Title: Foundation Initiative 2010

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ABSTRACT

The Foundation Initiative 2010 (FI 2010) project is an interoperability initiative of the Director, Test, Systems Engineering and Evaluation, Office of the Under Secretary of Defense (Acquisition and Technology), funded through the Central Test and Evaluation Investment Program (CTEIP). The Army is the lead service for execution, with Navy and Air Force support. The FI 2010 effort is postured to improve systems development, testing, training and fielding through the application of object-oriented systems interoperability between simulations, hardware-in-the-loop (HITL) test laboratories, live/operational tests, and training systems. The FI 2010 concept builds on High-Level Architecture (HLA) and Test & Training Enabling Network Architecture (TENA) standards and includes a core set of tools, inter-range communication capabilities, interfaces to existing assets, a repository of reusable software and procedures for conducting an object-oriented exercise.

FI 2010 serves as the foundation upon which ranges will want to build their future investments. Therefore, the development strategy relies upon partnering with ranges from the beginning, and this is accomplished through the creation of development test cells and coordination with Range Commanders Council and the Common Test and Training Range Architecture working groups. This paper provides an overview of the FI 2010 project and supplies details of the objectives to be accomplished in FY 98. These include tests and assessments of the simulation and federation object model development tools provided by the Defense Modeling and Simulation Office and a synthesis of requirements for a universal, flexible display engine with reusable components. They also include a check-out of the latest HLA runtime infrastructure and a Hardware-in-the-Loop to Open Air Range interaction investigation involving the Naval Undersea Warfare Center, the Air Force Development Test Center and the Naval Air Warfare Center. A video documentary of this investigation will be provided as part of the paper presentation.

1.0 Introduction

The Foundation Initiative (FI) 2010 project responds to Defense Science Board recommendations to establish standards, facilitate interoperability, and fully internet test and training ranges and facilities.

FI 2010 also responds to the increasing use of Modeling and Simulation (M&S) in general and to the Simulation Based Acquisition (SBA) and Simulate, Test, Evaluate Process (STEP) initiative of the Under Secretary of Defense (USD) for Acquisition and Technology (A&T) in particular. The architecture and products delivered by FI 2010 are intended to:

1) Reduce duplication and the cost of procurement and maintenance of range instrumentation and software.

2) Facilitate the integration of T&E and training range assets across multiple ranges.

3) Facilitate the integration of live, virtual and constructive simulations to create the larger, more complex, and more realistic test and training battlespace environments demanded by modern weapons systems and tactics.

The FI 2010 Project was established at the beginning of Fiscal Year (FY) 1998 at the recommendation of the Test and Evaluation Reliance and Investment Board (TERIB). It consolidated four existing Central Test and Evaluation Investment Program (CTEIP) Projects: the Test and Training Enabling Architecture (TENA), Common Display and Processing Systems (CDAPS), Virtual Test and Training Range (VTTR) and the Joint Regional Range Complex (JRRC). The products and commodities developed will entail concepts that foster extensive software reuse, use advanced computational developments, and exploit distributed interactive simulation techniques and commercial-off-the-shelf technologies (COTS), where applicable. The products will include sets of common, integrated software capabilities and processes to significantly improve the capability to configure and re-configure instrumentation resources to acquire, network, process, display, and archive data in support of T&E missions and training exercises.

The Full Operational Capability (FOC) to be provided by the FI 2010 architecture and products is notionally referred to as the Logical Range—a set of live, constructive and virtual resources assembled into a system of systems to support a specific test mission or training exercise. The Concept of Operations (ConOps) for the Logical Range is defined in the document of the same name dated March 1997 (Draft).

A simple example of a logical range is illustrated in Figure 1. The Navy Synthetic Environment for Tactical Integration (SETI) program integrates high fidelity torpedo simulation capabilities with live Fleet submarines operating at depth and speed on range. Using SETI, a submarine can fire on a live target using the Hardware In The Loop (HWIL) torpedo in the Weapons Analysis Facility (WAF) at the Naval Undersea Warfare Center (NUWC) Division Newport. Both firing and target submarines can "see" the simulated torpedo in real-time while submerged thus allowing for weapons wire guidance and target evasion. With planned connectivity enhancements SETI will provide simulated targets, countermeasures and ocean environments. The benefits of SETI include unlimited availability of virtual torpedoes to support crew training and torpedo hit or miss assessments, capabilities previously unavailable or unaffordable.

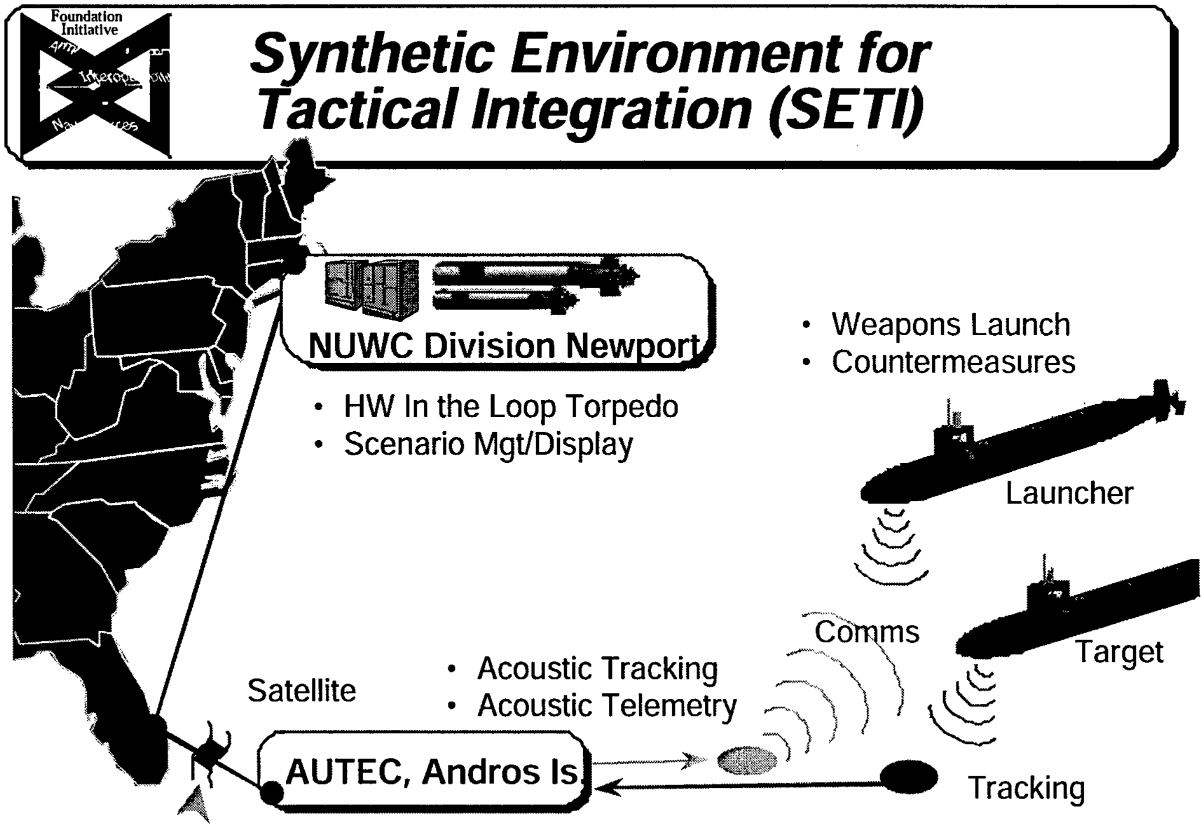

Figure 1. Synthetic Environment for Tactical Integration Exercise

The SETI project is one of three FI 2010 exercises to be conducted in FY 98. The remaining two are illustrated in Figures 2 and 3 below. Their purpose is to gain broad-based insight into the utility and feasibility of conducting distributed synthetic and live testing and training events using a common architecture and reusable software tools. The FY 98 exercises focus on linking hardware-in-the-loop facilities and open air ranges, and each investigates alternative configurations, interfaces and procedures.

The Joint Advanced Distributed Simulation (JADS) System Integration Test (SIT) II is a follow-on to the Advanced Distributed Simulation (ADS) test conducted in FY97 by the JADS Joint Test Force. Using HLA instead of a Distributed Interactive Simulation (DIS) implementation, the JADS SIT II replicates the original JADS SIT risk mitigation test scenario, linking the Pre-flight Integration of Munitions and Electronic Systems (PRIMES), the Guided Weapon Effectiveness Facility (GWEF), and the Central Control Facility (CCF) at the Air Force Development Test Center, Eglin AFB, FL. Operated and maintained by range personnel, a Development Test Cell (DTC) emulating the Major Range and Test Facility Base has been established to cost-effectively develop, test, and validate the software interfaces and exercise tools in a controlled environment. Toward our ultimate goal of range interoperability and reuse, the JADS SIT II exercise serves to be an integral step – generating comparison data to past DIS methodologies, identifying potential HLA shortfalls to be rectified by Test and Evaluation Enabling Architecture (TENA), and providing insight (when combined with results from other exercises) to the common aspects among ranges and facilities ideal for standardization.

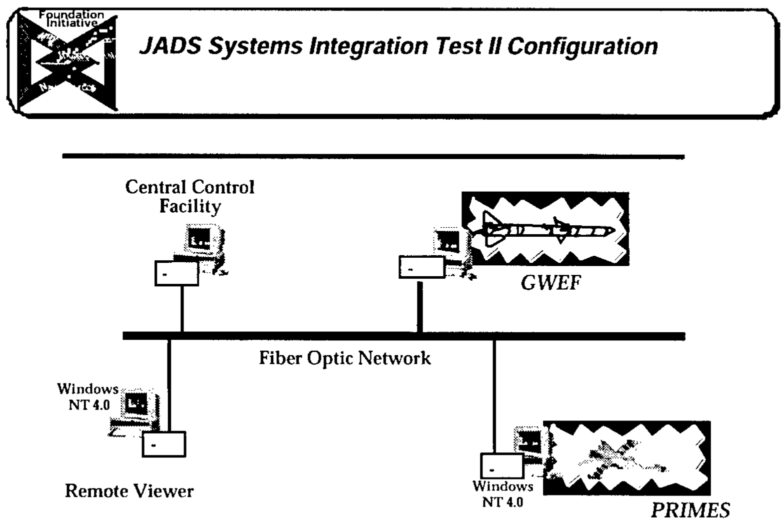

Figure 2. Joint Advanced Distributed Simulation (JADS) System Integration Test, Version II

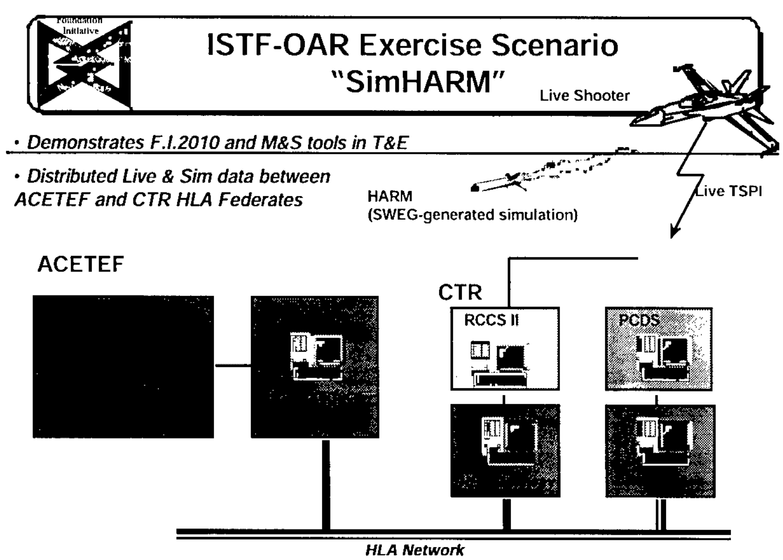

Figure 3. Simulated High Speed Anti-Radiation Missile (SimHARM) Exercise, Linking an Installed Systems Test Facility (ISTF) to an Open Air Range (OAR).

2.0 The Need for a New "Foundation"

The conceptual framework for military operations defined in Joint Vision 2010 is of size, scale, and scope that cannot be physically, technically, or economically recreated within the existing DoD Test and Training infrastructure. DoD Test and Training facilities have heretofore evolved autonomously, resulting in duplication of effort and resources, differing processes and procedures, and wide variations in the age, type, and capability of basic Test and Training resources such as instrumentation, computers, software, communication systems, and data displays. These variations limit the interoperability, sharing and reuse of resources demanded by the Joint Vision paradigm. In addition, the increasing use of modeling and simulation in support of acquisition streamlining portends a new era of duplication and disparity if a interoperability common framework is not established soon. A clear advantage of using modeling and simulation in test and evaluation is the potential to conduct distributed operations across a common network. To make this happen, participating models and simulations must have the ability to interact, and FI 2010 is charged with developing a promulgating the capabilities that will make this interaction practical.

3.0 FI 2010 Architecture and Products Characteristics

The FI 2010 architecture and products are designed to support the full spectrum of Test and Training facilities including Open Air Ranges (OARs), Systems Integration Laboratories (SILs), Hardware in the Loop (HWIL) Facilities, Measurement Facilities (MFs), Installed System Test Facilities (ISTFs), and constructive, live, and virtual Models and Simulations.

Several characteristics are required to foster interoperability, sharing, reuse and multi-domain polymorphic applications. Many of these characteristics are key to successfully implementing the logical range concept. All play a role in reducing duplication and cost in range infrastructure developments and in providing the desired multi-domain applicability to support the full spectrum of Test and Training facilities.

3.1 Distributability

The FI 2010 architecture and products will support execution on multiple hardware platforms that are geographically distributed and connected via one or more communication networks. Multiple users will be able to access data from various databases in order to plan potential exercises, and will be able to query potential participants about their availability and current or projected operational capabilities.

3.2 Extensibility

The architecture will also allow LR components to be easily upgraded or modified to support add-on requirements without requiring restructuring of the existing architecture. Add-ons could include providing more and/or different workstations from which planning and exercise control would be conducted, incorporating new data networks, including new sensors, and weapons and/or models to simulate them, etc.

3.3 Interoperability

Systems, units, or forces must be able to provide and receive services from other systems, units or forces, and to use the services such that they can operate together effectively. Interoperability is a system characteristic, which allows the assets of one test or training facility to be used and controlled by one or more other facilities "on demand"; as seamlessly as if they were an integral part of their organic systems.

3.4 Modifiability

The FI 2010 architecture and products will support, to the maximum extent possible, the ability of a hardware or software component to be easily modified to perform various tasks, to operate within new systems or environments, or to adapt to changes in scope or magnitude of performance requirements. Modifiability often depends on an item's modularity and use of standard interfaces and is normally more easily achieved with software. As an example, to be modifiable the simulation of a sensor or weapon system must provide for the various performance parameter values to be determined by preset and easily changeable data files/tables rather than "hard" coded.

3.5 Portability

This is the ability of a system, hardware or software component, or data to be easily transferred from one hardware or software environment/system to another. This requires the existence and use of common interfaces so that hardware/software components and data can be easily inserted into various environments/systems with minimal reformatting or interface modification. FI 2010 will assist in the development of commercial standards to promote development of common interfaces needed for portability.

3.6 Reusability

Reusability is the ability to use the same products and capabilities at multiple ranges and facilities. An example product might be a graphical display software package. Other examples may include processes, procedures and documentation templates (e.g., design, test, standards). Reuse supports a common-core of a product that is, in fact, exactly the same from instance to instance of that product, and it also supports the ability to adapt the reusable product in predetermined ways at the level of a local instance. Reuse is distinct from commonality in that commonality implies every instance of the reused product is exactly the same. Effective reuse is an optimization of commonality and flexibility that recognizes the unique requirements of individual ranges and facilities within a common core environment or domain. Reuse enables significant savings in long-term development and maintenance costs and is an effective and efficient path to sharing and interoperability.

3.7 Scaleability

Scaleability is the ability to use the same architecture and application software on many different classes of hardware/software platforms from personal computers to supercomputers and for tasks varying in scope and complexity (extends the portability concept). The capability to handle various operations of greatly different scales of operational requirements and to be able to easily grow to accommodate increased workloads beyond the initial capability. An example of scaleability in the LR context is to be able to run a single vehicle exercise at a single range or a multi-vehicle exercise at multiple ranges and other facilities with the same basic system.

3.8 Sharability

The FI 2010 architecture and products shall support sharing which is defined as the ability of one facility to directly use the products generated by another facility. Interoperability is the most extensive form of sharing, but is not the only form. This definition of sharing includes a variety of "one-way" information exchanges where data or data products are sent to many facilities, but control of the data generation is strictly at one source. An example of this capability is the effective transmission of post-test analysis products without custom translation required for each product user.

3.9 Usability

The FI 2010 products will enable the LR users to perform their tasks effectively and efficiently. A usable system is can be used by a variety of system operators for a variety of tasks. Although operators may have unique or specialized skills (e.g. test conductors, flutter engineers, graphics operator, etc.), they should not need special training to use those skills via standard system interfaces. Operator interfaces will be "friendly," and operators will be able to perform their tasks following the instructions and guidance provided in manuals or on-line help. Operator entries will be by point and click (mouse, track ball, etc.), pull-down menu selection, keyboard, or other simple interface device.

4.0 Operating a Logical Range

The FI 2010 architecture and products will support the ability to rapidly define, setup and execute a logical range and its associated battlespace environment for a test mission or training exercise by assembling and managing the necessary resources from a pool of available live, constructive, and virtual resources. Regardless of whether the particular resources used for a given event are actual or simulated, the objectives of the event are the same: to accurately test and / or evaluate the performance of a system under test (SUT) or training participant under a certain set of conditions. This is accomplished, usually in a stand-alone mode today through the use of numerous T&E and Training support resources known commonly as OARs, SILs, HWIL facilities, MFs, ISTFs, and M&S facilities. Meeting the objectives of reducing duplication, facilitating the integration of T&E and training range assets, and facilitating the integration of live, virtual, and constructive simulations requires that the capabilities to define, setup (configure), and operate the assets (e.g., instrumentation, environment generators, stimulators) be drawn from a common framework. This is also true for the assets used in conducting post-event analysis.

4.1 Defining a Logical Range

Current methods of defining the specific assets of T&E and Training support resources are predominantly unique to the particular resources being considered. Referring back to the SETI experiment as an example, the means for defining what torpedo information needs to be available during the conduct of that exercise (e.g., speed, heading, position) would be different for: an actual firing of a torpedo at AUTEC (underwater 'OAR'), a simulated torpedo launch in the WAF (HWIL facility), or a synthetic torpedo launch in a M&S facility. This could potentially be true for all of the participants required for a particular LR instance (i.e., test mission or training event). Recognizing that the cost of defining the assets required for a logical range operation must be significantly less than the current, aggregate cost of defining these assets for stand-alone operations, the logical range will provide the definition capabilities as described below. These capabilities will be common among the various resources being assembled for a logical range operation and transparent to the user with respect to the specific resource from which the asset is being identified (eg., OAR, HWIL, or M&S based).

Resource Asset Identification. This identification capability includes asset attributes such as name, type, location, input data, and output data. An example of a resource asset would be a radar (of type FPS-16 with output data of range, azimuth, elevation, and time).

Resource Asset Definition. A logical range resource asset definition allows a logical range operation planner to define, where necessary, the operation unique resource asset information. An example of such an asset would be a telemetry system. The format of the input stream, the processing to be applied to each raw data item decommutated from the stream, and the engineering units of the resulting data items are specific to a particular logical range operation.

Resource Repository. This repository shall includes typical data base capabilities to store, search, retrieve, copy, and modify entries. Entries will consist of the resource asset identification and definition information. It will also ensure that information is provided in a FI2010 compliant format.

Resource Browser. A resource browser capability allows remote access to the resource repository. This access capability will be available via existing community desktop computer systems (i.e., no logical range-specific or unique equipment).

Logical Range Definition Capability. This includes the means to assemble resource assets from the resource asset repository in accordance with the specific requirements of a mission or exercise. It includes the capability to designate primary and secondary resource assets to accommodate the rapid reconfiguration of a logical range due to failures and scheduling conflicts associated with designated primary resource assets during LR operations.

Logical Range Repository. This repository will include typical data base capabilities to store, search, retrieve, copy, and modify entries. These entries will consist of logical range instances stored via the logical range definition capability. It shall also ensure that information is provided in a FI2010 compliant format.

Logical Range Definition Utilities. The following utilities will be provided to support the logical range definition capability:

Performance Prediction. This utility shall analyze the resource asset interactions defined for a particular operation and identify potential performance discrepancies. This shall include items such as network bandwidth, missing data items, mismatched data item formats, and mismatched data rates. Using the SETI experiment as an example, the position of the launching submarine would be identified as a missing data item were it not defined for the AUTEC range asset as it is a required input to the torpedo systems of the WAF asset. A mismatched data item format would be detected if the AUTEC range asset defined the submarine's depth in feet when the WAF is defined to accept it in meters.

Network Simulation. This capability provides the means, based upon the resource assets and network assets defined for a particular LR operation, to simulate the planned LR network. This simulation capability provides the user with the capability to identify potential bandwidth, latency, protocol, and general LR asset interaction discrepancies of the actual operation but without directly utilizing the physical resources.

Logical Range Configuration File Generation. This capability generates the files required to configure the assets for a specific logical range defined within the logical range repository and selected by the user.

4.2 Logical Range Setup

Logical Range Setup capabilities will include:

a. Scheduling. Scheduling capabilities facilitate planning for the execution of an exercise or test on the logical range. Scheduling capabilities will accommodate, to the maximum extent practical, the various scheduling and accounting systems in use at DoD and contractor ranges and facilities.
b. Network Setup Support. The Network Setup Support Capability will support the translation of the logical network defined during the logical range definition phase into the physical network required to execute the logical range task. The Network Setup Support Capability will also support testing of the physical network prior to execution.

   Test Capabilities will include:

   1) Component Compliance Test. This capability will be used to support testing of each simulation for compliance with its definition and with the definition for the logical range before interaction is attempted with external simulations.

   2) One-on-one Interaction Testing. One-on-one Interaction Testing capabilities will support testing the interactions between each pair of components in the logical range definition to ensure that interactions occur as expected.

   3) Many-on-many Interaction Testing. Many-on-many Interaction Testing capabilities will support testing the interactions that are expected between components in the exercise environment.

   4) End-to-end Testing. End-to-end testing capabilities will support testing the interactions of all resources in the logical range. End-to-end testing is a complete rehearsal of the test/training exercise scenario.

4.3 Logical Range Execution Management

Logical Range Execution Management will include:

a. Logical Range Control. Logical range control capabilities will provide for human control, monitoring, and visualization of the LR during the execution of its resources. These include Resource, Network, Initialization, and Execution applications.

b. Logical Range Monitors. Monitors support the Control capabilities and will support monitoring the real-time operation of the logical range. Logical range monitors include:

    1) A Network Traffic Monitor to display status and control the flow of messaging on the logical range network.

    2) A Message Monitor to monitor and keep track of the message traffic between the various resources of the logical range.

    3) A Data Monitor to track the data being captured, perform quality checks, and display data on request.

c. Visualization Capabilities. Visualization capabilities will support the display of standard tactical, three-dimensional viewport, and graphical data and events and are used both for real-time visualization of events and post-test review and analysis.

d. Data Logging and Archiving. Data logging and archiving capabilities will support the capture and storage of data for playback and analysis.

4.4 Post Test Mission /Training Exercise Analysis

Post Test Mission /Training exercise analysis capabilities will include Playback, Data Extraction, Visualization, and Data Definition capabilities:

a. Playback Capability to reconstruct exercise or test events from messages and data logged during the execution of the logical range.

b. Data Extraction Capability to extract specific data elements or events selected from the data logged during the execution of the logical range.

c. Visualization Capabilities to support data analysis uses the same visualization capabilities used for logical range execution management.

d. Data Definition Capabilities used to characterize the data during the logical range definition phase also support post test/exercise analysis.

5.0 Summary & Conclusion

Obviously, the task of reinventing the test and training infrastructure is not for the faint of heart. The technical issues are vast and complex, but they are meager relative to the cultural and organizational issues, which this paper does not begin to address. There indications, however, that the time may be right to begin the discussion. The Defense Modeling and Simulation Office

(DMSO) High Level Architecture (HLA) and other DoD M&S initiatives, such as the Synthetic Environment Data Representation & Interchange Specification (SEDRIS), the Modeling and Simulation Resource Repository (MSRR), and the Master Environmental Library (MEL) are positive steps toward improved interoperability. In addition, DoD Manual 8320.1-M-1, Data Standardization Procedures, dated November 1996 (Draft) and the DoD Range Commander's Council (RCC) Data Interchange Standard, DR-19, are important resources for achieving this end, as the Joint Technical Architecture (JTA) and Defense Information Infrastructure (DII) Common Operating Environment (COE).

Initial Operating Capability (IOC) for FI 2010 is defined as the completion of a Joint Test Exercise (JTE) that successfully demonstrates the FI 2010 architecture and core set of products. However, during the execution of the FI 2010, products supporting the functionality of the LR will be developed and delivered incrementally to the ranges and facilities. Full Operational Capability (FOC) is to be determined; however, it is anticipated the FI 2010 architecture, products and the logical range concept of operations will continue to evolve indefinitely after IOC, funded by non-CTEIP mechanisms.

References

Defense Modeling and Simulation Master Plan, dated 17 October 1995.

DoD 8320.1-M-1 ,Data Standardization Procedures, November 1996 (draft)

Proceedings of the Fourth, Fifth, and Seventh Common Test and Training Range Architecture (CTTRA) Workshops

Vision 21, The Plan for 21st Century Laboratories and Test-and-Evaluation Centers of the Department of Defense, dated April 30 1996

DDR&E Memorandum dated 10 February 1993, Final Report of the Defense Science Board Task Force on Simulation, Readiness and Prototyping, Washington D. C.

Concept of Operations (ConOps) for the Logical Range, March 1997 (draft)

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