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The Joint Synthetic Test and Evaluation Battlespace (JSTEB) is the permanent infrastructure needed to support routine distributed test and evaluation. The JSTEB is comprised of networks, common data standards and protocols, integrated scheduling, configuration and mission control. It facilitates the accessibility of live, virtual, and constructive models and simulations from widely dispersed locations. JSTEB is usable by the Acquisition, Test and Evaluation, Training, and Operations communities. Most importantly, it enables the early and continuous involvement of the warfighter, user, developer, and tester in the acquisition process. A synthetic battlespace is needed to facilitate Simulation Based Acquisition, implement the Simulation, Test, and Evaluation Process, perform comprehensive test and evaluation, and assess joint warfighting capabilities. The understanding of weapon systems and their capabilities gained as a result of using a synthetic battlespace for test and evaluation will enhance the fundamental understanding of warfighting systems and make it easier to optimize designs for performance, producibility, and affordability.

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Implementing the Joint Synthetic Test and Evaluation Battlespace

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The Joint Synthetic Test and Evaluation Battlespace (JSTEB) is the permanent infrastructure needed to support routine distributed test and evaluation. The JSTEB is comprised of networks, common data standards and protocols, integrated scheduling, configuration and mission control. It facilitates the accessibility of live, virtual, and constructive models and simulations from widely dispersed locations. JSTEB is usable by the Acquisition, Test and Evaluation, Training, and Operations communities. Most importantly, it enables the early and continuous involvement of the warfighter, user, developer, and tester in the acquisition process. A synthetic battlespace is needed to facilitate Simulation Based Acquisition, implement the Simulation, Test, and Evaluation Process, perform comprehensive test and evaluation, and assess joint warfighting capabilities. The understanding of weapon systems and their capabilities gained as a result of using a synthetic battlespace for test and evaluation will enhance the fundamental understanding of warfighting systems and make it easier to optimize designs for performance, producibility, and affordability.

Test and evaluation challenges

Comprehensive test and evaluation. The Honorable Jacques S. Gansler, Under Secretary for Acquisition and Technology, in his keynote address at the National Defense Industrial Association's Simulation-Based Acquisition Workshop held in Orlando, Florida, on March 17, 1998 said, "We must also make far greater use of modeling and simulation in our test and evaluation process. We must actually replace some of our testing with simulation and do so in ways that actually improve the quality of the process."

The address further pointed out that "simulations are of extremely limited value if they are not validated by realistic system and subsystem testing." The speech went on to confirm that comprehensive testing is not done today with the statement, "testing itself is of extremely limited value considering the very few data points obtained with exceptionally high cost of modern weapons, and the vast array of possible test conditions." (Gansler 1998) The limited value of testing can be greatly enhanced through the use of credible simulations.

Simulation-Based Acquisition/Simulation, Test and Evaluation Process. The competing factors of reduced funding versus increased readiness have forced the Department of Defense (DoD) to look for strategies to build more technologically sophisticated systems cheaper and faster than ever before. Simulation-Based Acquisition (SBA) is DoD's vision of an acquisition process that dramatically reduces system life cycle costs while increasing the quality, military utility and supportability of systems developed and fielded. The intent of SBA, however, can only be achieved if a system is originally designed to cost less to operate and maintain. Thus, SBA is enabled by state-of-the-art simulation and data sharing technology integrated across acquisition phases and programs to provide comprehensive and reliable data for measuring

program costs and performance results and making well-informed decisions before life cycle costs are effectively rendered unchangeable. Acquisition program managers must plan for the use of modeling and simulation (M&S) in their acquisition strategies and make the up-front investment in the necessary applications and technology to make SBA a reality.

A key element of SBA is the Simulation, Test, and Evaluation Process (STEP) which significantly reengineers the way models and simulations are used in the test and evaluation (T&E) process. STEP more effectively integrates simulation into the T&E process for the purpose of iteratively evaluating and improving the design, performance, joint military worth, survivability, suitability, and effectiveness of systems to be acquired. The product of STEP is consistent and comparable performance information that the requirements, acquisition, T&E, and training communities can apply throughout a system's life cycle. By beginning the process early, models and simulations can provide clear and up-front information on critical design aspects. This allows for multiple design iterations before hardware is available for test. STEP results in an efficiently designed and thoroughly understood system and provides developers and testers high confidence in its operational effectiveness, suitability and survivability.

On October 3, 1995, Dr. Paul Kaminski, then Under Secretary of Defense for Acquisition and Technology, wrote that he was requiring STEP be an integral part of Test and Evaluation Master Plans (TEMPs). STEP Guidelines were distributed in December 1997 and are expected to be reflected in test planning, conduct and TEMPs.

Joint Vision 2010. Joint Vision 2010 provides a conceptual template of how U.S. Armed Forces will fight in the 21st Century and a template to guide the transformation of these warfighting concepts into joint operational capabilities. Joint Vision 2010 describes the changing and uncertain strategic and operational environment in which our Armed Forces will be expected to achieve full spectrum dominance. Military success in this environment will depend upon the quality of our fighting forces enabled by enhanced jointness, information superiority, technological advances, enhanced multinational operations, and our ability to understand and adapt to changing, potential adversaries.

Just as Joint Vision 2010 provides a template to guide the transformation of warfighting concepts into joint operational capabilities, it also provides a template to guide the transformation of T&E capabilities to "test the way we fight" for assessing the warfighting capabilities of future systems.

Needed Capability

Acquiring systems with joint warfighting capabilities imposes significant demands on the acquisition process. Specifically, the variety and scale of joint task force scenarios make it impractical to consider staging such events as the principle means of testing the efficacy of newly developed or upgraded systems. Through the use of advanced distributed simulation (ADS) techniques, however, synthetic environments could be created to serve in place of large-scale joint task force scenarios to test the effectiveness of systems in joint operations. In this context, *synthetic* means anything short of war. Therefore, the synthetic environment used to test a new system could consist of an assembly of live, hardware-in-the-loop, man-in-the-loop and digital simulations networked over geographically dispersed locations and configured to represent the desired operational or test environment. These synthetic environments would not replace live tests, but would be used to supplement them or extend system assessments to areas not feasibly evaluated using live tests. Furthermore, live testing is essential in verifying the performance and credibility of synthetic environments.

Similarly, constraints on testing such as safety, regulatory, inadequate test assets, lack of representative environment, lack of operational realism, cost, treaty, security and limitations on test instrumentation preclude comprehensive evaluations based on live testing alone. Again, synthetic environments used to complement live testing will provide decision-makers with needed information which otherwise would not be available.

The traditional acquisition process, build-test-fix-test..., depends on iterations of hardware builds to develop the resulting operational capability. From a testing perspective, developmental and operational testing is pushed towards the final phases of hardware development where opportunities for change are few and expensive. The STEP or model-test-model...-build process is achieved by using virtual prototypes, in lieu of physical prototypes, for T&E of specific system characteristics. Virtual prototypes afford the following advantages, they can be: 1) produced quickly and at a relatively low cost; 2) endowed with characteristics for which technological solutions are not at hand and without the expense of achieving the technical solution; and 3) operated by the user or tester in advance of committing funds and large development programs to produce a physical test article. Synthetic environments are required for engineers, users, and testers to operate virtual prototypes of weapon systems and benefit from the understanding of their capabilities gained as a result of using STEP. Likewise, these synthetic environments would consist of simulations of components of an actual combat environment, configured to emphasize system and subsystem optimization and integration and allow early and continuous involvement of warfighters, developers and testers.

Assessment of existing T&E capabilities

Many of the sophisticated simulations that could be used in constructing synthetic environments already exist. Test and training ranges, laboratories and facilities have developed unique assets which could make invaluable contributions in synthesizing "battlefields." Test and training capabilities, however, have autonomously evolved, resulting in duplication of effort and resources, and differing processes and procedures, which limit the interoperability, sharing, and reuse of resources demanded by synthetic environments.

The extensions or enhancements to test and training infrastructure necessary to accommodate assembly and use of synthetic environments are a prudent investment. As stated by Senator John McCain in his address to the Senate regarding American military readiness: "Long experience has shown us that even the best test and evaluation efforts can leave equipment with significant problems that are only exposed in combat. Comprehensive test and evaluation is expensive, and it is tempting to cut corners. Any reduction, however, means a loss of readiness." (McCain 1993) Synthetic environments are critical to expose and correct significant problems prior to combat.

Joint synthetic test and evaluation battlespace

The Joint Synthetic Test and Evaluation Battlespace (JSTEB) is the capability to routinely and cost effectively assemble and use synthetic environments for the primary purpose of T&E. *Figure 1* illustrates the operational concept of the JSTEB.

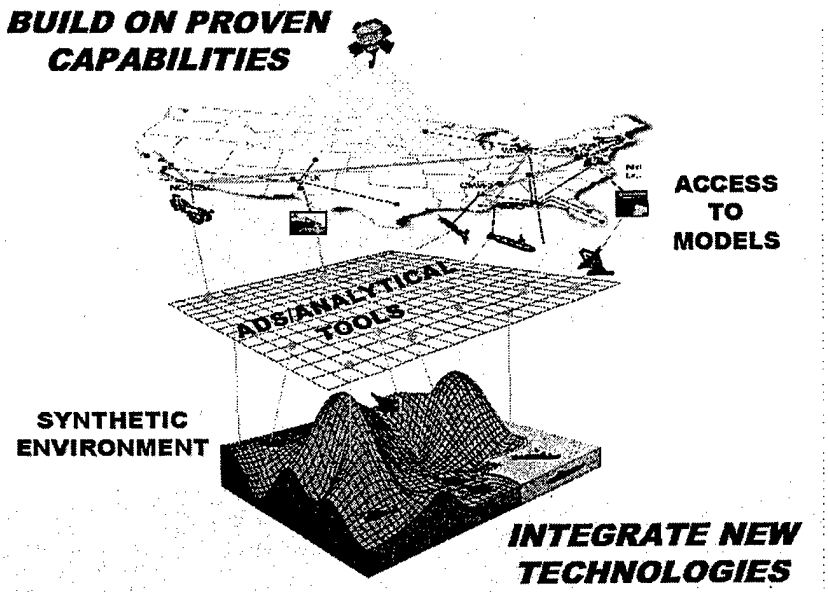

Figure 1. JSTEB operational concept

The JSTEB builds upon proven T&E resources and capabilities, makes optimal use of limited and expensive test and training assets, and integrates them with new technologies to create the synthetic environments needed to augment live testing. The JSTEB responds to both long-standing and emerging challenges in the test community with a framework that enables interoperability, reuse, and sharing of models, simulations, and data. It benefits other communities and functions as well, for example, in training, it allows commanders to see the battle at different levels of detail or increases the possibilities for innovative or enhanced training *(Figure 2).*

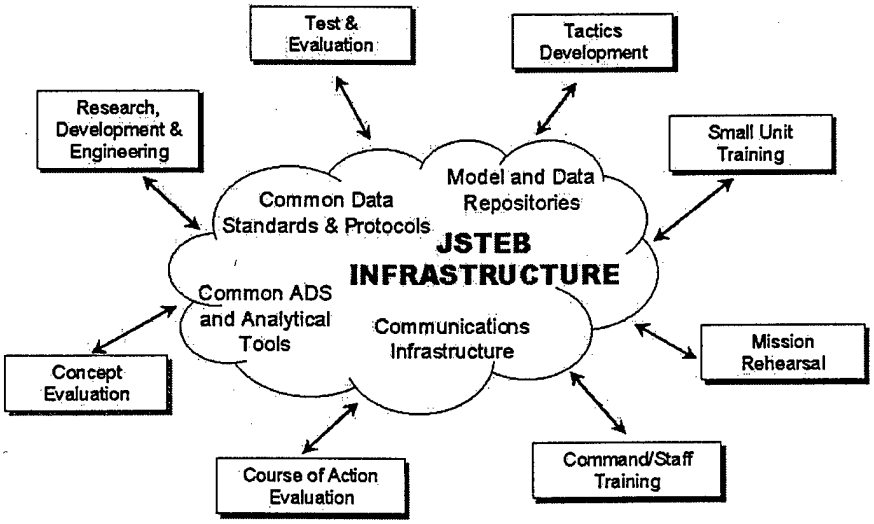

Figure 2. JSTEB functional concept

Funding and implementation strategy

The concept of the JSTEB was first disseminated in May 1997 with the publication of the Navy Test and Evaluation Modeling and Simulation Master Plan. The Test and Evaluation Modeling and Simulation Management Office (TEMSMO), chartered by the Director for Test and Evaluation and Technology Requirements (N091), and located at the Naval Air Warfare Center (NAWC) Aircraft Division (AD), Patuxent River, Maryland, has the responsibility for execution of the master plan. The TEMSMO has adopted a strategy of incrementally building JSTEB on a least cost basis as a cost-effective means of improving the long-range resources of the T&E community. Leveraging other M&S initiatives and programs to provide ADS and analytical tools and technology for JSTEB is also included as part of the strategy.

The TEMSMO has set into motion a number of initiatives to make JSTEB a reality. The charting of these initiatives, in conjunction with the leveraging of other programs, as an implementation strategy is illustrated in *Figure 3*.

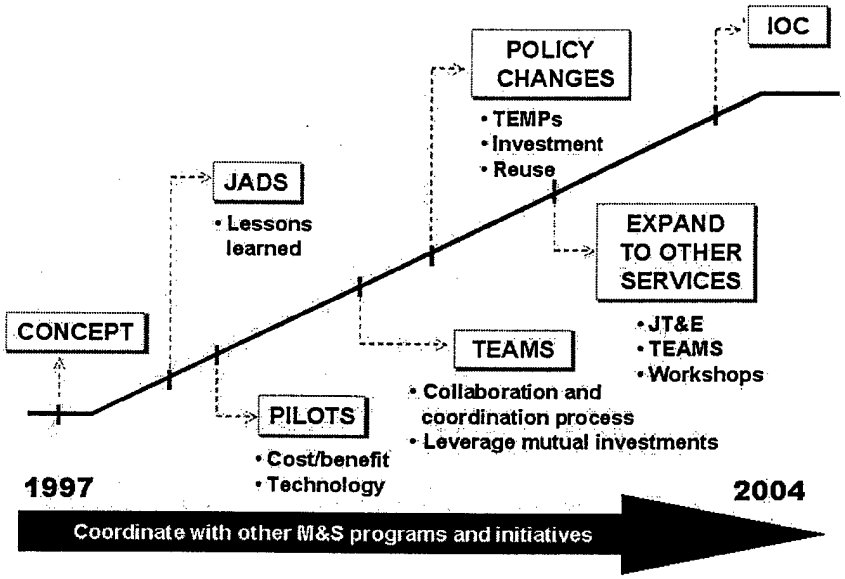

Figure 3. JSTEB implementation strategy

Pilots. We can no longer afford to build things simply because they are good ideas. Pilot programs are focused experiments to demonstrate the utility and cost/benefit of synthetic environments supporting T&E while developing specific portions of JSTEB. Pilot programs also afford the Navy the means to take a measured approach in creating JSTEB before significant dollars are spent.

Navy T&E currently has two pilot programs: Integrated Ship Defense (ISD) Modeling and Simulation Pilot Program and the Joint Strike Fighter (JSF) Program:

Integrated Ship Defense M&S Pilot Program. The ISD M&S Pilot Program goal is to develop and demonstrate a comprehensive modeling and simulation capability in support of the design and evaluation of components and systems directed towards phases of the ship defense mission, i.e., detect, control, and engage. The objective is to utilize ADS technology to support the acquisition of Navy systems using SBA initiatives and emerging M&S technologies.

Interfaces to battlegroups, joint warfare simulations, and natural environment simulations will be developed to improve hard kill and electronic warfare assessment capabilities. In addition, the pilot will establish network technology for interoperability, determine the cost and technical challenges associated with becoming High Level Architecture (HLA)-compliant, and determine ways to use M&S to reduce limitations to scope of testing.

ISD's contributions to JSTEB include secure networks and basic federation infrastructure for reuse at the Integration Test Facility located at the MITRE Corporation in Reston, Virginia and an HLA-compliant federate of existing models.

Joint Strike Fighter Program. A key objective of the JSF Program is to ensure that a robust, "core suite" of models, simulations and supporting databases are available for Government and Industry to leverage mutual investments and provide a common frame of reference for analysis. The JSF Program refers to this robust, "core suite" of models, simulations and supporting databases as the Virtual Strike Warfare Environment (VSWE). The VSWE extends beyond single facilities through the use of ADS networks and protocols that allow for the seamless integration of constructive, virtual and live simulations among geographically separated facilities. VSWE M&S will comply with emerging DoD standards such as the HLA, the Defense Information Infrastructure/Common Operating Environment, and the Global Command and Control System, to reduce the cost, time and risk of integrating the JSF and its M&S support systems into a Joint system-of-systems architecture.

JSF's contribution to JSTEB is open-systems software that supports the integration of Manned Flight Simulators in the Air Combat Environment Test and Evaluation Facility, NAWC-AD, Patuxent River, Maryland with the Manned Flight Simulator in the Virtual Prototyping Facility, NAWC-Weapons Division, China Lake, California.

TEAMS. Because of the independent nature of acquisition programs, there is little synergy among them today on common M&S and T&E issues. The Test and Evaluation/Acquisition Alliance for Modeling and Simulation (TEAMS) is a consortium of acquisition and T&E professionals that come together to address common M&S and T&E issues and benefit from any synergies found. Specifically, TEAMS addresses standards and common infrastructure needs associated with assembling and using synthetic environments and other issues associated with the integrated use of modeling and simulation across assessment, design, development, and T&E. TEAMS ensure program requirements are considered in determining JSTEB development priorities, and ensures a JSTEB architecture is developed that is widely understood and compatible with a broad range of user requirements. This is essential for the establishment, growth and evolution of JSTEB. TEAMS products include a roadmap to guide the development of JSTEB and pilot projects that implement specific portions of the roadmap. The TEAMS process is illustrated in *Figure 4*.

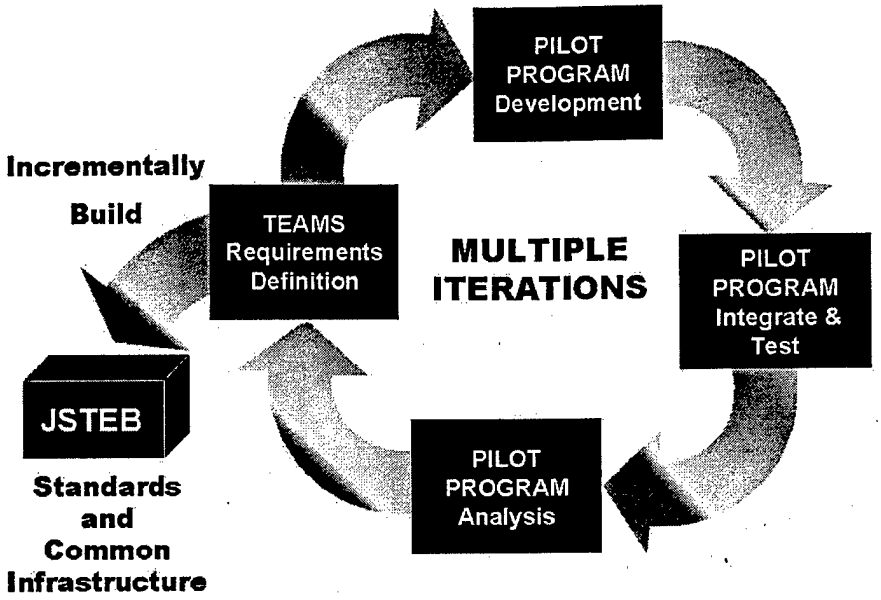

Figure 4. T&E / Acquisition Alliance for M&S - TEAMS - process

Policy. Once risk reduction is completed and the cost/benefit of using synthetic environments for T&E has been fully demonstrated, policy for TEMPs will be addressed to ensure acquisition programs take advantage of the increased capability to assess the performance of military systems and provide substantial cost containment to programs. T&E investments will be addressed to institutionalize immediate and future improvements in T&E resources necessary to meet the demand for the JSTEB capability. Currently, policy is being considered to stimulate and enhance M&S reusability by requiring all developers and authors of T&E models and simulations register their models and simulations in the Navy Test and Evaluation Repository for Models and Simulations (NTERMS).

Workshops. Navy TEMS Workshops have been critical in informing the T&E community about TEMS initiatives, gaining support for those initiatives, and establishing requirements for interoperability and reuse of T&E M&S. There have been four workshops to date with the first workshop held in February 1994.

During the JSTEB development process, Navy T&E will be coordinating JSTEB requirements with the M&S programs and initiatives of the Office of the Secretary of Defense (OSD), Army, Air Force, and the Marine Corps. This will ensure interoperability and reuse with other Service M&S. A Multi-Service T&E M&S Workshop is planned for 6-8 April 1999 to address joint issues for JSTEB. The workshop is entitled, "The Joint Synthetic Test and Evaluation Battlespace -- Meeting the Warfighter's Needs."

Joint Advanced Distributed Simulation. The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation, sponsored by the OSD Joint Test and Evaluation Program is a "test" of ADS applied to T&E. JADS legacy products will be incorporated into the JSTEB architecture.

Summary

Constraints on testing preclude comprehensive evaluations based on live testing alone. Synthetic environments consisting of live, hardware-in-the-loop, man-in-the-loop, and digital simulations can augment or complement live testing to cost effectively provide decision-makers with needed information which otherwise would not be available. Synthetic environments support a changing acquisition process by enabling the integration of the T&E process across a product's life cycle. Synthetic environments will also be critical in assessing future Service and joint warfighting capabilities. In the future, the T&E community will use JSTEB to routinely and cost effectively assemble and use synthetic environments to perform comprehensive T&E, achieve the objectives of SBA and STEP and to "test the way we fight" when assessing future warfighting capabilities.

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Endnotes

1. The views expressed in this article are those of the author and do not represent the official view of the United States Department of Defense or the United States Navy.
2. Additional information concerning the Joint Synthetic Test and Evaluation Battlespace is available from the Navy Test and Evaluation Modeling and Simulation World Wide Web site at http://www.nawcad.navy.mil/tems.

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