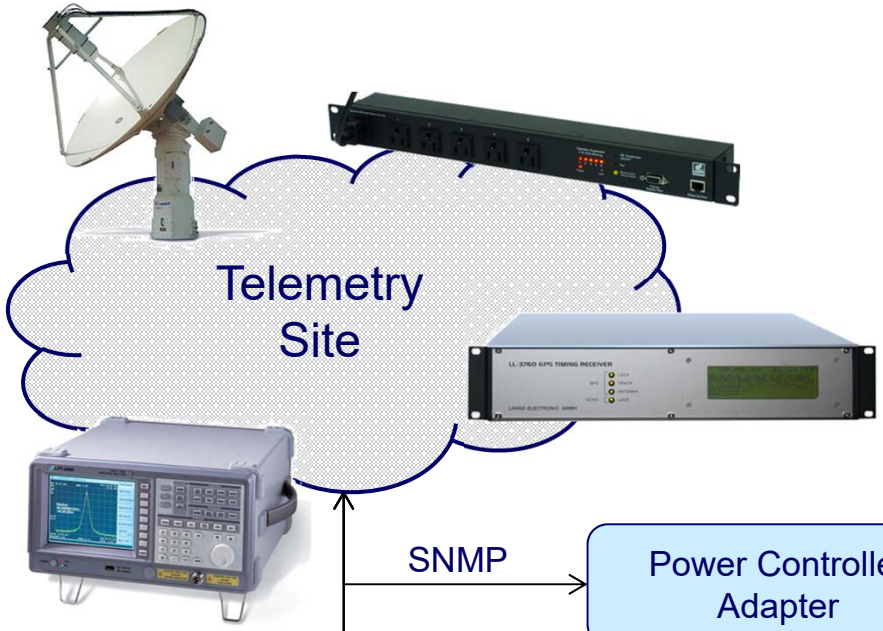
Power controller system publishes object with identification and status information. Client applications monitor status and can invoke methods.

Interface specification simplified and comments removed for presentation purposes

Adapter Approach for Remote Operations

- **What is an Adapter?**
  - A software module designed to wrap a particular system with a common system interface (with extensibility, when needed) to promote interoperability across different vendor implementations
  - Adapter can be configured to be used as a stand-alone computer process, either running on the same computer as the existing system, or an adjacent computer
  - Adaptor can also be configured to be used in-line with an existing system in a virtual network interface manner
- **How are Adapters used?**
  - Remote operator GUI-based systems are developed according to the common interfaces presented by the adapters in order to break the tight coupling that often occurs with proprietary point-to-point solutions
  - Operator systems are designed from the perspective of supporting the ability to efficiently switch between different sites and different vendor-based systems
    - Support overlapping operators, as well as supervisory monitoring
    - Identify remote operation fault conditions and promote proper operator procedural handling of these faults
    - Provide access to vendor specific remote access tools, when that level of access is available and required
- **Additional Adapter Benefits**
  - Remote configuration of range instrumentation systems handled in a common manner, permitting the development of tools and infrastructure to minimize configuration problems
  - Existing data collection capabilities can be used to capture configuration settings and operational status information related to the range instrumentation systems for either during event or post-event analysis

Adapter Illustration



SNMP → Power Controller Adapter

VISA → Spectrum Analyzer Adapter

TCP proprietary → Telemetry Antenna Controller Adapter

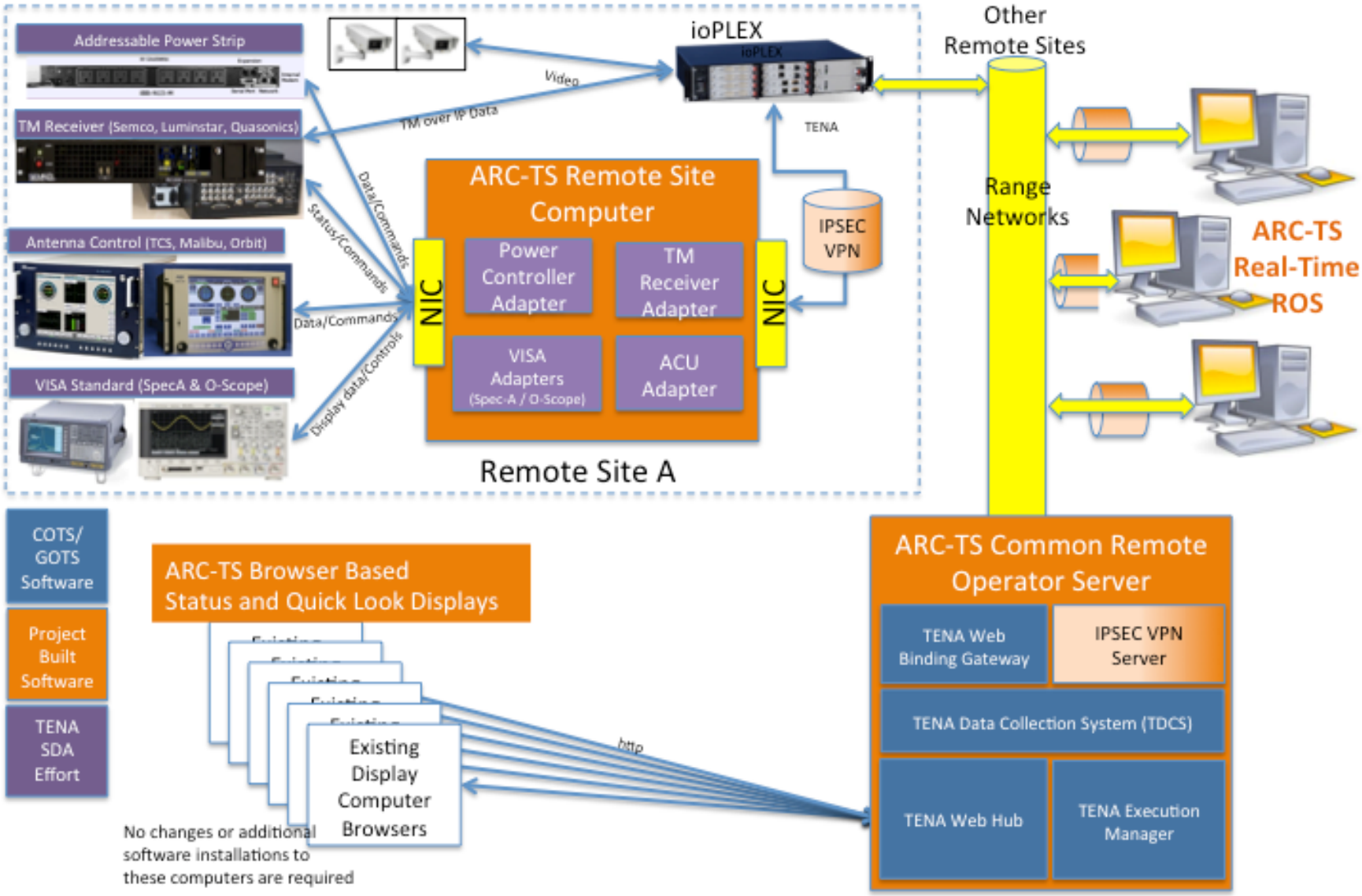
VISA → Telemetry Receiver Adapter

. . .

Range Instrumentation Network

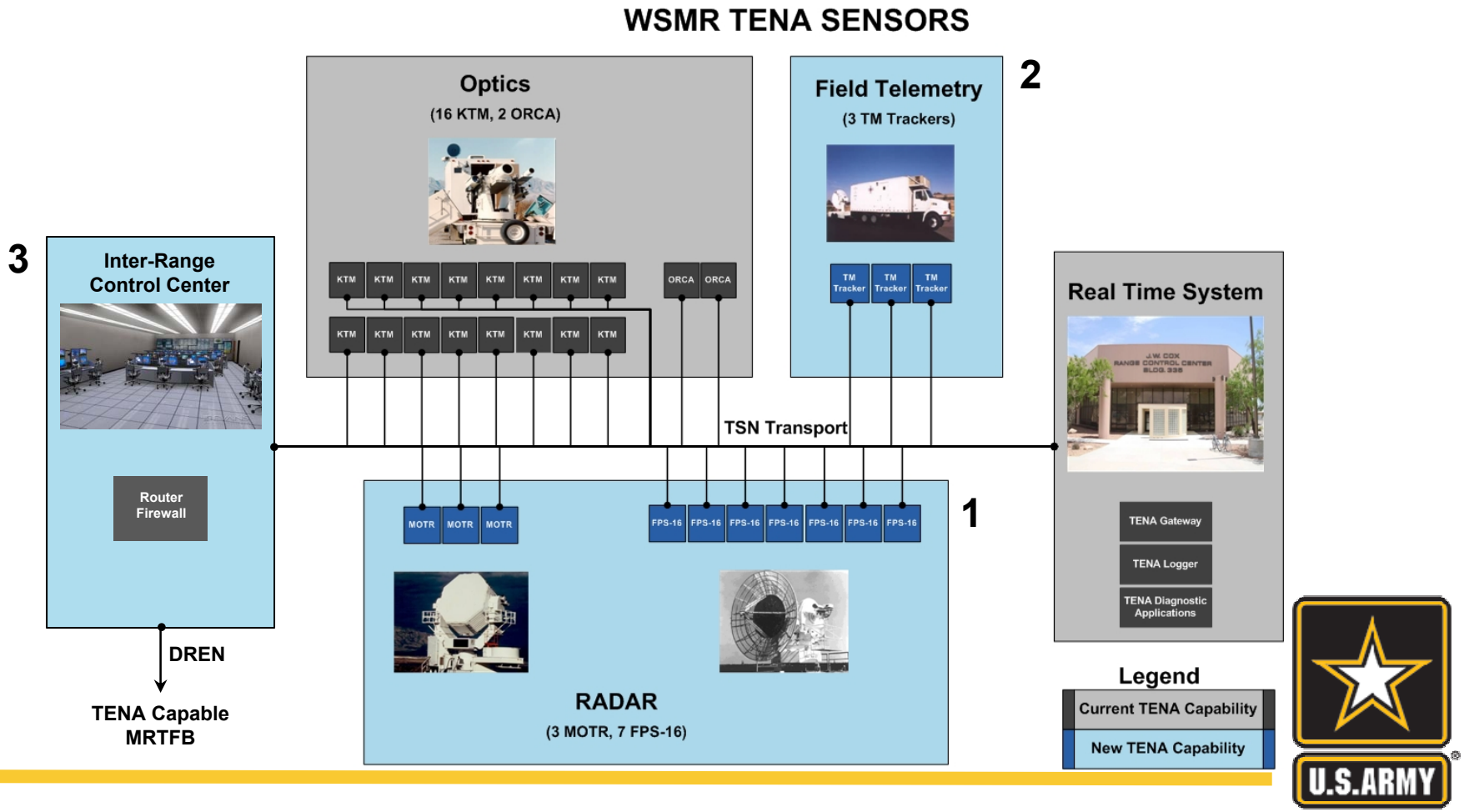
- Event Management Tools
- Remote Configuration Control
- Remote Operator Station(s)
- Range Supervisor Station(s)
- Data Collection, Analysis, & Playback
- Data Visualization Tools

Target Architecture



Bottom Line Up Front – 3 WSMR Deliverables to TRMC

1. TENA Capable Range Interface Unit for Radars
2. TENA capable Telemetry Tracker pointing data interface – Mod of existing RIU
3. Persistent distributed TENA capability through IRCC



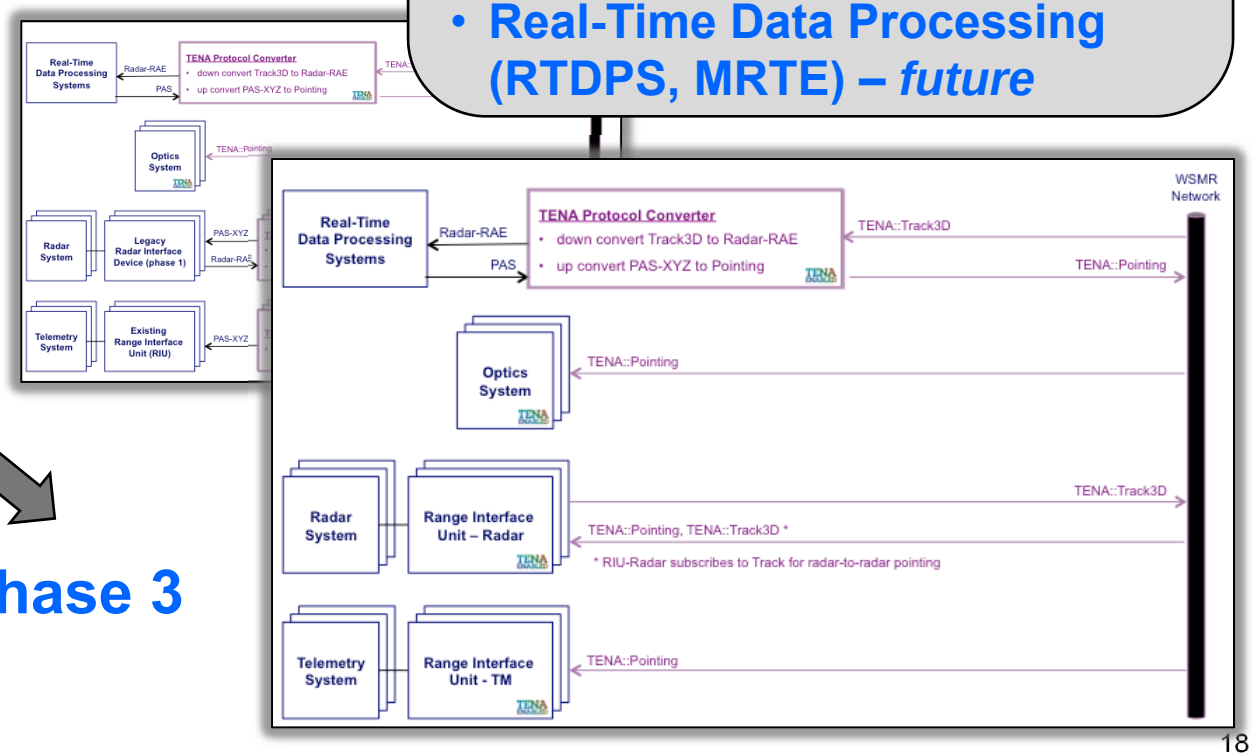
WSMR DICE
"TENA Way Forward" Phases

TENA will be used to connect the following range systems:

- **FPS-16 Radars**
- **Telemetry Systems**
- **Optics Systems**
- **Real-Time Data Processing (RTDPS, MRTE) – *future***

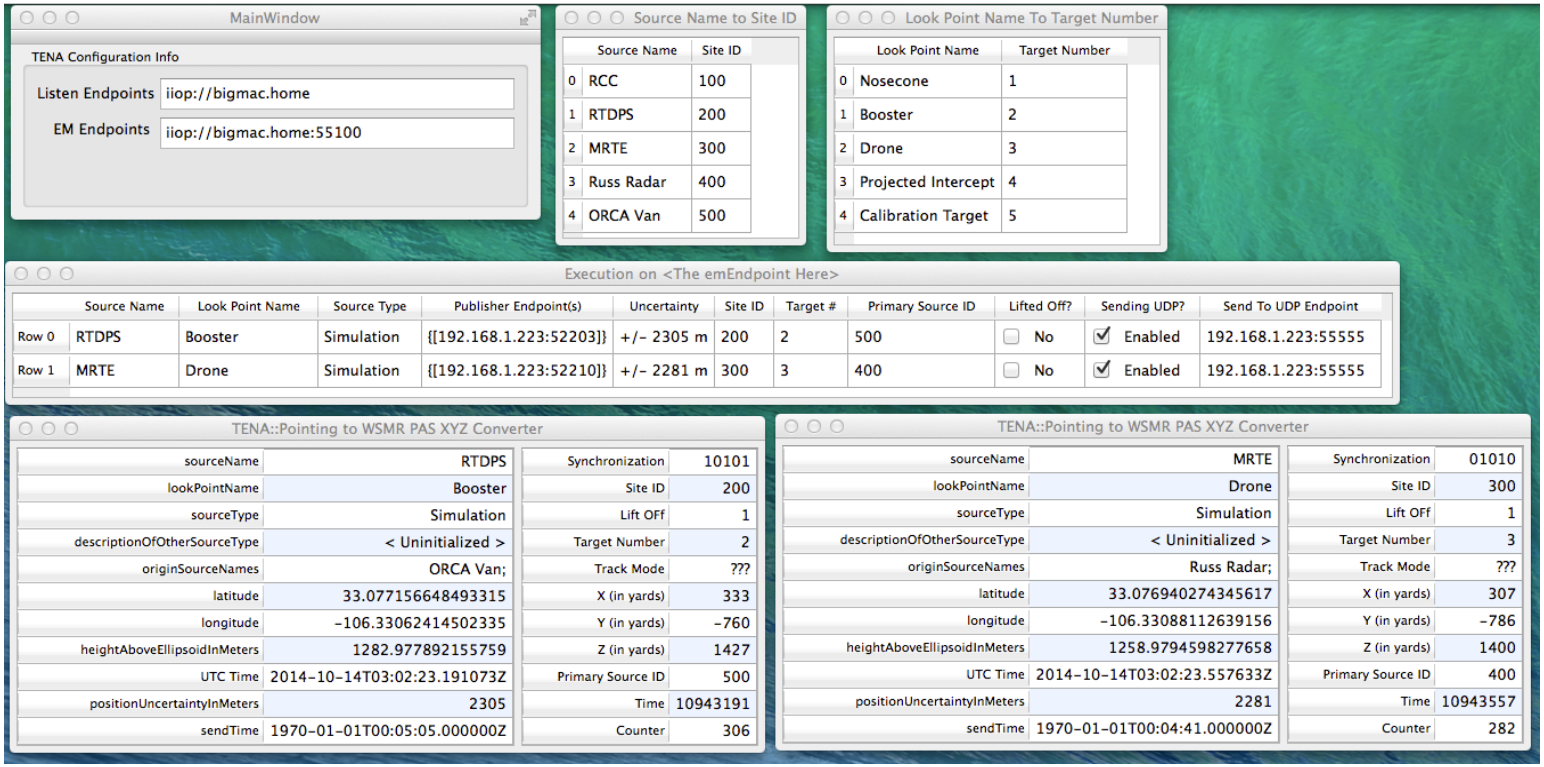
Phase 1

Phase 3



TENA Adapter

- **TENA::Pointing <> PAS-XYZ**
  - Developed portions of this particular Protocol Converter as a prototype to evaluate particular architectural design considerations
  - Need to continue to evolve the implementation into an exemplar for defining the Protocol Converter architecture
  - Plan to provide documentation and source code for community review



DICE Object Models

- **TENA-Pointing**
  - Standard OM created while working WSMR optics systems several years ago
- **TENA-RangeInstrumentation (TENA-RI)**
  - Emerging standard OM structure specifically designed for range instrumentation systems (see subsequent slides)
- **WSMR-DICE**
  - Provides extension to the standard OMs for WSMR specific attributes:

```
enum WSMR::TrackMode {No_Track, Acquisition, Coast, Skin, Beacon};
WSMR::Pointing extends TENA::Pointing {
  TrackMode trackMode;
};
WSMR::Track3D extends TENA::Track3D {
  int8 AGCquality;
  int8 bandwidth;
  TrackMode trackMode;
};
```

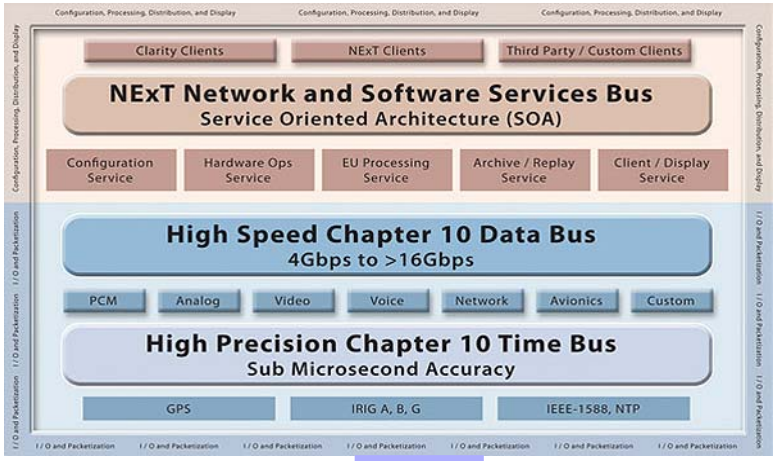
  - Adds LiftoffIndicator and WeatherMeasurements classes

TENA Enabled TM Control at YUMA

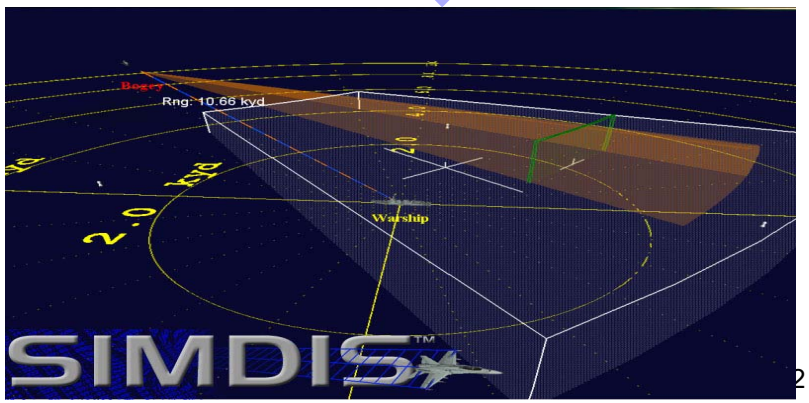
- **TCS Antenna Control Unit (ACU) model M1 completing TENA interface**
- **Remote monitoring and control of telemetry antenna system using TENA is undergoing operational testing**
- **To be used on Yuma TM pedestals**
- **Updated controller to be procured this year with Red Hat 6 Operating System**

TENA Enabled TM Data at RTC

- Using TENA to pull real time TSPI data from the Smartronix Omega NeXT decom software
- Developed "Data Adapter Tool" in 2 weeks
- Transporting the data via TENA using the Standard platform object model
- Using SIMDIS to display real time 3D moving map with the TENA plugin for SIMDIS
- Data Adapter Tool fuses other real time TSPI sources such as IMU and differential GPS

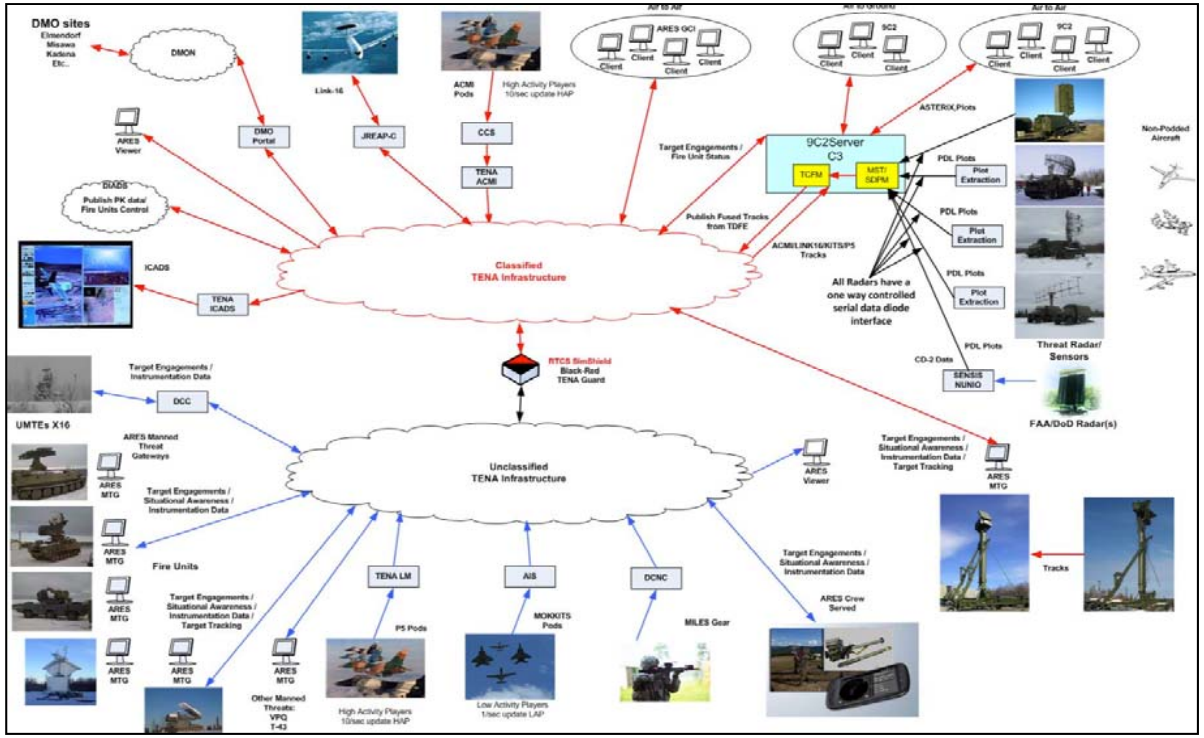


TENA



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**

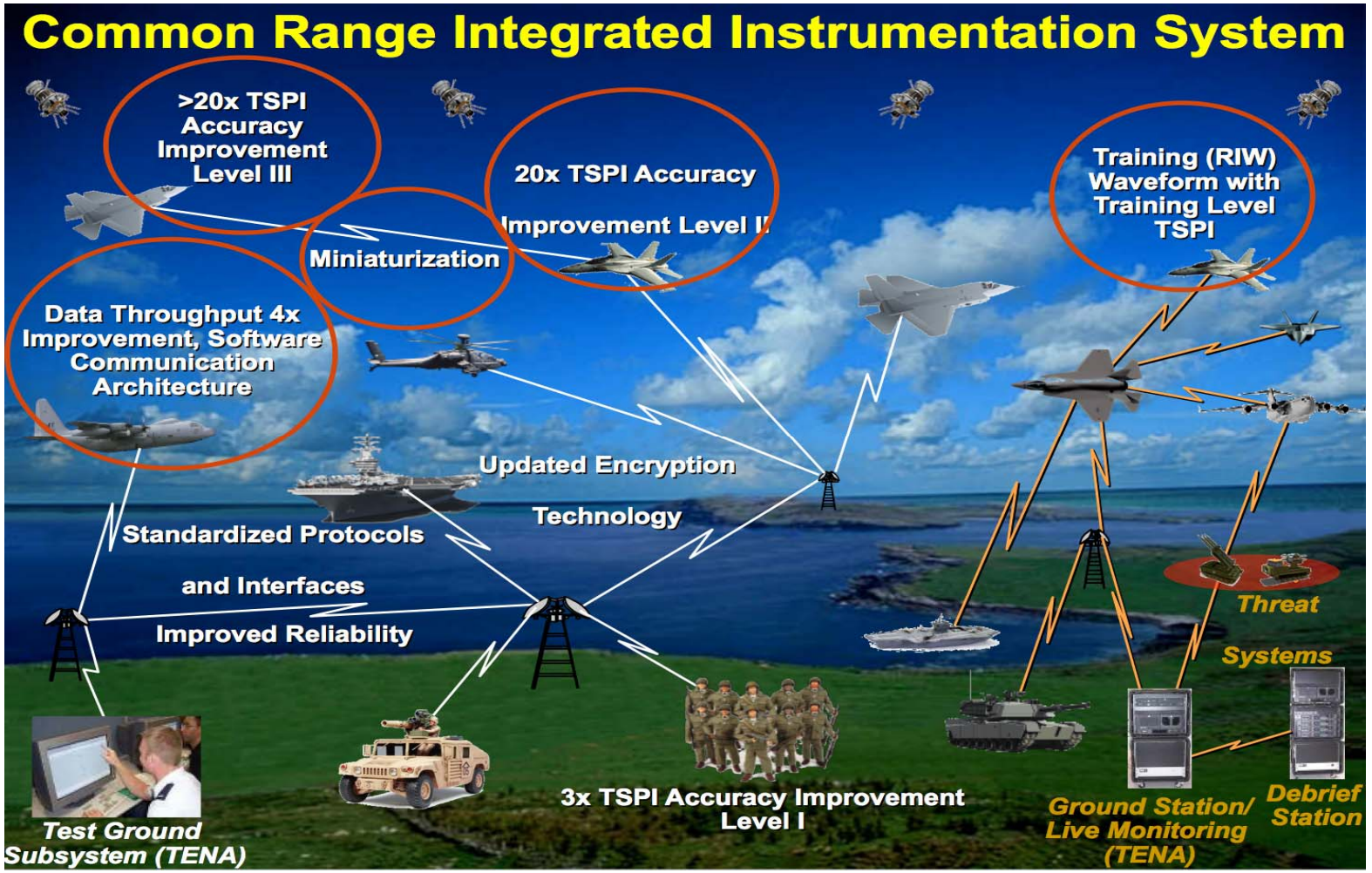


"TENA is the greatest thing that ever happened to us. We couldn't be doing today with all these systems–and we couldn't have all the participants that we do–if it weren't for TENA"

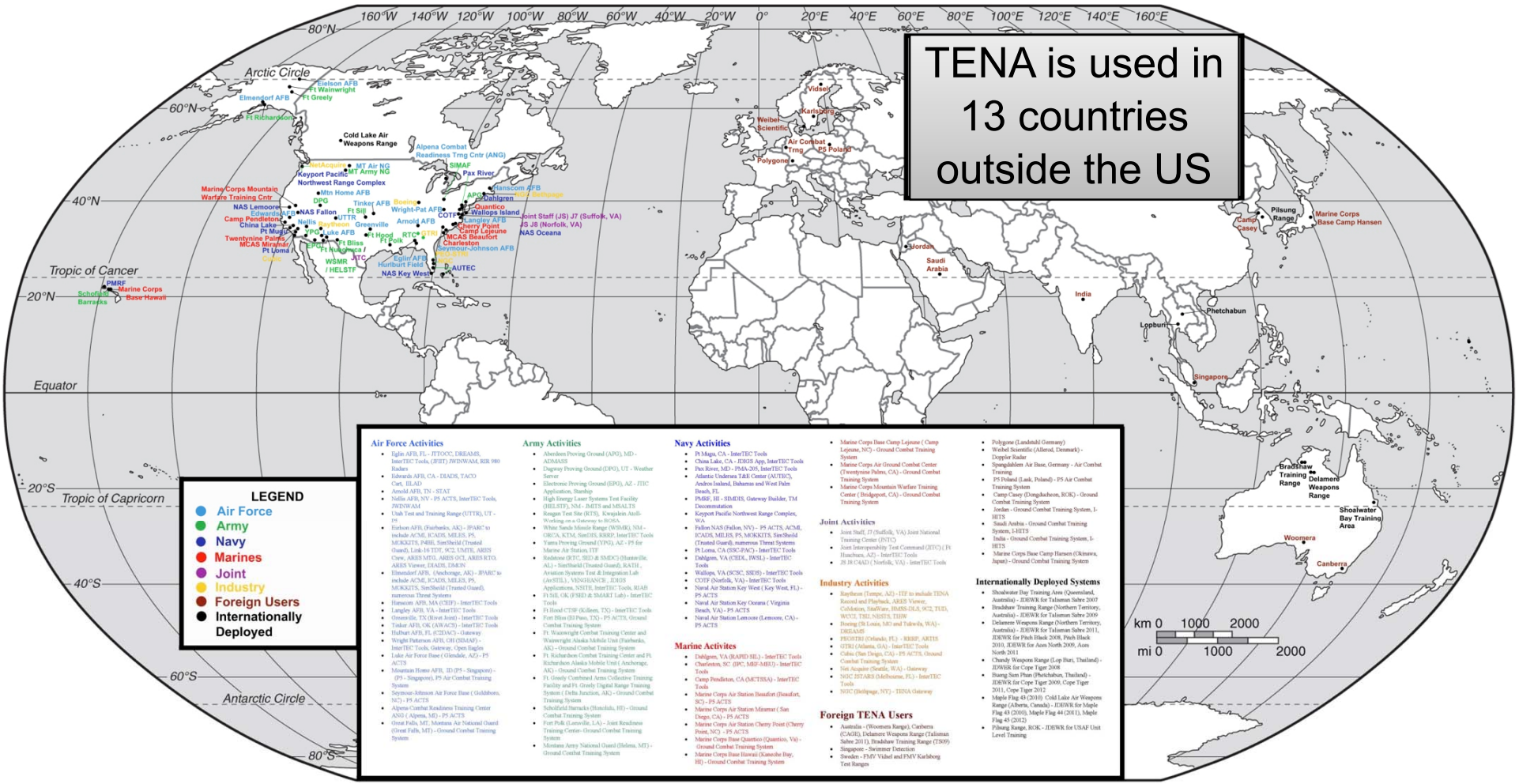
Billy D. Smith
Chief of electronic combat training requirements for Red Flag at JPARC

Common Range Integrated Instrumentation System (CRIIS)

- **TENA specified in CRIIS acquisition program requirements for ground system communication**



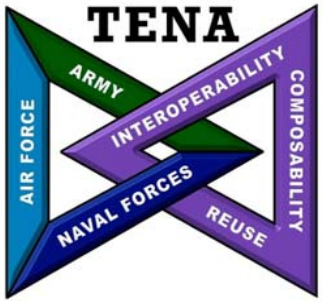
Worldwide Use of TENA



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, TDLI
Norfolk COMOPTEVFOR
Dam Neck CDSA
Dam Neck JMETC NOSC
Wallops Island (2): SCSC, SSDS
Newport News NGC VASCIC
McLean MITRE NSEL
Kingstowne SAIC

As of 10 Feb 2014

Army
Air Force
Navy
Marines
Joint
Industry
Academi

How a Test Planner Should View JMETC

Hardware-in-the-Loop (HWIL) Availability

All linked by JMETC

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 week of Feb 5 in Atlanta**
    - **Next JMETC User Group week of Feb 5 in Atlanta**

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