TENA and JMETC Overcoming Challenges in Distributed Testing

Gene Hudgins

TENA and JMETC

User Support Lead

TENA Mission

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

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

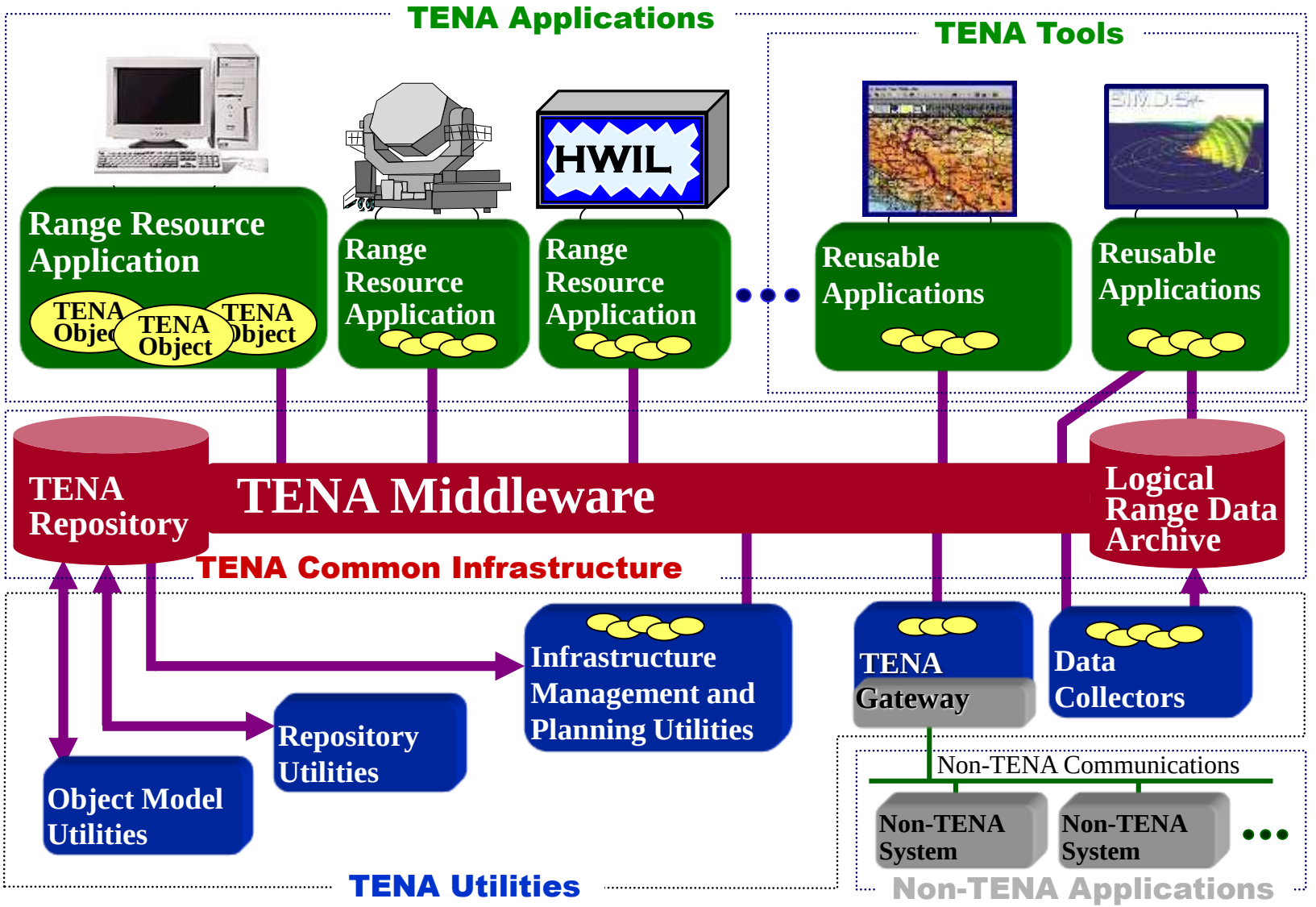
- **Enable interoperability among range, C4ISR, and simulation systems used across ranges, HWIL facilities, and development laboratories**
- **Leverage range infrastructure investments across the DoD to keep pace with test and training range requirements**
- **Foster reuse of range assets and reduce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

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

Benefits of TENA

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

TENA Architecture Overview



How do we integrate TENA into our existing environment?

- **Gradual Deployment**
  - TENA can be introduced into an existing environment in a gradual manner in which certain systems are replicated using TENA functionality
  - These initial systems will typically require temporary gateways to bridge between TENA and the legacy protocol and systems
- **Gateway with Legacy Protocol and Systems**
  - TENA gateway systems are well understood, and a separate project, PRITEC, has even created a Gateway Builder product to facilitate automated gateway creation
  - Migration to TENA can be coordinated with respect to publishing/subscribing characteristics to minimize any performance degradation caused by the gateway
- **Utilize Redundancy during Testing**
  - Access to both the legacy and the upgraded TENA system provides system redundancy during initial testing and operational deployment to minimize risk

TENA can be introduced to a range gradually using a properly designed protocol gateway system

Architecture Management Team (TENA AMT)

- **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**
- **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

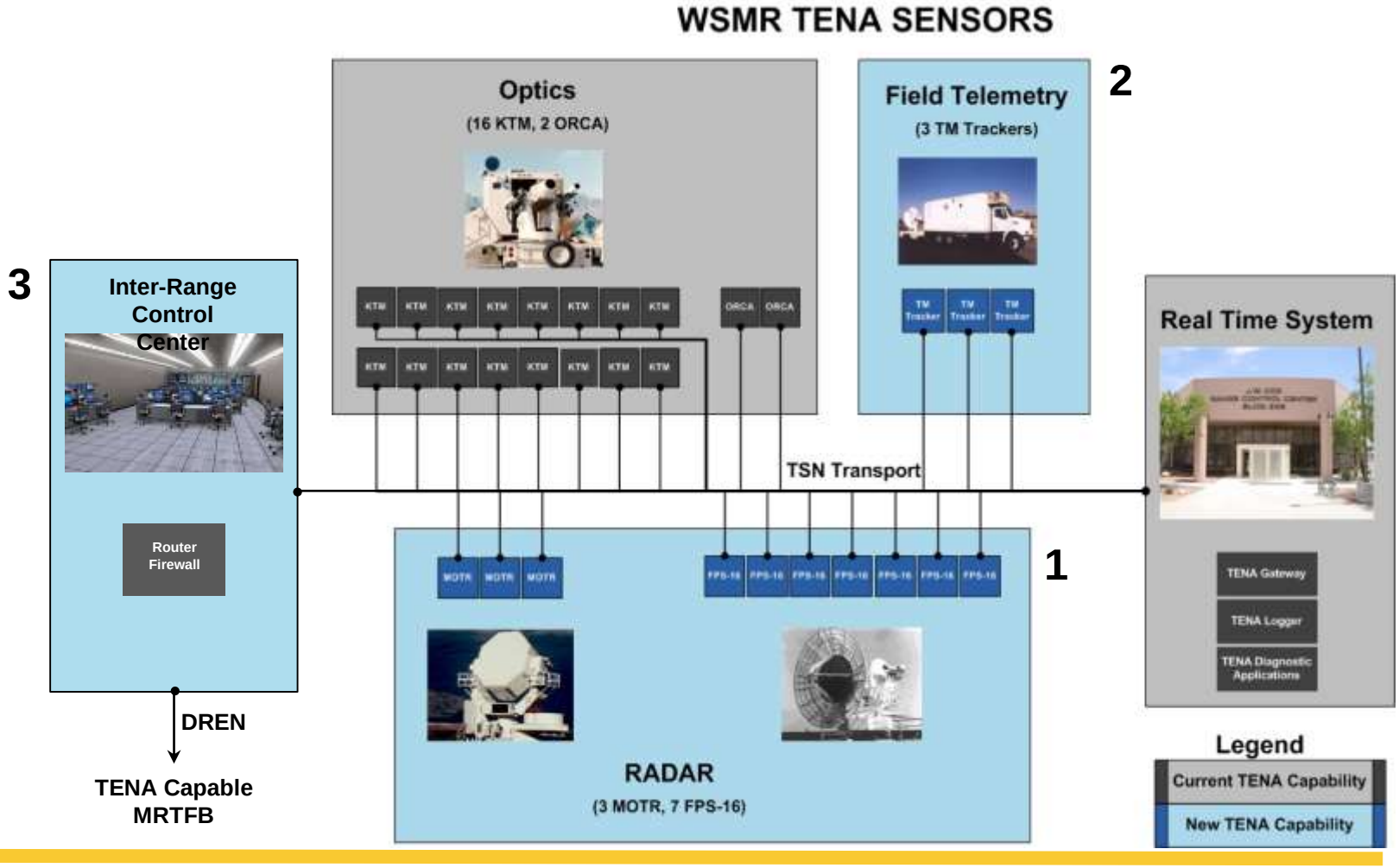
TENA project works with IA organizations to reduce cost and delays to improve IA considerations with TENA applications

TENA Range Instrumentation with Telemetry Activities

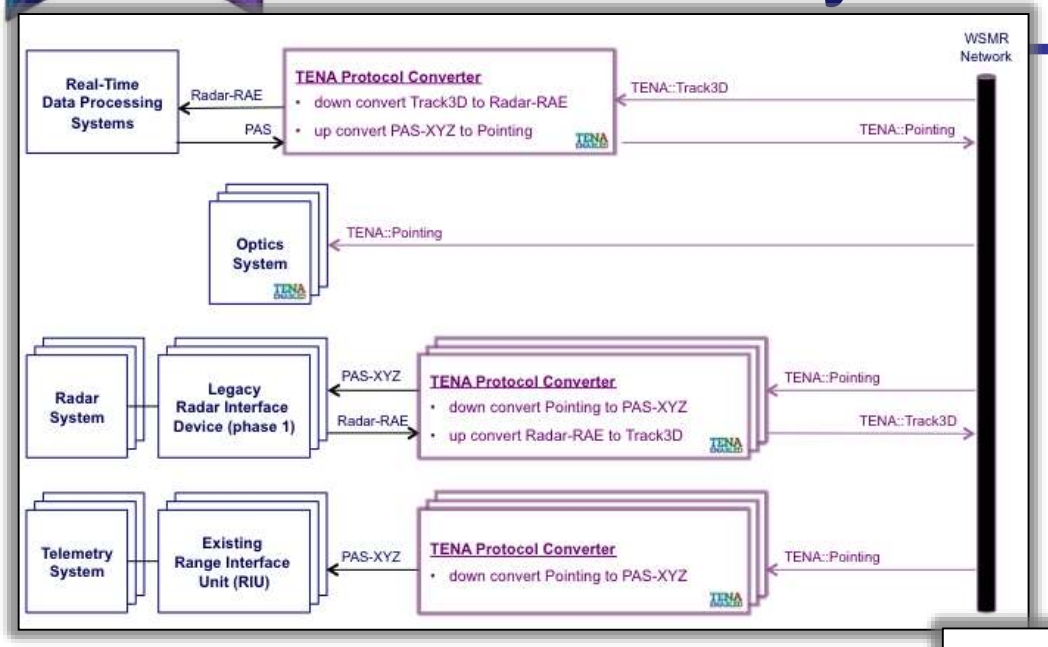
- **WSMR-Distributed Instrumentation Control Enterprise (DICE)**
  - Optics systems continue to use TENA operationally (~8 years)
  - TENA Interface to FPS -16 and MOTR Radars, Telemetry Trackers and Real Time Data Processing
- **PMRF-Next Generation Range Control and Data Distribution (NGRC&DD)**
  - Several range data systems have been re-designed to use TENA (which provided functional enhancements) and have been operating in “shadow” mode for ~2 year, and now moving to next step in certification
  - Plan to integrate TENA into SIS software that is used for all of the range instrumentation systems with initial focus on optics systems
- **Yuma- TM Antenna Control**
  - Completing the operational testing of the remote monitoring and control capability for telemetry antennas using TENA (active mode being used operationally)
  - Modified existing range systems and vendor, TCS, antenna control unit software
- **Pax River-Advanced Remote Control TM System (ARC-TS)**
  - Investigating the use of TENA for remote monitoring and control of telemetry systems, planning to provide more extensive capabilities than was implemented at Yuma

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

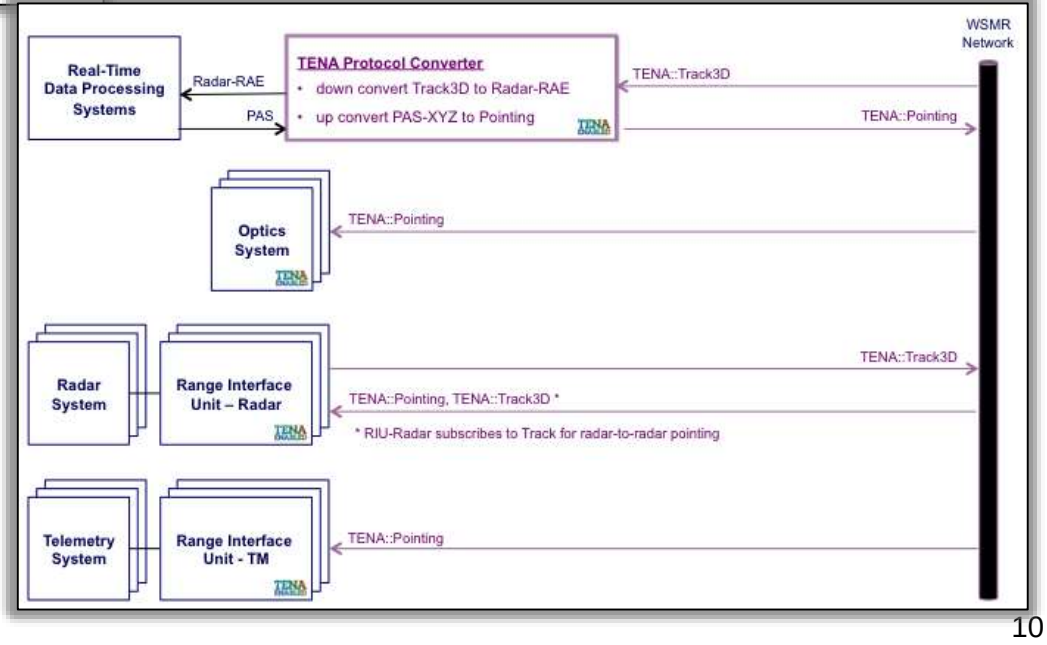


Phase 1

TENA will be used to connect the following range systems:

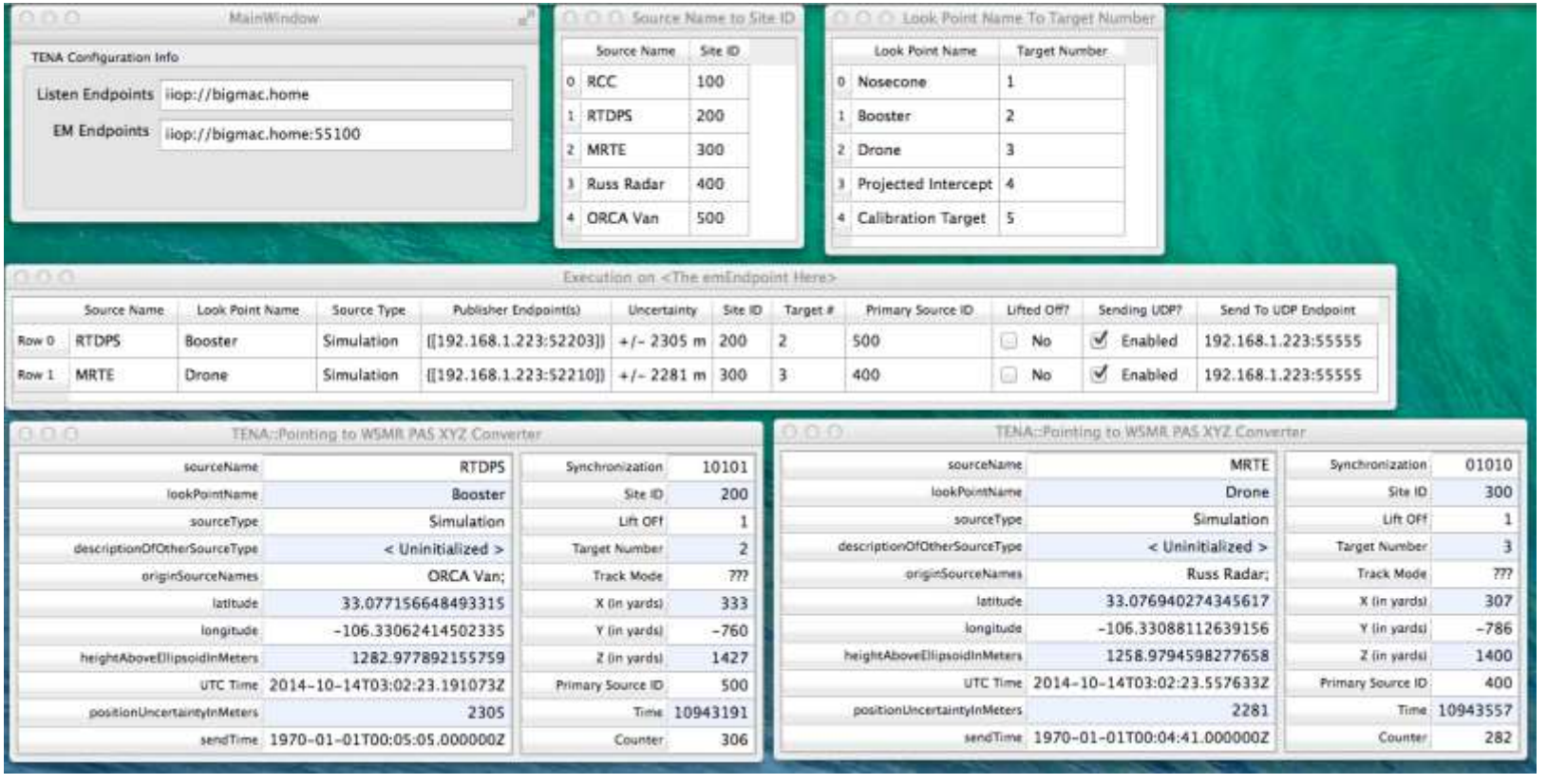
- **Real-Time Data Processing (RTDPS, MRTE)**
- **FPS-16 Radars**
- **Telemetry Systems**
- **Optics Systems**

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



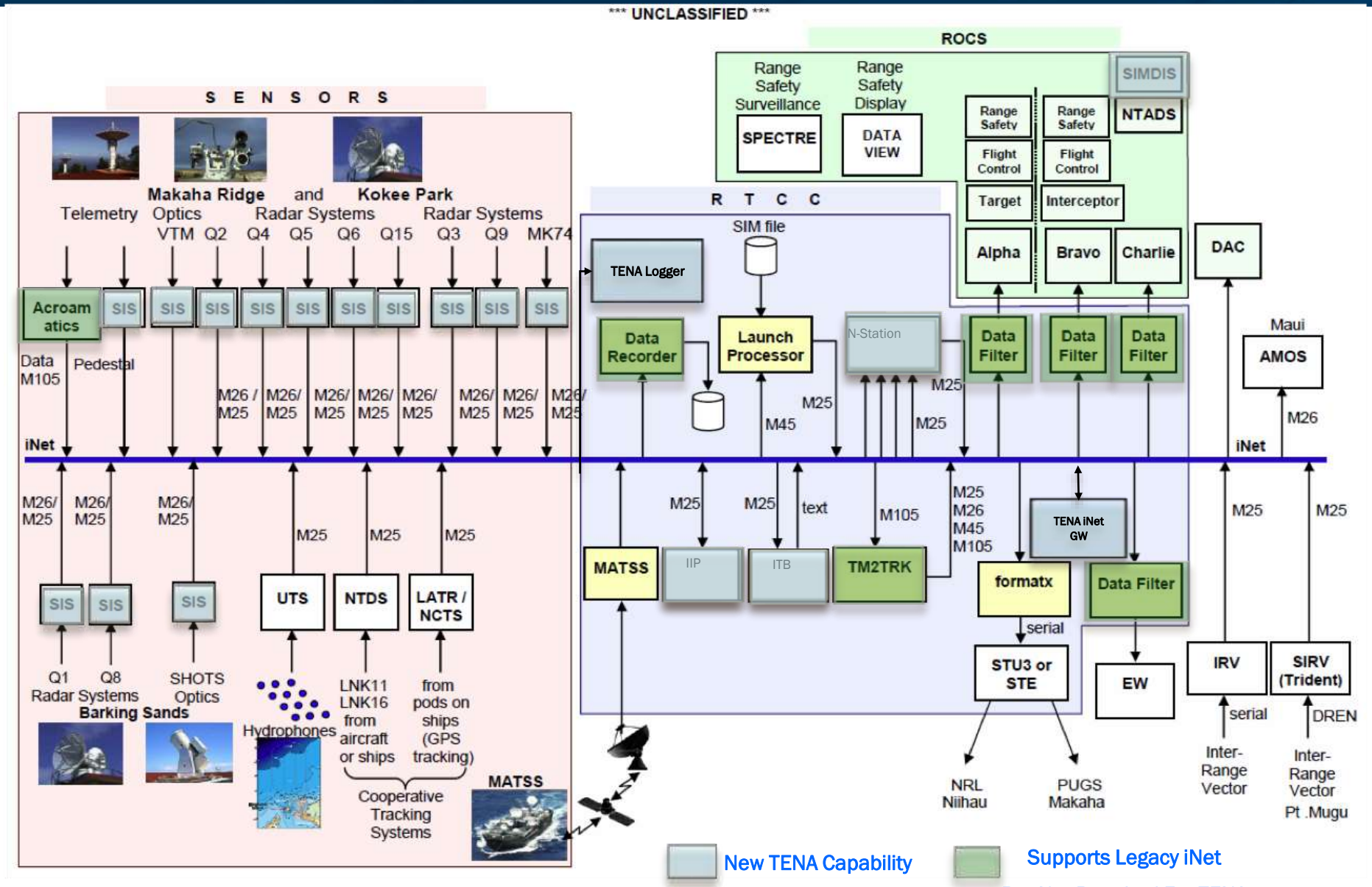
DICE Object Models

- **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
- **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

End State at PMRF



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**

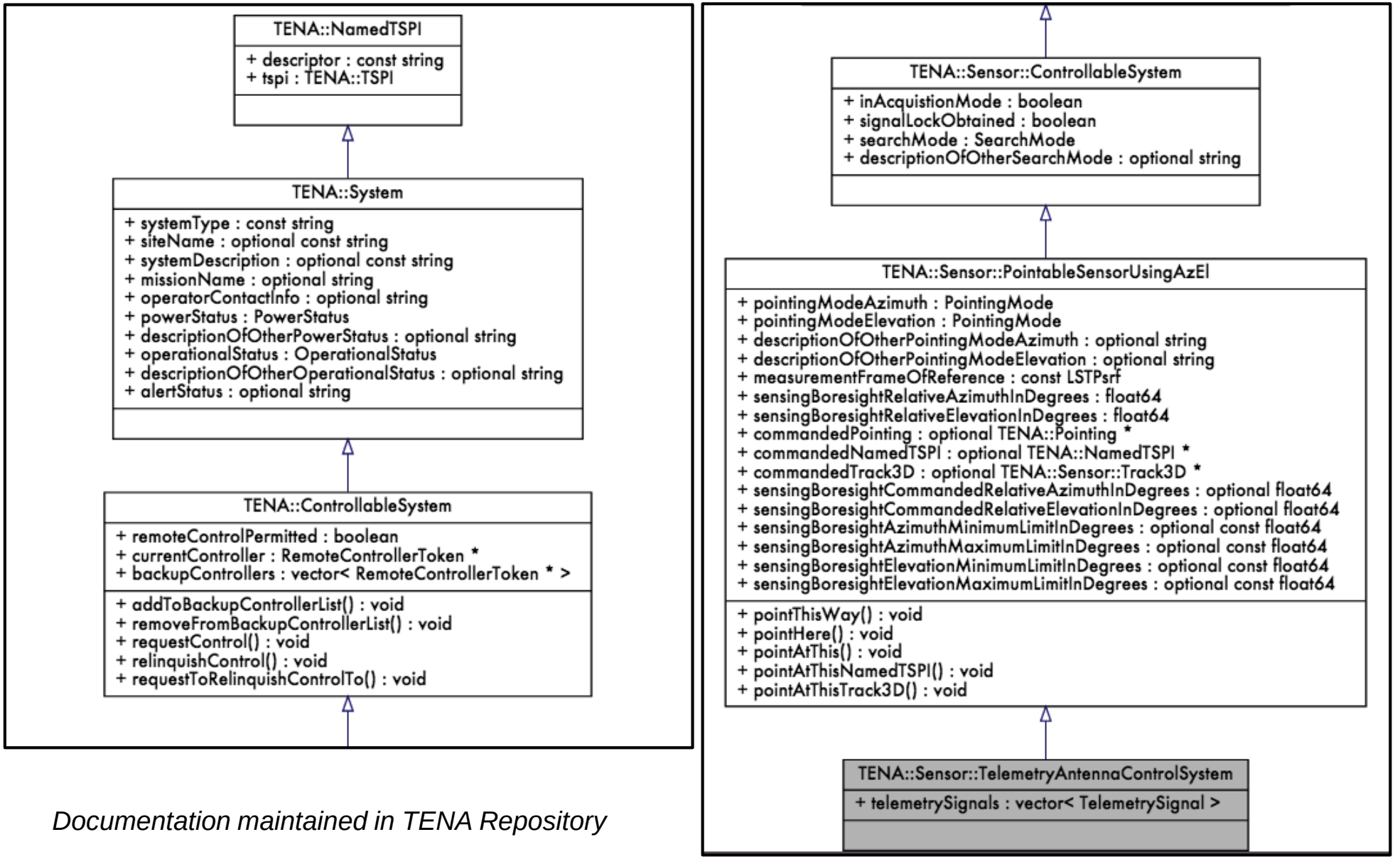
Remote Operations High Level Requirements

- **Minimal Interference**
  - Ranges have made significant investments into their event procedures and infrastructure which are not easily changed, so the introduction of remote operations must be done in an additive manner that does not disrupt existing operations
  - Use of TENA to support remote configuration and operations of range systems can not interfere with the current communication mechanisms used for the range instrumentation operational data
- **Multiple Vendor Support**
  - Remote configuration, monitoring, and control of the range instrumentation systems needs to work with multiple vendors of a particular system type
  - A common system interface will be promoted for enterprise interoperability, but vendor unique capabilities important to the range need to be supported
- **Unified Range Instrumentation Operator Station**
  - A proper evaluation of the operator “human machine interface” design is required to harness the increased productivity potential with remote operations, as duplication of existing single operator GUIs may be limiting to a remote operator capable of dealing with multiple systems simultaneously
- **Side-by-Side Testing**
  - Remote operation capabilities need to be deployed incrementally with the ability to “shadow” current event operations to support side-by-side testing to correct deficiencies and gain the confidence needed to be used operationally
- **Fault Handling**
  - Unmanned remote operations will present additional challenges associated with detecting and handling faults that need to be incorporated into the design and development of these capabilities

Object Models (OMs)

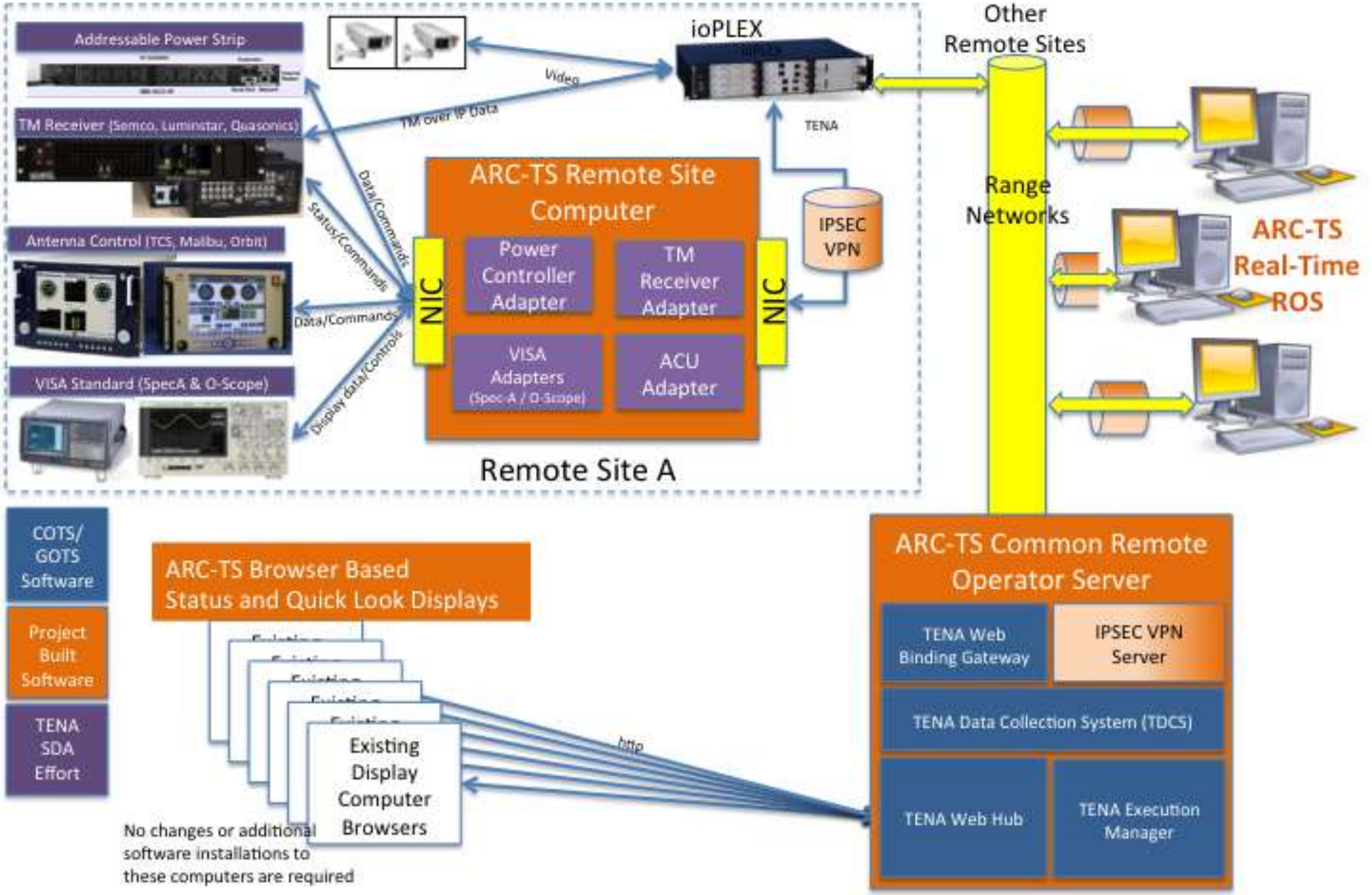
- **Object Models**
  - Object Models formally define system information and services with support for automatic code generation
  - Users are permitted to derive extensions to TENA standard OMs, or users can establish their own OMs
  - TENA SDA collects requirements and implementation considerations 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

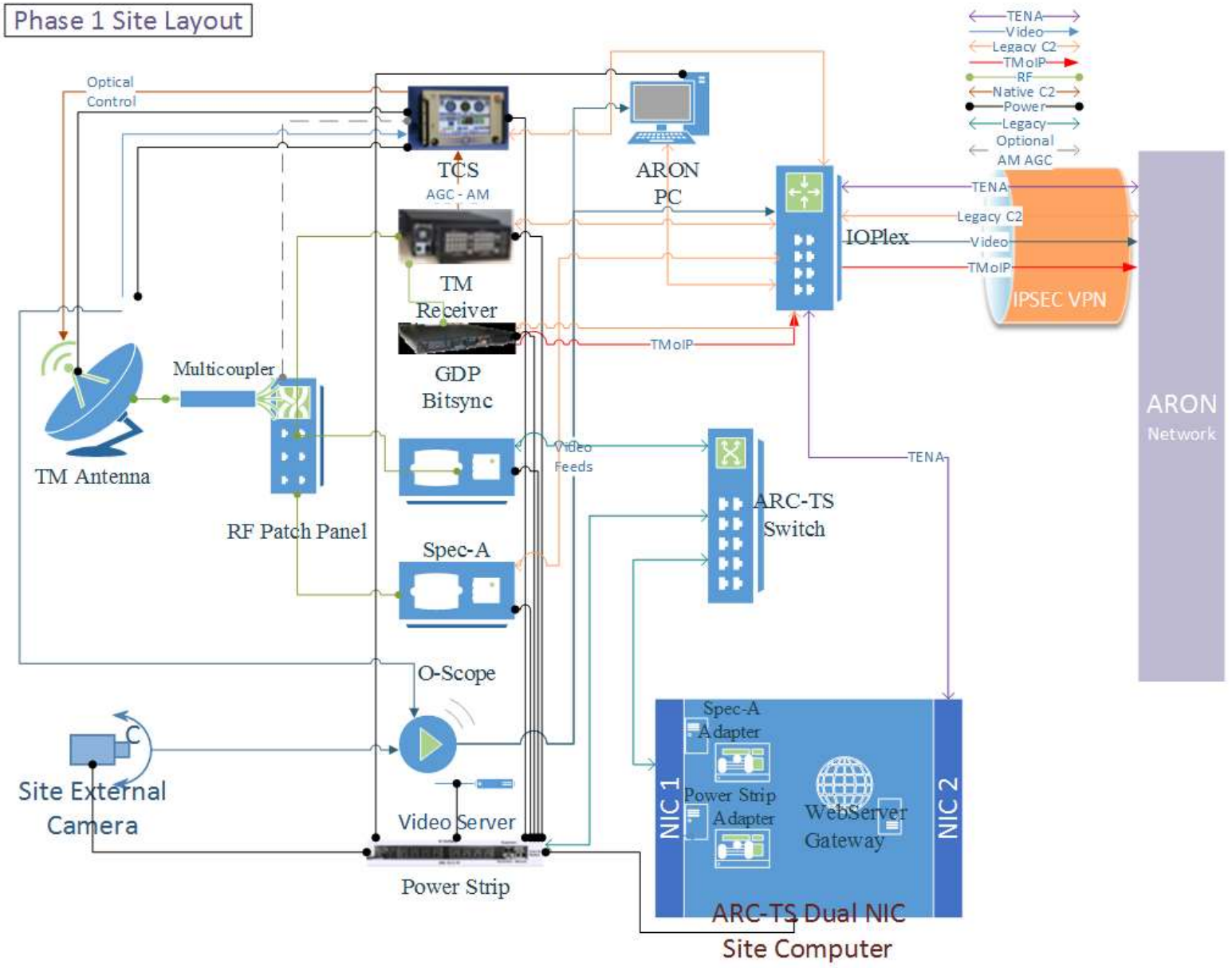


Documentation maintained in TENA Repository

Advanced Remote Control Telemetry System (ARC-TS) Architecture

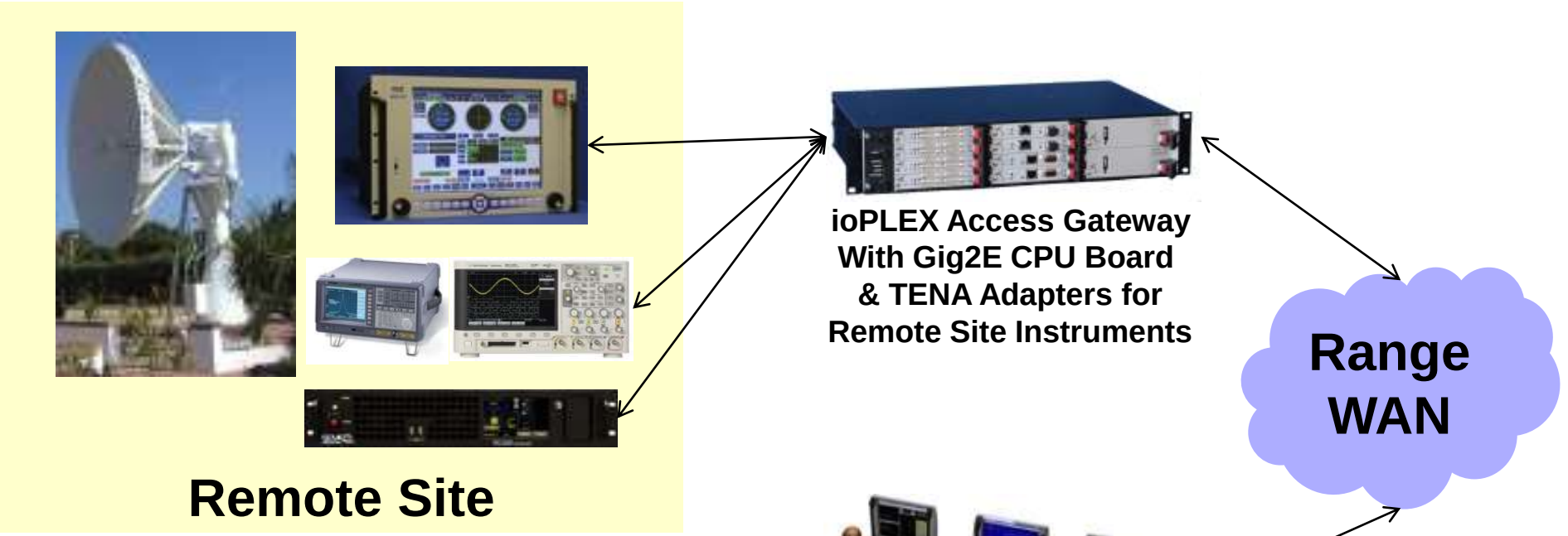


Advanced Remote Controlled Telemetry System (ARC-TS)

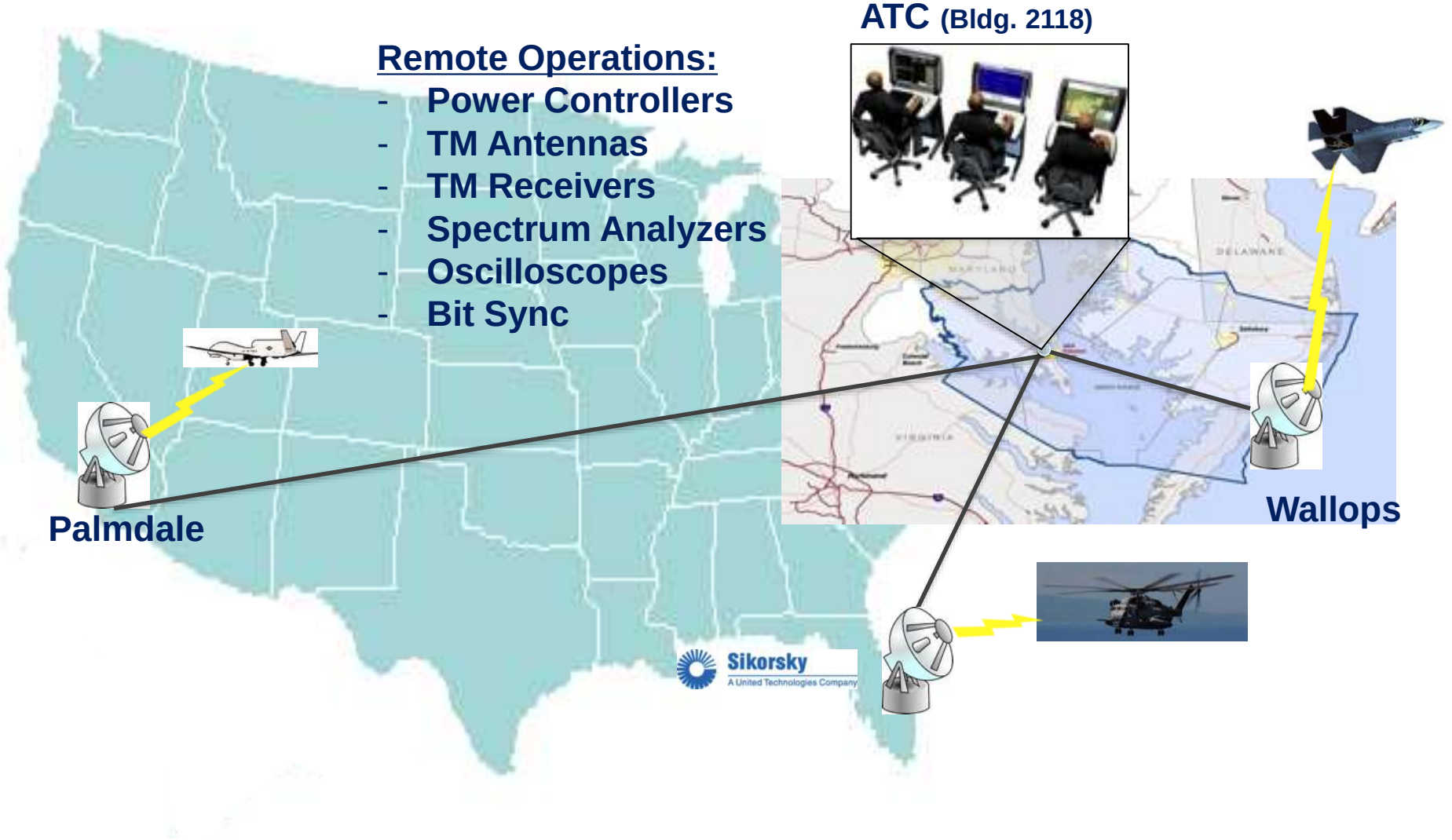


Remote Instrumentation Bridge Concept Using ioPLEX

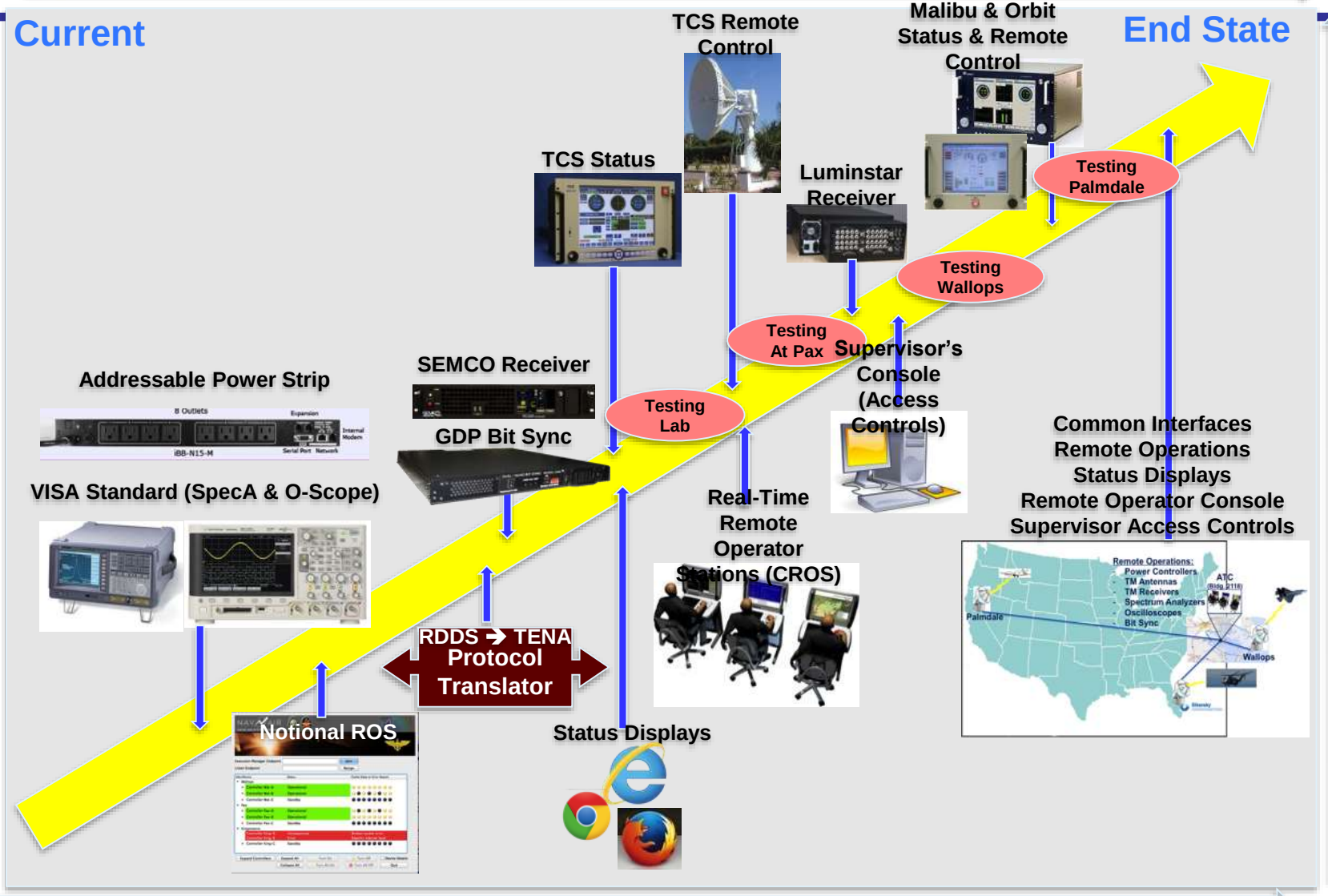
- **ioPLEX Gig2E Cards for Plugin TENA Adapter Approach**
- **Linux based quad-core CPU to host TENA Adapters and VPN**
- **Roll in increased functionality as part of the ATM – IP Conversions where this type of device used??**



Advanced Remote Control Telemetry System (ARC-TS) Operational View (OV-1)

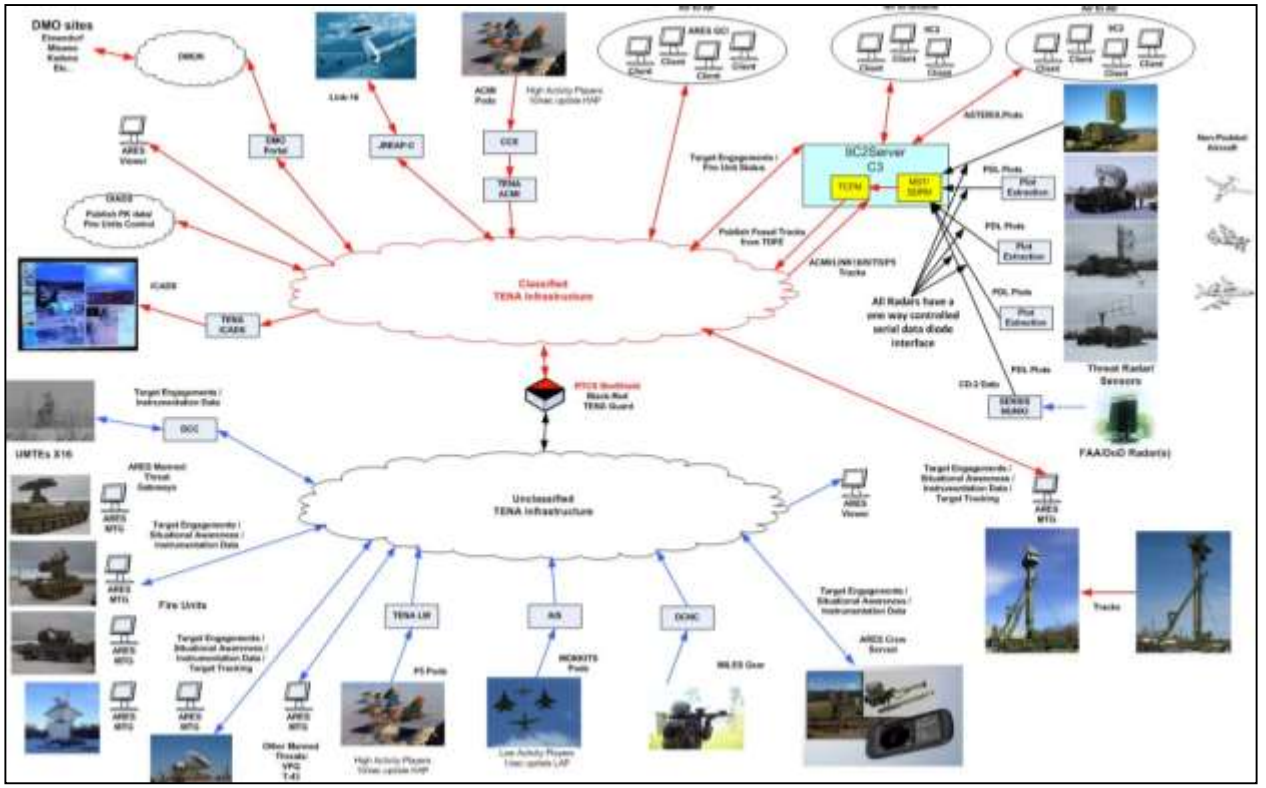


ARC-TS Roadmap Overview



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**

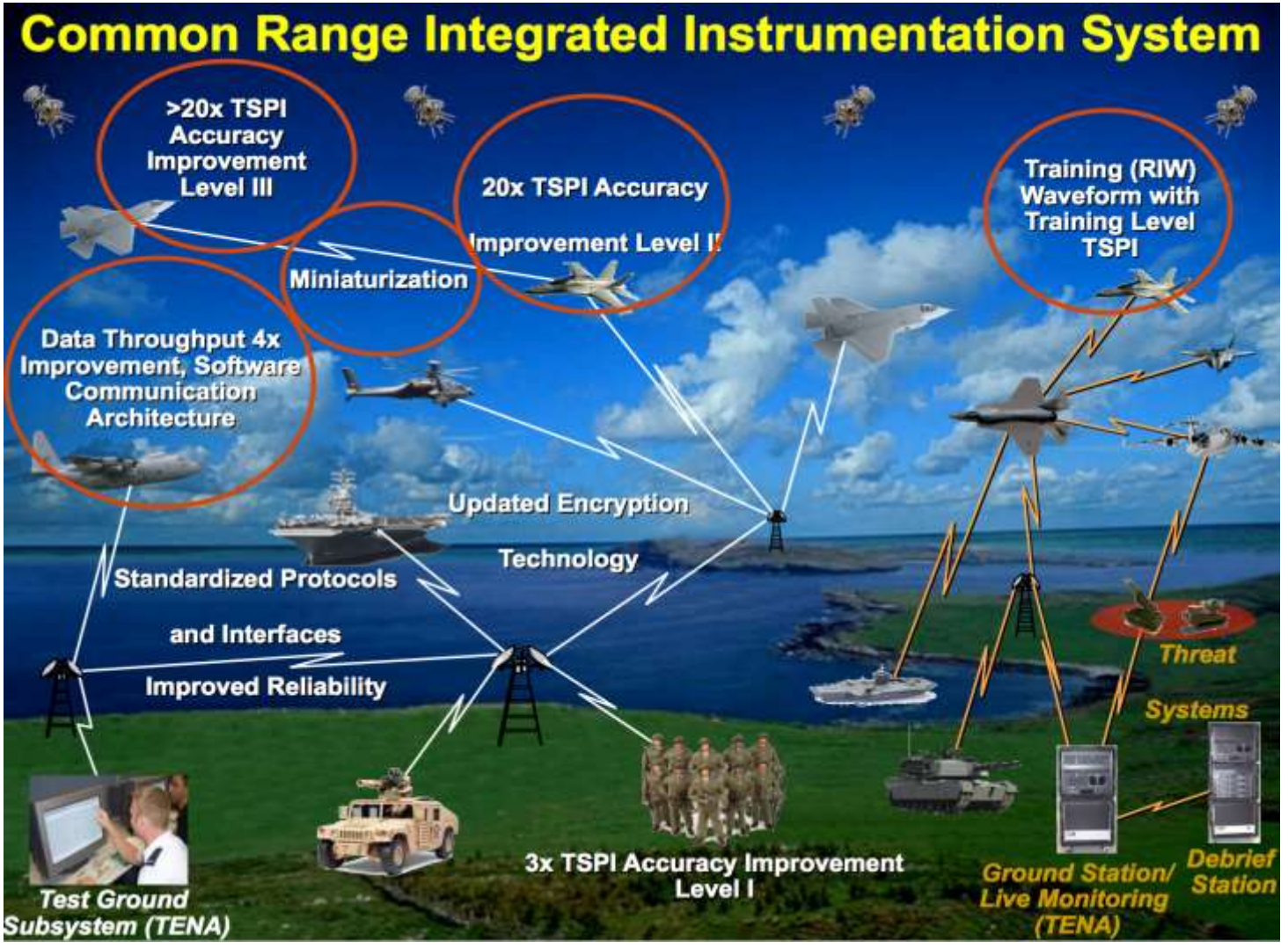


"TENA is the greatest thing that ever happened to us. We couldn't be doing today with all these systems–and we couldn't have all the participants that we do–if it weren't for TENA"

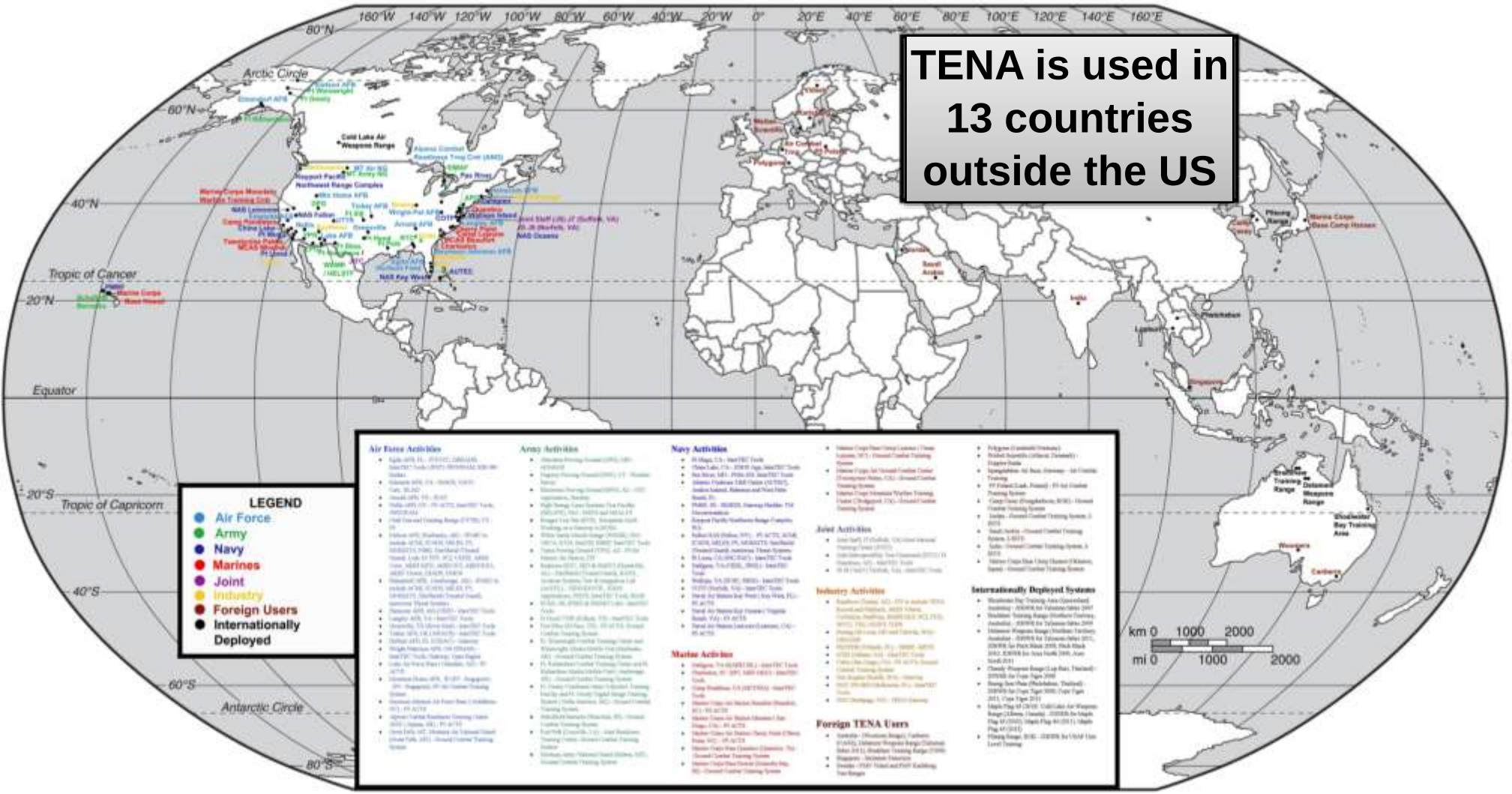
Billy D. Smith
Chief of electronic combat training requirements for Red Flag at JPARC

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

Army
Air Force
Navy
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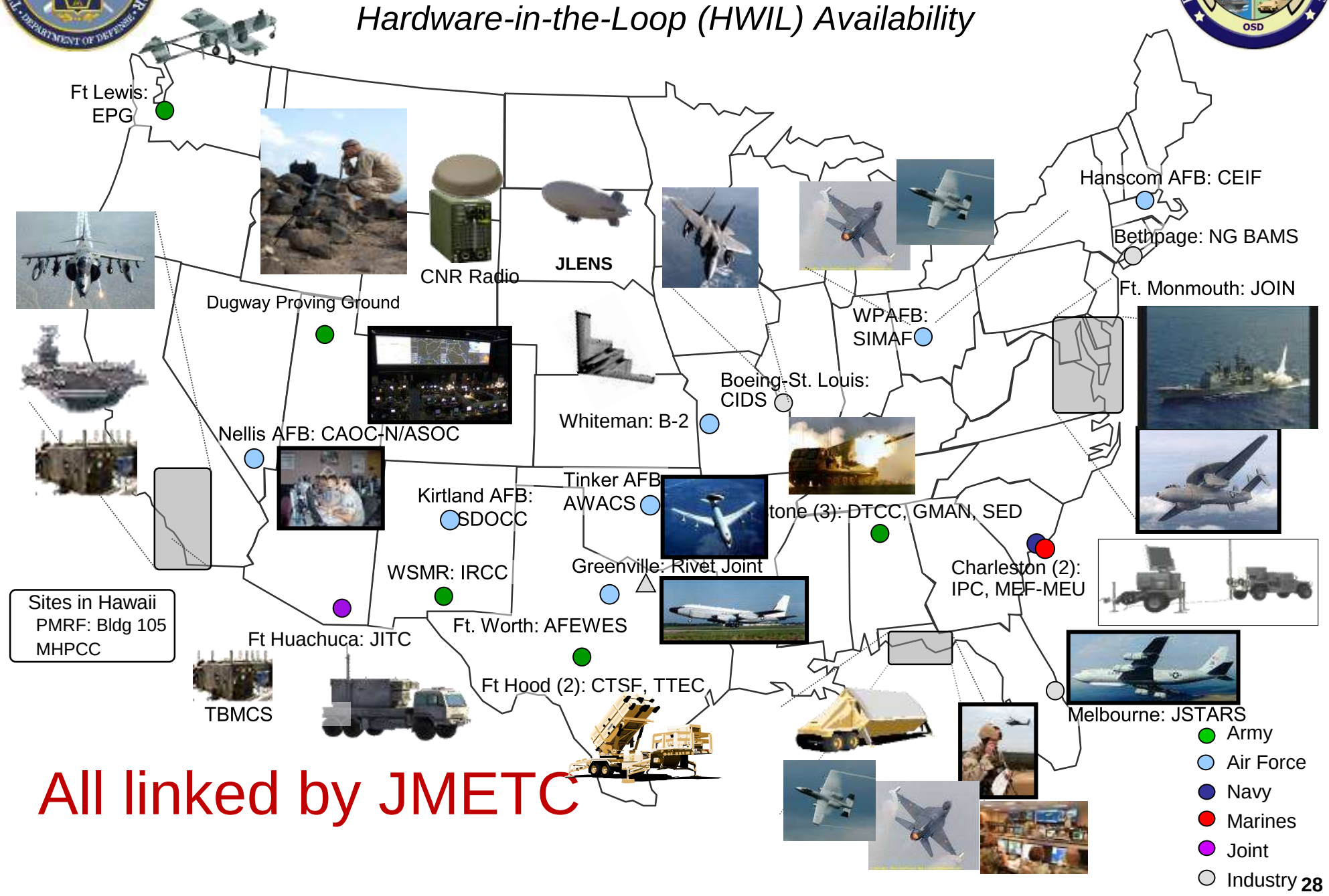
As of 10 Feb 2014

How a Test Planner Should View JMETC

Hardware-in-the-Loop (HWIL) Availability



All linked by JMETC

JMETC Event Support Services

- Pre-Test / Test Integration Emphasis:
  - Test Development/Design
    - Convert customer infrastructure requirements into JMETC-provided infrastructure solutions
  - Network Engineering
    - Designs, configures, establishes, and baselines connectivity solutions for test customers
  - IA Engineering
    - Ensures strong security posture for entire JMETC infrastructure
    - Works with JMETC sites directly to mitigate risks associated with IA and security
  - User Support
    - Ensures JMETC sites have the knowledge, skills, abilities, and site-specific examples to address test resource interoperability issues
    - Realizes test workarounds to event-specific interoperability issues
- Test Execution Emphasis:
  - JMETC SYSCON
    - Verifies infrastructure readiness and proactively troubleshoots problems as they are discovered
    - Partnership with NAVAIR AIC 5.4.1
  - Event Support
    - Provides direct support to customer test activities on an as-needed basis
- Post Test Emphasis:
  - Capture Lessons Learned and Infrastructure Gaps/Limitations

Major FY15 JSN Events

Customer	Event	Execution Dates	Onsite Support
MDA/Navy	Ballistic Missile Defense (BMD) Critical Experiment	Nov 19-21, 2014	No
MDA/DARPA	DARPA Air Dominance Initiative (ADI)	Dec 1-5, 2014	Yes
Joint	P-8A/High Value Unit (HVU) Escort, Anti-Submarine Warfare (ASW) Simulation Experiment (SIMEX) 15-2	Dec 8-12, 2014	Yes
NAVSEA	Interoperability Development & Certification Test (IDCT)	Dec 8-12, 2014	Yes
USSTRATCOM	Distributed Test Demonstration	Dec 15-19, 2014	Yes
Joint	F-35 Record/Playback	Jan 12-16, 2015	Yes
Joint	JITC Joint Interoperability Tests (JITS)	Jan 20-30, 2015	Yes
Joint	Joint Unmanned Air System (JUAS)	Jan 26-30, 2015	Yes
Air Force	Air Force Systems Interoperability Test (AFSIT)	Feb 2-20, 2015	--
Navy	Integrated Flight Demonstration (IFD) Live Fly	Feb 4-5, 2015	Yes
Navy	Aegis BDM Baseline	Feb 24-Mar 13, 2015	Yes
Joint	F-35 Record/Playback	Feb 24-27, 2015	Yes
Joint	JITV Joint Interoperability Tests	Mar 17-31, 2015	Yes
Navy	Aegis Integrated Air Missile Defense Baseline Test	Mar 23-27, 2015	Yes
MDA/Navy	Distributed Weighted Engagement Scheme (DWES)	April 20-24, 2015	Yes
Joint	Distributed Integration & Interoperability Assessment Capability (DIIAC) BMD FST	June 8-12, 2015	Yes
Joint	JITC Joint Interoperability Test	June 29- July 7, 2015	Yes
Joint	F-35 Record/Playback	Aug 20-28, 2015	Yes
Joint	Simulation Exercise 15-5 (SIMEX)	Aug 24-28	Yes
Joint	Joint Unmanned Air System (JUAS)	Sept 15-17, 2015	Yes
Joint	JIAMDO Correlation/De-correlation Interoperability Test (C/DIT)	Sept 14-18, 2015	Yes

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 Fall 2016**
    - **Next JMETC User Group Fall 2016**

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

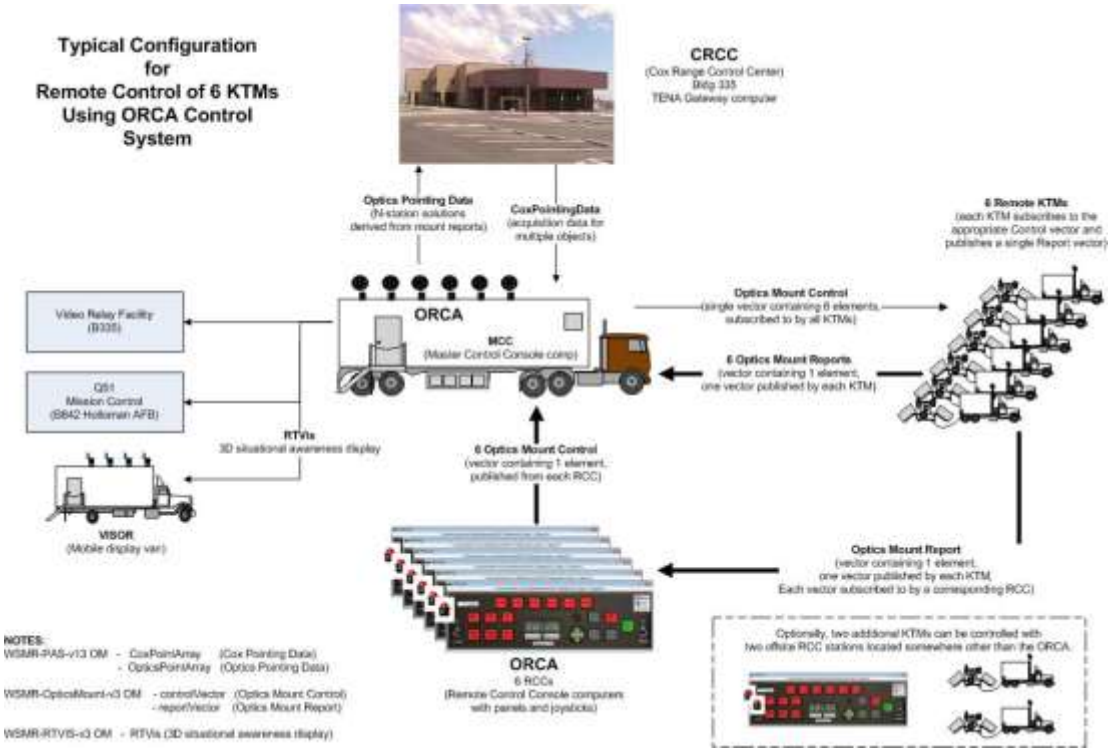
- **JMETC Program Office Contact:**
  - E-mail: **jmetc-feedback@jmetc.org**
  - Telephone: (571) 372-2699
  - JMETC Website: **http://www.jmetc.org** – under construction

- **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

Backup Slides

TENA at White Sands Missile Range (WSMR)

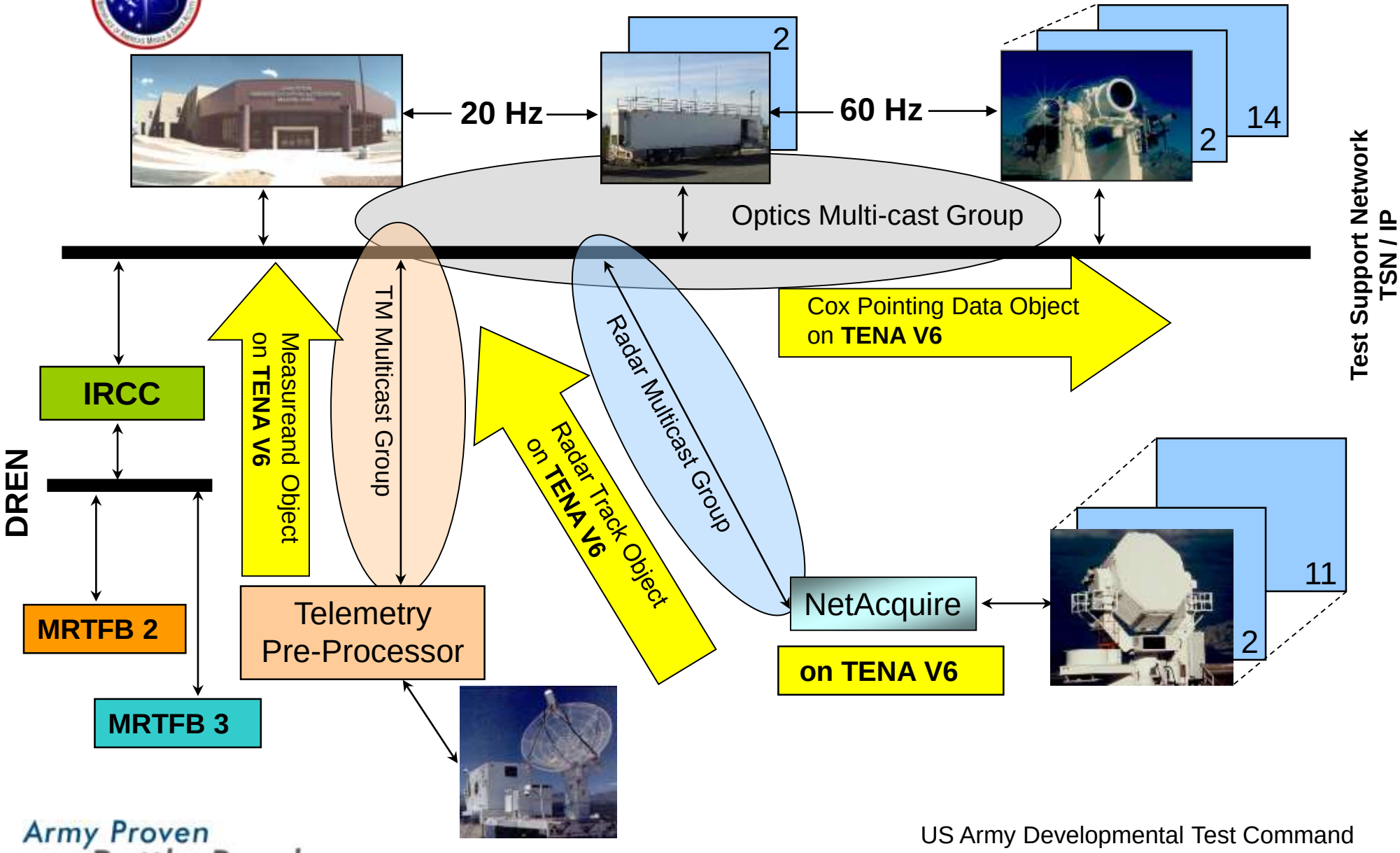
- **TENA has been supporting the real-time distributed operation of the WSMR optics systems for the past 7 years, including data exchange and remote operation**
  - **Based on the success of optics, TENA is being expanded to other range systems**



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

Charlie Conroy
WSMR Optics Development Engineering Lead

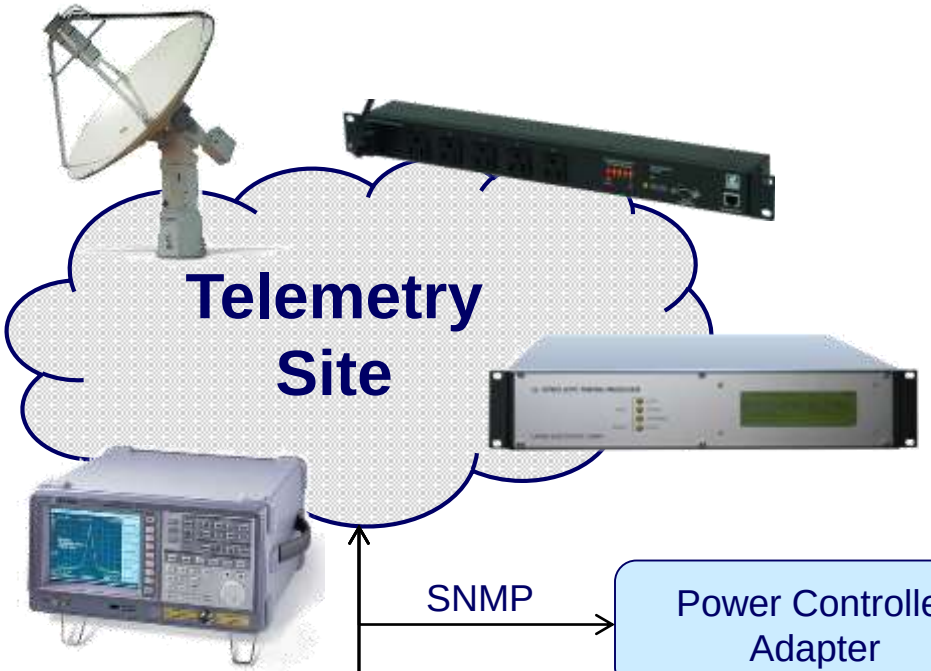
A Compelling, Comprehensive Range Instrumentation Use Case at White Sands



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

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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