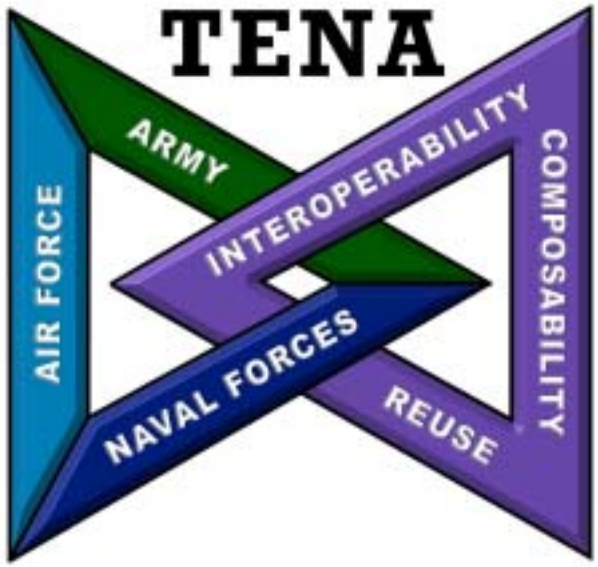


Test and Training Enabling Architecture (TENA)

The Foundation for DoD Range Interoperability

Gene Hudgins

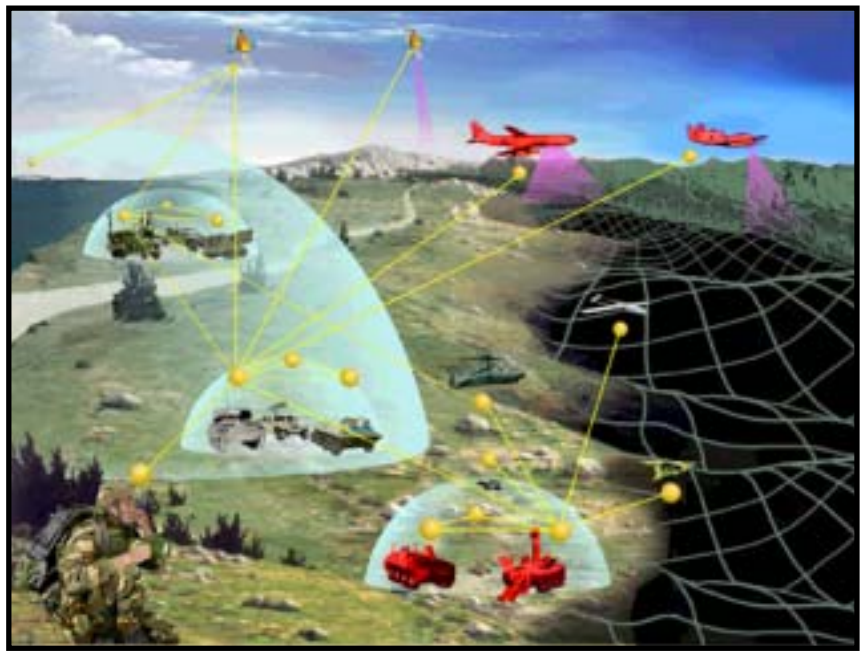
TENA Training and RCC Coordinator

26 June 2003

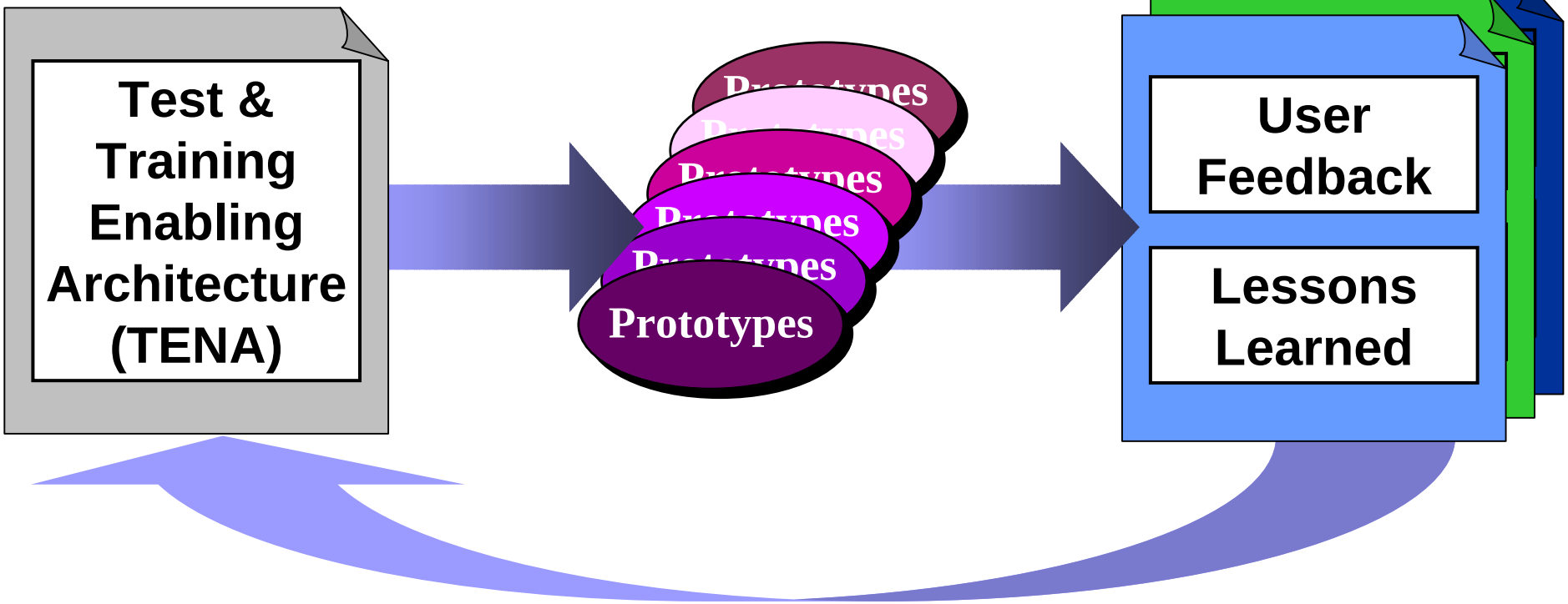
ATEC Test Technology Symposium 2003
"Distributed Testing for Systems of Systems"

Foundation Initiative 2010
Overall Vision

- **Design and prototype a technological infrastructure to enable interoperability and reuse within the range community**
  - Seamless environments that integrate test ranges and facilities, training ranges, laboratories, and modeling and simulation (M&S) assets
  - Improve the scope and scale of testing and training the increasingly complex systems and missions in a cost-effective manner
- **Recognize that our solutions need to be more than quality software, we need to:**
  - Elegantly solve key usability issues
  - Satisfy the core operational and performance requirements
  - Work with the range community so the solutions are implemented
- **Lay the groundwork for full support for integrated multi-range events**



Overall Development Strategy



- TENA was revised based on user feedback and lessons learned from working software prototypes
- TENA will be revised in the future based on future prototypes

TENA is based on real-world tests at real ranges

Driving Technical Requirements

1. **Interoperability**
   - The characteristic of a suite of independently-developed components, applications, or systems that implies that they can work together, as part of some business process, to achieve the goals defined by a user or users.

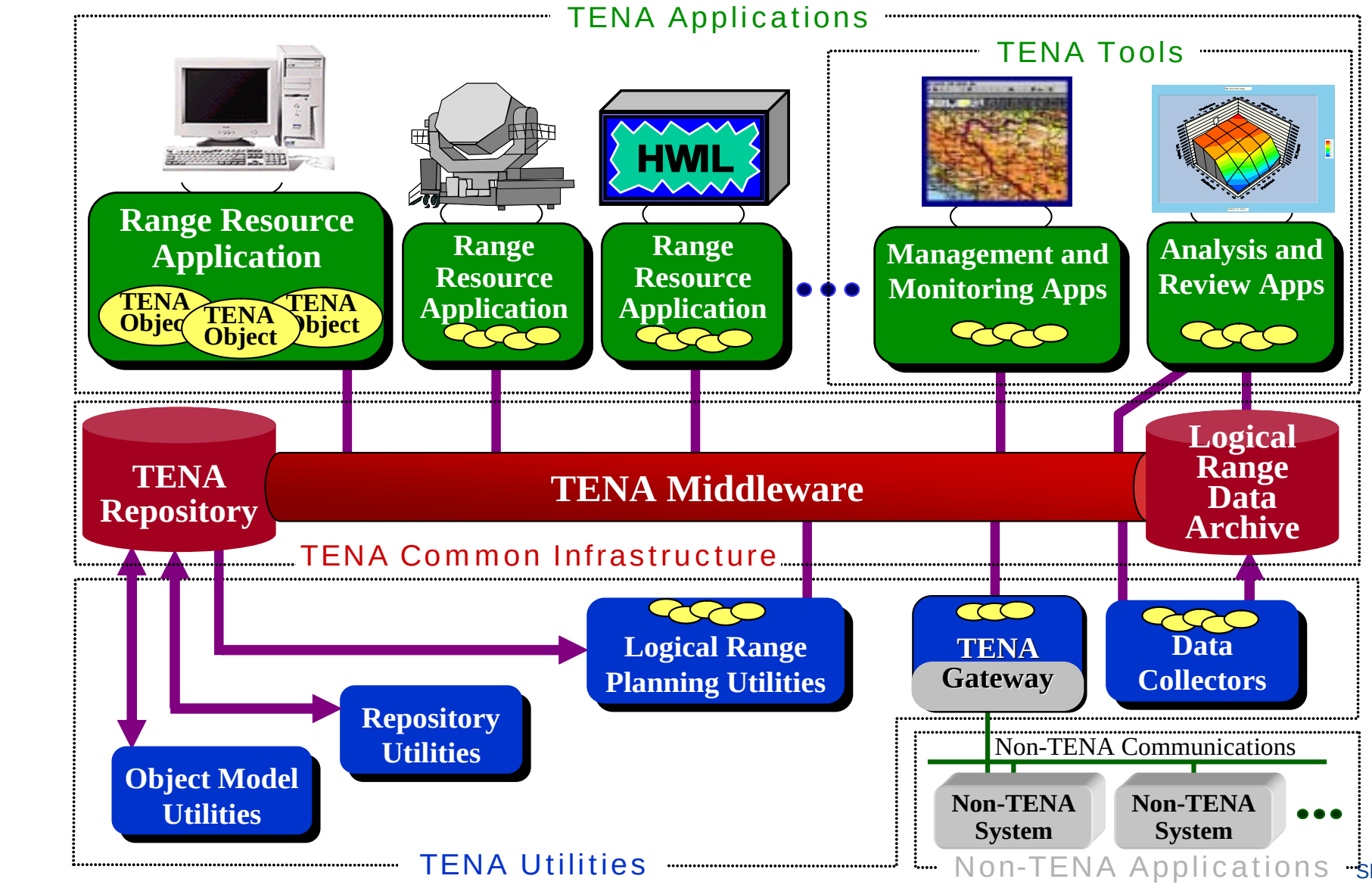
2. **Reusability**
   - The characteristic of a given component, application, or system that implies that it can be used in arrangements, configurations, or in system-of-systems beyond those for which it was originally designed.

3. **Composability**
   - The ability to rapidly assemble, initialize, test, and execute a system from members of a pool of reusable, interoperable elements.
   - Composability can occur at any scale — reusable components can be combined to create an application, reusable applications can be combined to create a system, and reusable systems can be combined to create a system-of-systems.

Achieving Interoperability, Reuse, and Composability

- **Interoperability requires:**
  - A common architecture → **TENA**
  - An ability to meaningfully communicate
    - A common language → **TENA Object Model (OM)**
    - A common communication mechanism → **TENA Middleware**
    - A physical connection between the two systems → **Network, shared memory**
  - A common context
    - A common understanding of the environment → **TENA Object Model (Environment)**
    - A common understanding of time → **TENA OM, TENA Middleware**
    - A common technical process → **TENA Technical Process**
- **Reuse and Composability require the above, plus**
  - Well defined interfaces and functionality for the application to be reused → **Reusable Tools, Repository**

TENA Architecture Overview



Ways TENA Middleware Can Exchange Data

- **TENA presents to the range user a unification of several powerful inter-application communication paradigms**
  - **Publish/Subscribe**
    - Similar in effect to HLA, DIS, or other PDU-based communication systems
    - Each application publishes certain types of information (the publication state) which can be subscribed to by any other application
  - **Remote Method Invocation**
    - Similar to CORBA or Java RMI
    - Each object that is published may have methods that can be remotely invoked by other applications
  - **Messages**
    - Individual messages that can be sent from one application to one or more other applications
  - **Data Streams**
    - Native support for audio, video, and telemetry

Key Functionality of TENA Beyond HLA

Standard Object Model

TENA provides for the managed evolution of a standardized Object Model (interfaces, data formats, data definitions, control commands, etc.)

Significance: ***Range-community-wide agreed upon data formats, definitions, etc. promotes interoperability to a greater degree than the HLA specification***

High Performance and Reliability

TENA Objects are "compiled-in" when the application is made TENA-compliant

Significance: ***Higher performance, plus higher reliability since any errors in data formats will be discovered during software compiling (pre-mission) rather than during the test mission (at run-time)***

Manages Persistent Data

TENA provides for the management and standardization of database information throughout the range event lifecycle, including scenario information and data collected during an exercise

Significance: ***Interoperability is achieved before, during, and after a range event, leading to easier setup, initialization, and analysis, saving both time and money***

Support for Data Streams

TENA supports real-time delivery and storage of data stream information (audio, video, and telemetry)

Significance: ***A substantial amount of test information is streaming data. Fully integrating data streams into TENA provides high-performance management of this type of information in a standard, reusable, interoperable fashion***

Support for More Complex, Meaningful, User-Defined Object Models

TENA allows for objects to be composed of other objects (objects can contain other objects)

Significance: ***Small "building block" objects (Time, Position, Orientation, etc.) can be standardized and reused to efficiently define other more complex objects, yielding more interoperability quickly and at less cost than with the HLA***

TENA Middleware marshals/demarshals data, rather than relying on individual applications to do so

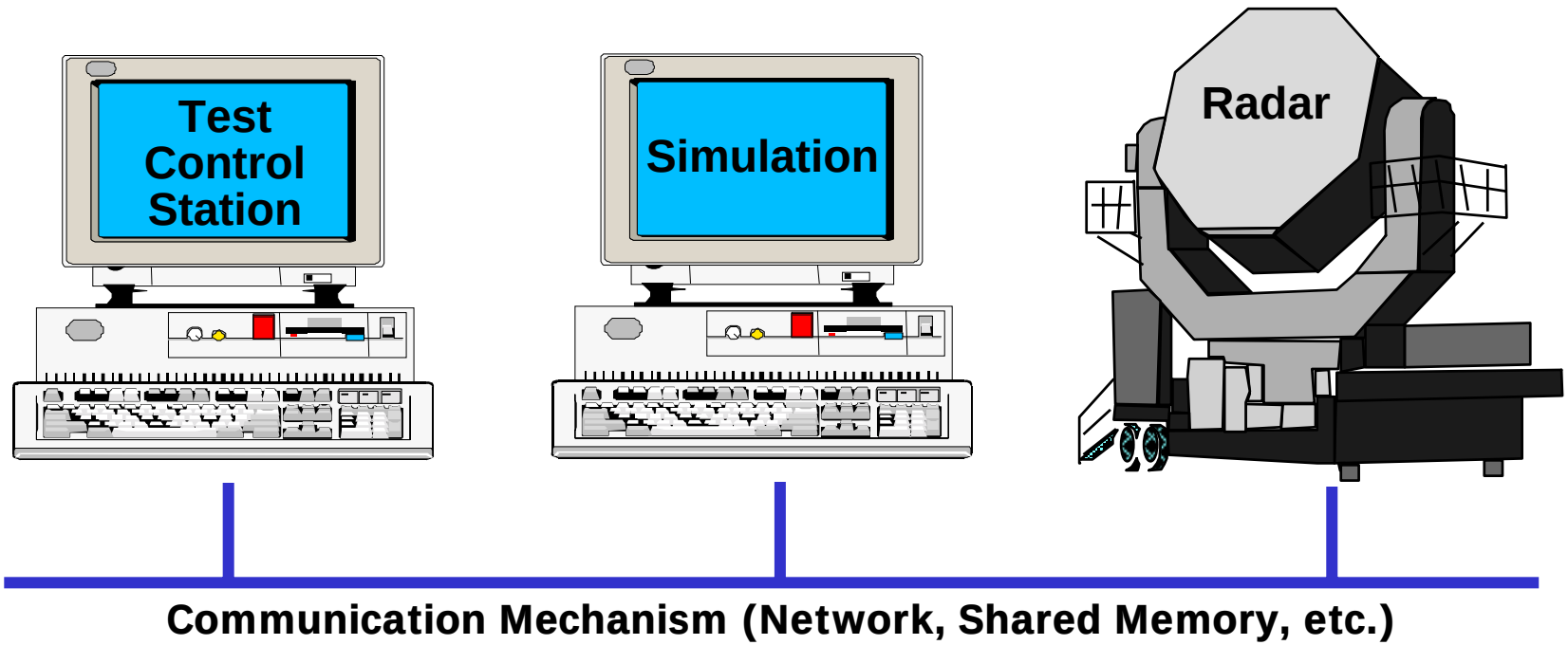
Significance: ***Middleware marshaling makes it easier to integrate different computer platforms (Windows, Linux, Sun, etc.) in a distributed test event and avoid integration errors due to inconsistent user-written software***

TENA supports remotely invoking "methods" (control commands, operations, processes) of another application

Significance: ***Software interfaces can be designed more naturally and effectively for distributed test events***

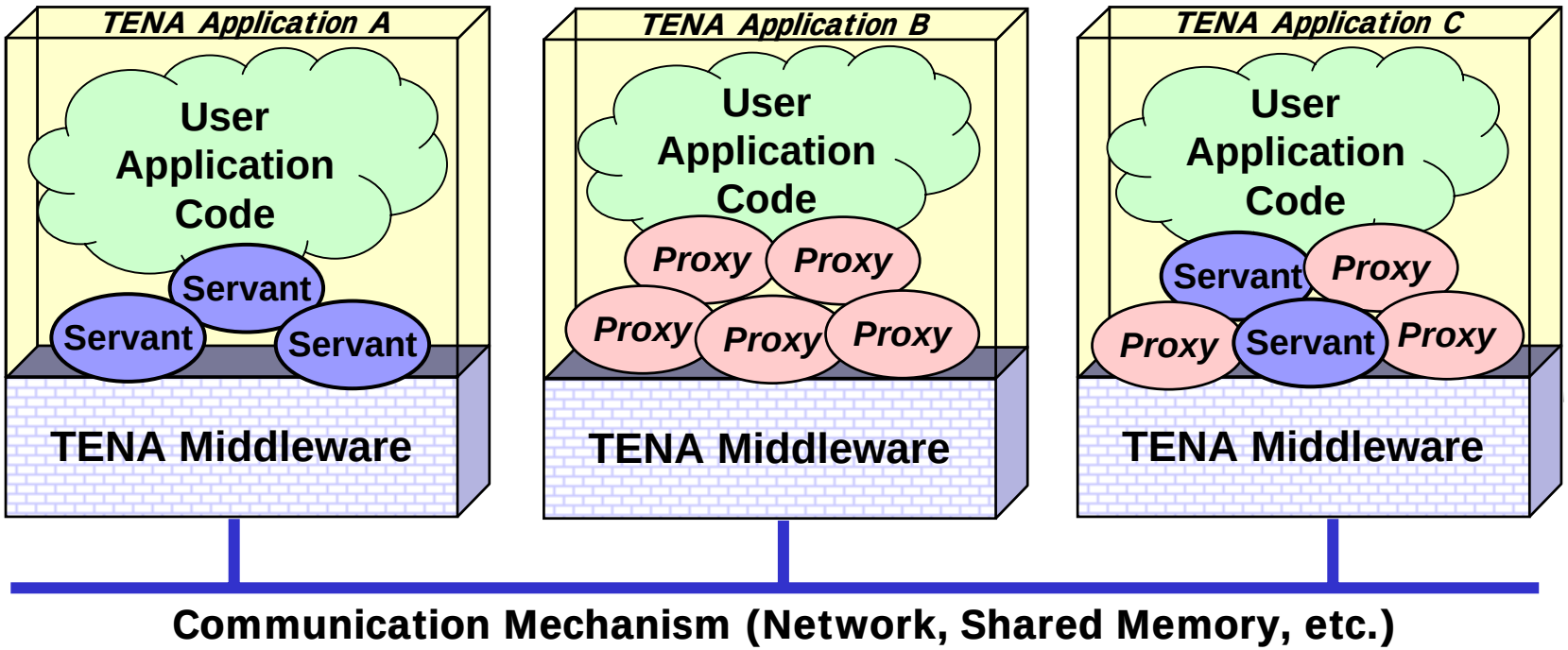
Logical Range Simple Example

TENA specifies an architecture for range resources participating in logical ranges



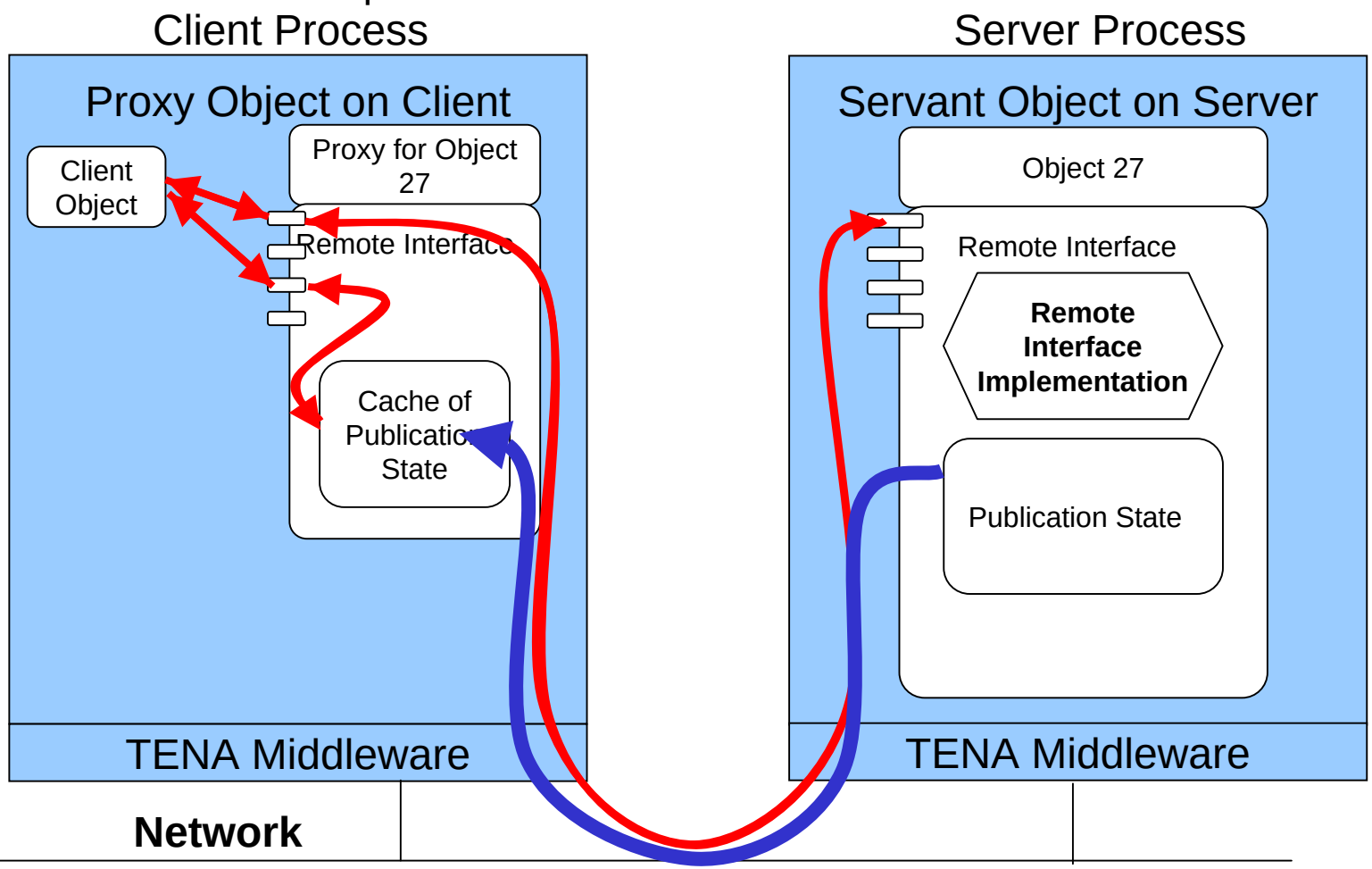
Logical Range Simple Example

- **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

- **When objects are distributed across multiple processes or machines**
  - One object is the “real” object – the one with the implementation
  - All the others are “proxies”



TENA Middleware Platform/Language Support

- **Release 3.0 Platform Support**
  - Windows NT 4.0 / 2000 / XP with MSVC++ 6.0sp5 (to be retired)
  - Windows NT 4.0 / 2000 / XP with MSVC++ 7.0
  - Linux Red Hat 7.2 with gcc 3.0.3
  - Sun Solaris 8 (SunOS 5.8) with gcc 3.0.3
- **Additional Platforms To Be Supported**
  - Sun Solaris 8 with SunPro 5.4 compiler
  - SGI IRIX 6.5.12 with gcc 3.0.3 on SGI hardware
  - VxWorks 5.5, Motorola MPC7XXX PowerPC, Tornado 2.2 with gcc 3.0.3
- **Programming Language Support**
  - C++ support provided with current release
  - OCX (COM) wrapper developed by one of the TENA users (RTTC)
  - Java application layer developed by one of the TENA users (Eglin)

Range Integration in Millennium Challenge 2002 (MC02)

Blue Forces

- Ships
- Ground forces
- Aircraft

Opposing Forces

- Aircraft & air targets
- Ships
- Ground forces

Nellis AFB
TENA Gateway

Land Range/China Lake
TENA Gateway

National Training Center/Ft. Irwin
TENA Gateway

Electronic Combat Range/China Lake
TENA Gateway

Sea Range/Point Mugu
TENA Gateway

US Marines/So. California Logistics Airfield

Joint Network

Joint Training, Analysis, and Simulation Center

TENA Gateway

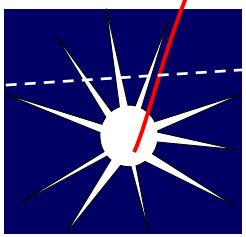
Integrating Software

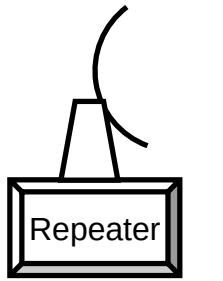
Global Command & Control System

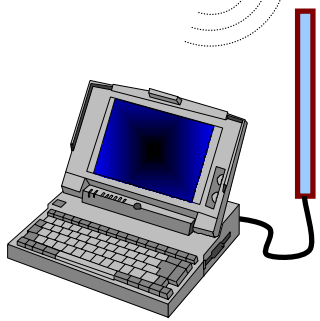
Model & Simulation Feed

Command, Control, Communications, Computers, Intelligence Feed

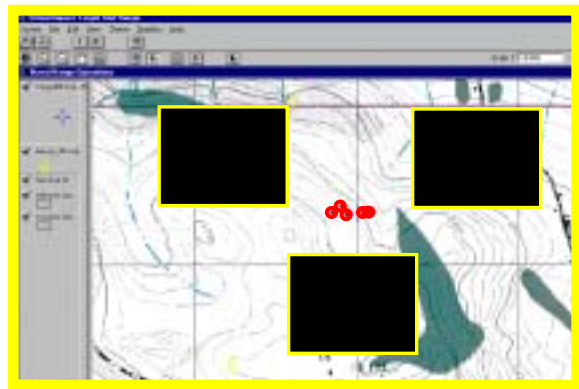
Gulf Range VAST/IMPASS







Shipboard Processing
Map Rendering
Virtual Target



Acoustic Processing
GPS
Communication Link

VAST/IMPASS Network Connectivity

Eglin Central Control Facility

TENA on NIPRNET

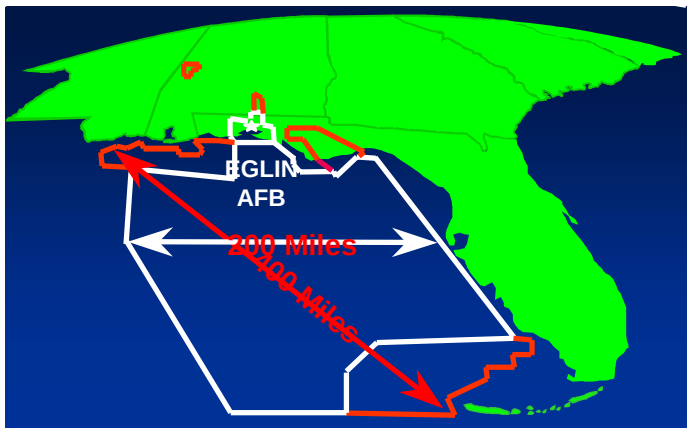
CDSA
Dam Neck, VA

TENA on Fiber

TENA on Microwave

Eglin Range Site A-15

CSS
Panama City, FL



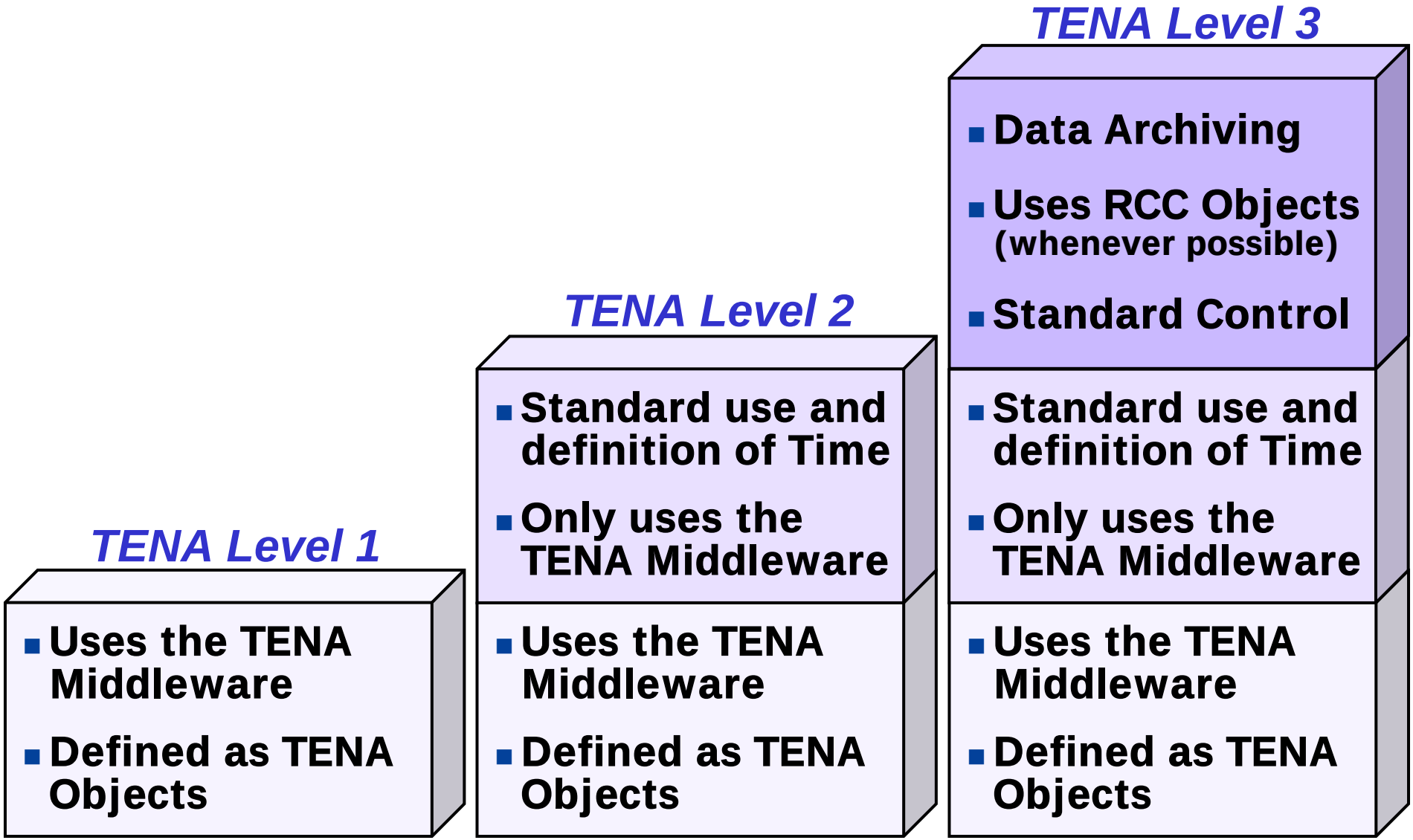
Architecture Management Team (TENA AMT)

- **System Engineers & Technical Leads for the current major stakeholders of TENA**
  - AAC, Eglin AFB FL
  - NUWC, Newport RI
  - NAWC-AD, Pax River MD
  - WSMR, White Sands NM
  - RTTC, Huntsville AL
  - EPG, Fort Huachuca AZ
  - NAWC-WD, China Lake & Point Mugu CA
  - Virtual Proving Ground (VPG)
  - Common Training Instrumentation Architecture (CTIA)
  - PMRF Synthetic Range
  - National Unmanned Underwater Vehicle T&E Center (NUTEC)
  - Enhanced Range Applications Project (EnRAP)

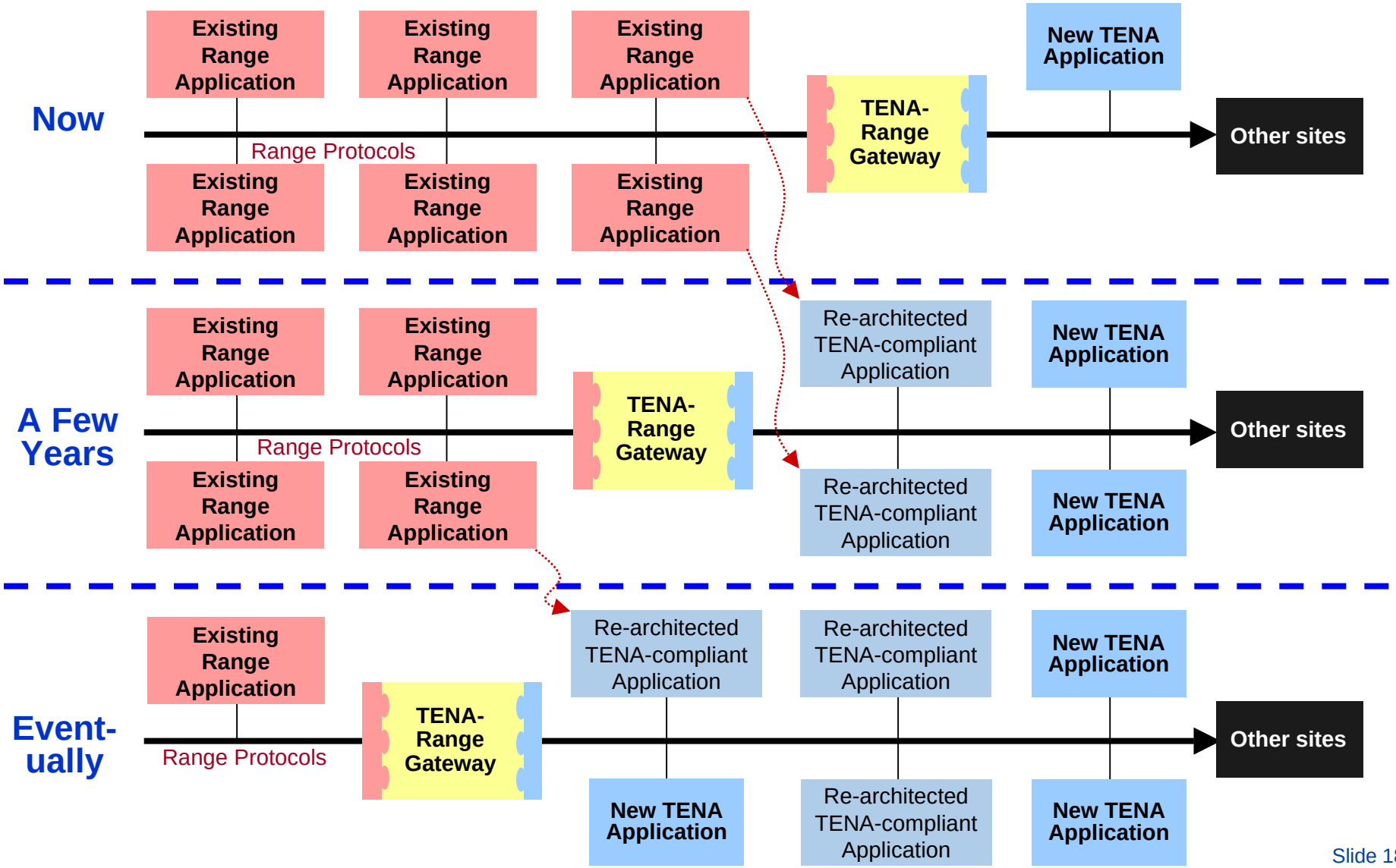
Meetings every 4-6 weeks

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

TENA Compliancy Levels



Gradual Deployment of TENA



Summary of What We Have

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 Sun
- **A Process to Develop and Expand the Architecture**
  - CTTRA Workshops, AMT Meetings, and RCC Coordination
- **A Technical Strategy to Deploy the Architecture**
  - Gateways provide interim solutions as TENA interfaces
- **A Definition of Compliancy**
  - Levels of compliancy to enhance communication among systems engineers and investment decision makers