TENA and JMETC  Overcoming Challenges in Distributed Testing

Gene Hudgins
TENA and JMETC
User Support Lead
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
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

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

TENA will be used to connect the following range systems:

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

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-RangelInstrumentation (TENA-RI)**
  - Emerging standard OM structure specifically designed for range instrumentation systems

- **WSMR-DICE**
  - Provides extension to the standard OMs for WSMR specific attributes:

```cpp
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

**Sensors**

- Makaha Ridge
- Kokkee Park
- Telemetry
- Radar Systems

**Acromatics**
- Data M105
- Pedestal

**iNet**
- VTM Q2
- Q4
- Q5
- Q6

**Supports Legacy iNet**

But Not Required For TENA

**New TENA Capability**
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
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??

Remote Site

ioPLEX Access Gateway With Gig2E CPU Board & TENA Adapters for Remote Site Instruments

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

Remote Operations:
- Power Controllers
- TM Antennas
- TM Receivers
- Spectrum Analyzers
- Oscilloscopes
- Bit Sync

ATC (Bldg. 2118)

Palmdale

Wallops
ARC-TS Roadmap Overview

Cost Savings (Remote Manning / Travel)

Autonomy and Maintainability

Remote Operations Functionality

FY 2015

Current

Addressable Power Strip
VISA Standard (SpecA & O-Scope)

End State

FY 2016

TCS Remote Control
Luminstar Receiver

FY 2017

Malibu & Orbit Status & Remote Control
Testing Palmdale

Testing Wallops

Common Interfaces Remote Operations Status Displays Remote Operator Console Supervisor Access Controls

Real-Time Remote Operator Stations (CROS)

Supervisor’s Console (Access Controls)

Testing At Pax

Testing Lab

RDDS ➔ TENA Protocol Translator

Notional ROS

Status Displays

FY 2015

FY 2016

FY 2017
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.

“This 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

TENA is used in 13 countries outside the US
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
- 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

Sites in Alaska
- Ft. Greely: CRTC

Sites in Hawaii
- PMR: Bldg 105
- MHPCC

Redstone (10): SMDC
- RTC: DTCC, DISTL
- SED: Patriot, THAAD, FAAD, GSIL, JLENS, MUSE, C-RAM
- AMRDEC
- JMETC NOSC

Charleston (2): SSC Data Ctr
- MEF-MEU
- WNW

Edwards (2): Ridley
- 412th EWG IFAST
- F/A-18, IBAR, TSPIL
- ITEC, EA-6B, EW CyCon
- Camp Pendleton
- MCTSSA
- Corona: NSWC
- Palmdale, BAMS
- Point Loma:
  - SSC-PAC 59140
  - SSC-PAC HAIFP
  - FPC-PAC JEDI
- West Agg Rtr.
- Rancho Bernardo, NGC BAMS

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

Army
- Joint
- Industry
- Navy
- Academia
- Marines

As of 10 Feb 2014

Graph:
- FY07, FY08, FY09, FY10, FY11, FY12, FY13, FY14
- Y-axis: 0 to 100

Orlando NCR
- LMCO Global Vision Network
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
<table>
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<th>Customer</th>
<th>Event</th>
<th>Execution Dates</th>
<th>Onsite Support</th>
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<td>MDA/Navy</td>
<td>Ballistic Missile Defense (BMD) Critical Experiment</td>
<td>Nov 19-21, 2014</td>
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<td>MDA/DARPA</td>
<td>DARPA Air Dominance Initiative (ADI)</td>
<td>Dec 1-5, 2014</td>
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<td>P-8A/High Value Unit (HVU) Escort, Anti-Submarine Warfare (ASW) Simulation Experiment (SIMEX) 15-2</td>
<td>Dec 8-12, 2014</td>
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<td>Interoperability Development &amp; Certification Test (IDCT)</td>
<td>Dec 8-12, 2014</td>
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<td>USSTRATCOM</td>
<td>Distributed Test Demonstration</td>
<td>Dec 15-19, 2014</td>
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<td>Joint</td>
<td>F-35 Record/Playback</td>
<td>Jan 12-16, 2015</td>
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<td>JRTC Joint Interoperability Tests (JITS)</td>
<td>Jan 20-30, 2015</td>
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<td>Jan 26-30, 2015</td>
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<td>Feb 2-20, 2015</td>
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<td>Integrated Flight Demonstration (IFD) Live Fly</td>
<td>Feb 4-5, 2015</td>
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<td>Aegis BDM Baseline</td>
<td>Feb 24-Mar 13, 2015</td>
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<td>JRTC Joint Interoperability Tests</td>
<td>Mar 17-31, 2015</td>
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<td>Aegis Integrated Air Missile Defense Baseline Test</td>
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<td>Distributed Weighted Engagement Scheme (DWES)</td>
<td>April 20-24, 2015</td>
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<td>June 8-12, 2015</td>
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<td>JRTC Joint Interoperability Test</td>
<td>June 29- July 7, 2015</td>
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<td>Joint Unmanned Air System (JUAS)</td>
<td>Sept 15-17, 2015</td>
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<td>JIAMDO Correlation/De-correlation Interoperability Test (C/DIT)</td>
<td>Sept 14-18, 2015</td>
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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](http://www.tena-sda.org)
  - Download TENA Middleware
  - Submit Helpdesk Case ([http://www.tena-sda.org/helpdesk](http://www.tena-sda.org/helpdesk))
  - Use for all questions about the Middleware

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

- **TENA Feedback:** [feedback@tena-sda.org](mailto: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

20 Hz

60 Hz

Optics Multi-cast Group

Cox Pointing Data Object on TENA V6

NetAcquire on TENA V6

Telemetry Pre-Processor

TM Multicast Group

Radar Multicast Group

IRCC

DREN

MRTFB 2

MRTFB 3

Test Support Network

TSN / IP

OPSEC Review, 4 May 11 - APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITE
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

Telemetry Site

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

Range Instrumentation Network

SNMP
Power Controller Adapter

VISA
Spectrum Analyzer Adapter

TCP
Telemetry Antenna Controller Adapter

proprietary

VISA
Telemetry Receiver Adapter