VERIFICATION, VALIDATION, AND ACCREDITATION (VV&A) ISSUES OF THE NATIONAL MISSILE DEFENSE (NMD) INTEGRATED SYSTEM TEST CAPABILITY (ISTC) TRANSITION TO A DISTRIBUTED TEST SYSTEM

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ABSTRACT: *The Integrated System Test Capability (ISTC) is the National Missile Defense (NMD) system level, hardware-in-the-loop (HWIL) test resource. It is a computer-based system for testing actual NMD element data processors and NMD element software in an integrated configuration through the use of simulated environments. Individual elements of the NMD system are represented in the ISTC on individual, stand-alone computer stations known as nodes.*

This paper examines how the ISTC, which is a detailed, high fidelity HWIL program with hardware and software components of the NMD Battle Management Command, Control, and Communications (BMC3), Ground Based Radar (GBR), Ground Based Interceptor (GBI), Upgraded Early Warning Radar (UEWR), Forward Based X-band Radar (FBXB), and Space Based Infrared Satellite (SBIRS) program, plans to meet this challenge. Issues associated with the verification, validation and accreditation (VV&A) of a software test resource which transitions to a distributed test and evaluation (T&E) system will be discussed. The added complexity to verify and validate such a system includes latency in time, network problems, standardization of policy, and syntactic vs. semantic consistency. This paper, using the ISTC as an instance, will illustrate what is needed for further refinement of the VV&A methodology for distributed simulations within the T&E domain.

1.0 INTRODUCTION

This paper identifies some of the technical and managerial issues which may need to be resolved with respect to the VV&A of a software test resource which transitions to a distributed T&E system.

Many challenges are imminent for the ISTC due to the fact that it currently operates closed-loop within the Advanced Research Center (ARC) but will be required to support distributive testing for the NMD materiel acquisition program for Ballistic Missile Defense Organization (BMDO).

Within the ISTC, each NMD element node incorporates actual NMD element mission and communications processors, running actual element software. The individual element nodes are interconnected by a NMD system communications network driven by real time system interfaces and threat and environment input data. The nodes are also connected by separate ISTC networks that control the test equipment. The ISTC supplies the autonomous nodes with a simulated threat and environments, natural and man-made, that are consistent for each NMD element in the test scenario. In this manner, ISTC exercises the entire NMD system simultaneously.

The ISTC currently operates closed loop via a Tactical Communications Network and Test Networks within the ARC; but, there is an emerging requirement to support distributive testing in the FY99 time frame to incorporate other NMD Element representations which cannot be duplicated and placed into the ARC. This will require hardware and software changes in the ISTC. The issues associated with applying interoperable simulations in T&E will need to be addressed to ensure that NMD test objectives are met.

1.1 Purpose

This paper addresses the additional V&V planning and assessment activities necessary for utilization of distributed simulations within the T&E environment by:

1) *Identifying* some problems associated with applying interoperable simulations in T&E;

2) *Proposing* an approach and candidate activities to ease the VV&A hardships associated with the ISTC's transition to a distributed system.

Much work has already been performed by the Defense Modeling and Simulation Office (DMSO) and DoD activities regarding applying the VV&A process to a distributive, interactive simulation (DIS) and DIS exercise.

Also, the Joint Advanced Distributed Simulation (JADS) program has also made great strides in furthering the VV&A process to ensure its usefulness and manageability. This paper will utilize lessons learned from this previous work and apply these ideas to the ISTC VV&A process.

1.2 Overview

This paper addresses the concept of a DIS and the VV&A questions which must be answered in order to gain proper accreditation of the DIS with respect to ISTC. The identification of proposed processes which can be applied to these issues are also made. Finally, the application of this guidance as it pertains to the ISTC VV&A process is addressed.

2.0 BACKGROUND

The ISTC VV&A strategy and the directive regarding distributed tests are discussed in the sections which follow.

2.1 Need for Explicit VV&A

The requirement for model and simulation (M&S) V&V throughout the DoD community provides the motivation and need for development of the ISTC V&V strategy and formal V&V Plan.

Several directives, policies and related publications such as the DoD Directive 5000.59, DoD Directive 5000.61 and the DoD VV&A Recommended Practices Guide developed by DMSO stress the importance of a formal V&V program for M&S and provide guidance for the simulation and modeling community in developing a V&V program. An ISTC V&V Plan has been developed and tailored in accordance with this guidance and conforms to the current standards and practices set forth by the DoD.

A primary objective of any M&S V&V activity is to ensure that a credible model or simulation is provided to the user community. The ISTC V&V activities selected for execution are intended to provide essential, fundamental V&V information to support accreditation decisions. As a consequence, accreditation is a principle objective in the definition of ISTC V&V activities. The ISTC must produce realistic, unbiased, credible measurements of specific NMD system performance or suitability parameters when operated within a specific domain of scenario and environmental conditions, for it to be acceptable for use in supporting evaluations that may impact the NMD system deployment decision.

Moving the ISTC to a distributed test environment raises many concerns which need to be addressed to ensure these test objectives are met. Differences emerge when working in a distributed environment including network inconsistencies, distributed element representation, test planning, control and execution, and data management.

2. 2 Distributed Test Directive

In March of 1997, the NMD T&E Division created an Integrated Product Team (IPT) to "…discuss what is possible, practical, the costs involved and a schedule for Distributed Testing if the decision is made to proceed" with distributed testing within ISTC. The Distributed Test IPT membership included representatives from the US Air Force, UEWR, the Operational Test Agency (OTA), the Joint National Test Facility (JNTF), and System Test and System Engineer representatives of the NMD BMC3 and ISTC offices. The IPT considered its primary focus to be on the near term in support for the FY99 contingency deployment decision for NMD. Consideration was given to such long term concepts as distributed tests involving Kwajalien Missile Range (KMR), deployed sites, US Army Space Command (USARSPACE) and SBIRS.

The NMD Distributed Test IPT operated under the following requirements:

1) The current NMD test planning documents were silent on "distributed testing" needs.

2) Risk reduction for flight tests and the deployment decision is necessary.

3) Planned tests needed to consider evolving operational configurations (e.g., operational physical locations and operational

communications, tactical hardware and software, and environmental conditions).

4) Tests needed to demonstrate collateral mission interoperability and external systems interfaces, such as simultaneous UEWR support of Integrated Tactical Warning/Attack Assessment (ITW/AA) and NMD missions, and BMC3 support of the NMD and Cheyenne Mountain Operations Center (CMOC) missions.

5) Must integrate into Cheyenne Mountain Complex.

6) Support user needs such that the operator can gain insight into the current NMD system.

7) The facility must be convenient to the operator and equipment must be available for training and crew drills. This enables the operational tester and operators to refine procedures, measures of effectiveness (MOE) and measures of performance (MOP) as the NMD system evolves.

8) The system must improve user participation with development efforts and add flexibility to support user requirements (e.g., enhance Command and Control Simulations (C2Sims) and Concept of Operations (e.g., CONOPS) development, and support BMC3 Capability Increment (CI) User Assessment activities).

The NMD Distributed Test IPT focused on the FY97 to FY99 timeframe. This was due to program uncertainties and the large number of variables beyond the FY99. The IPT considered existing, planned and proposed NMD element representation candidates. The cost and schedule for test design and execution were based on two different Test and Control (T&C) environment implementation approaches. And a program decision on the X-band radar candidates will be needed prior to inclusion into this architecture.

The Distributed Test IPT recommended endorsing the distributed test concept with a phased implementation as NMD elements mature with a goal for implementation to coincide with IGT-2A scheduled for 2nd Quarter, FY00.

The NMD Distributed Test Architecture proposed for FY99 is illustrated in Figure 2.2-1, below.

The IPT also identified many distributed test unique issues which needed to be addressed:

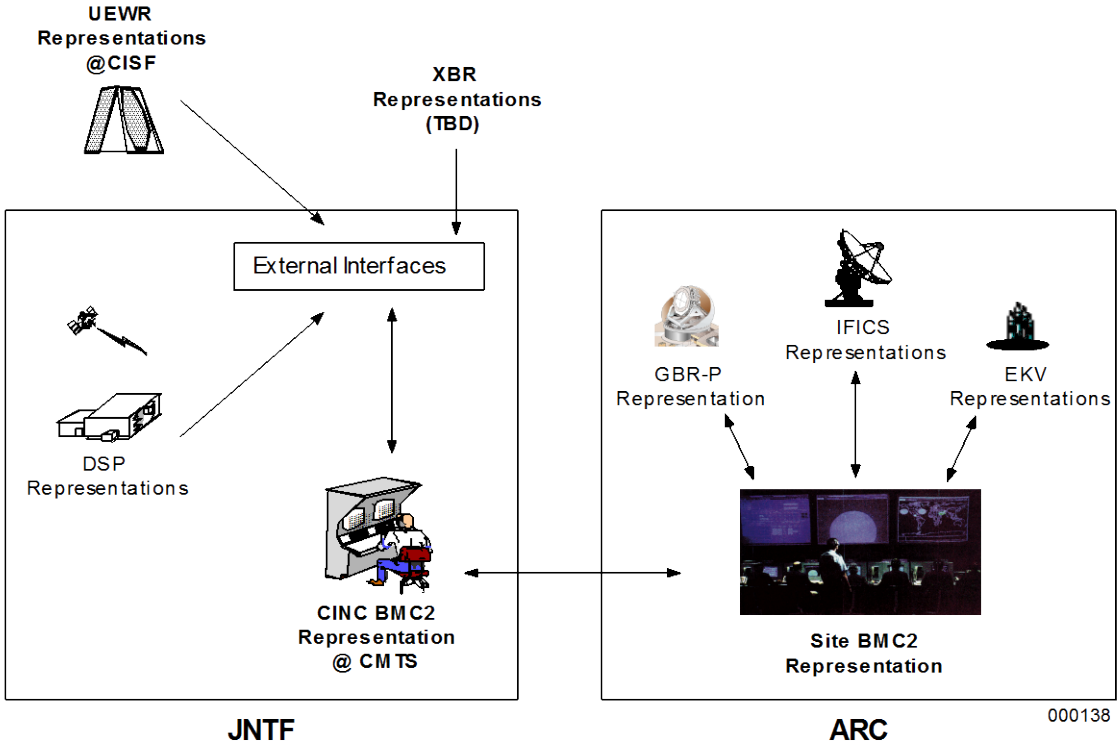

Figure 2.2-1. Proposed NMD Distributive Test Architecture.

- the need for a common test controller;
- distribution and management of threat, environment and T&C information;
- time synchronization among the elements participating in the test;
- identification of realistic data latencies;
- integration of real and test communications;
- development of additional element drivers;
- availability of test articles;
- distributed test planning and execution; and
- data collection management and distribution.

2.3 Distributed Test Issues For ISTC

Several pitfalls and issues were identified for the conduct of a distributed test using the ISTC. These issues included:

- The scheduling of networks, test assets, operators, etc., and associated operational and support staff.

- The latency associated with distributed test assets geographically will probably make some types of distributed testing infeasible for the ISTC.

- The added complexity to VV&A the distributed test network will be difficult to manage, and more potentially more costly than the VV&A of ISTC in a stand-alone configuration.

- Data collection, management, and dissemination for a distributed test will be more complicated than using ISTC in its stand-alone configuration.

- Reliability of the test network infrastructure is a potential problem for the developmental and operational testers.

2.4 Distributed Testing and VV&A Guidance

The DoD has provided direction for M&S management and VV&A activities through promulgation of DoD Directive 5000.59, DoD Directive 5000.61, and the new DoD VV&A Recommended Practices Guide issued by the DMSO. A review of these directives and the individual service component VV&A policies and directives indicates a growing consensus within DoD on the necessity to subject all M&S, especially those supporting materiel acquisition decisions, to a formal, structured program of V&V activities.

Applying the VV&A Process Model for DIS: The DMSO has made great strides in providing guidance by supporting development of the IDEF0 Model Specification for Verification, Validation and Accreditation Process for Distributed Interactive Simulations (Reference 1).

This specification frankly notes that: "*It must be well understood that the VV&A process has to follow and agree with the planning, development and construction process of distributed simulations to which it is applied. The VV&A process must be flexible to accommodate changes which occur in the development process of distributed simulations. The VV&A planning process must allow for some latitude in procedures, methods and tools to react to unforeseen difficulties which occur in the development of distributed simulations.*"

For ease of reference, the process diagram illustrating the nine-step process for DIS VV&A has been extracted from the IEEE Std 1278.4-1996, "*Recommended Practice for Distributed Interactive Simulation - Verification, Validation, and Accreditation*", which was developed from the IDEF0 model (see Figure 2.4-1).

This VV&A process diagram illustrates the synergetic relationship between the exercise life cycle and the VV&A process. While the process appears to be linear, a considerable amount of iteration occurs between each and all steps. The standard states that the results of each VV&A activity, including risk assessments and recommendations, are reported to the exercise manager and, as necessary, to the exercise architect, network manager, and appropriate model and data providers. Critical issues are reported immediately to avoid costly delays and to facilitate a timely recovery. The exercise manager reviews VV&A results and coordinates with the exercise sponsor to determine the course of action.

The IEEE Std 1278.4-1996 provides procedures and guidelines for planning and conducting exercise VV&A by individually discussing the nine basic activities comprising the VV&A process. Each activity addresses specific objectives and fulfills a unique function in the overall VV&A process. The VV&A process diagram in Figure 2.4-1 provides a number of the V&V techniques normally associated with the individual activities.

The IEEE Std 1278.4-1996 suggests that, although an individual exercise VV&A effort involves each of the nine activities, the tasks and techniques selected depend on the exercise requirements and resource availability.

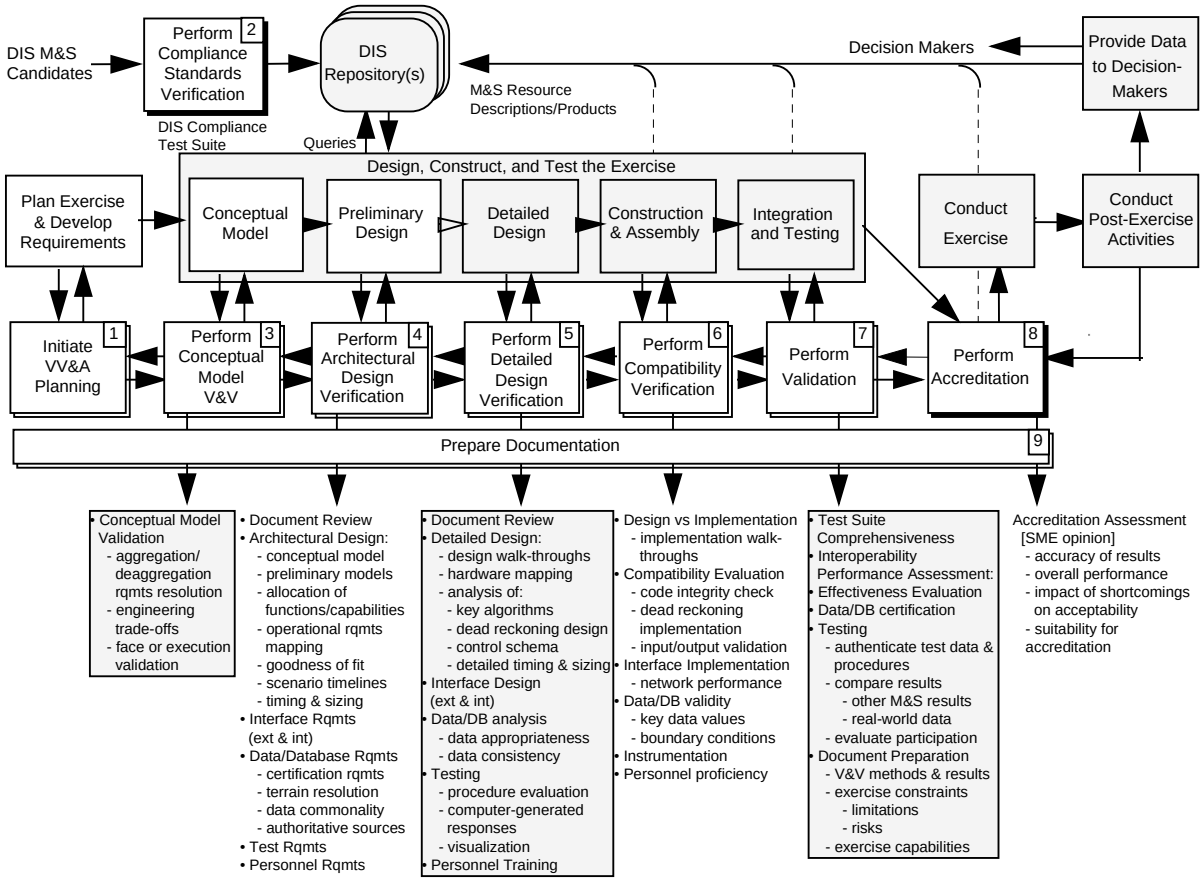

Figure 2.4-1. Nine-Step Process Model for DIS VV&A.

Utilizing Managed Investment: Mr. William F. Waite and AEgis Research have for several years advocated the use of a managed investment strategy in the definition of V&V programs (Reference 3). Managed investment is the execution, from all the possible, candidate V&V activities, a carefully selected subset of V&V activities:

- Offering the "best return on investment" by providing the essential information necessary for V&V reports findings, and

- Providing the evidence required to support the accreditation decisions of Service and DoD agencies and activities.

As a consequence, cost as an independent variable is considered during development of the V&V program.

The V&V activities subset is chosen based upon the:

- accreditation data needs,
- realities of the M&S program, and
- fixed resources available for V&V.

As the most cost-effective set of activities within the space of possible activities, the actual V&V evaluation suite subset of V&V activities constitutes an optimal investment in V&V. The next activity implemented is the one that provides the best marginal return on investment for the expended resources in terms of the value associated with the data product developed.

This managed investment strategy addresses the problem of specifying scope and detail of V&V activities and allows near-optimal investment in V&V activities and products for an economically constrained environment. This investment strategy provides for a deliberate and progressive outlay of resources that garners the information necessary to support accreditation decisions.

Thus, an actual V&V evaluation suite can be identified which is the most cost-effective within the space of possible candidate activities. This sub-domain constitutes an optimal investment within program resource constraints.

This strategy is graphically portrayed in Figure 2.4-2.

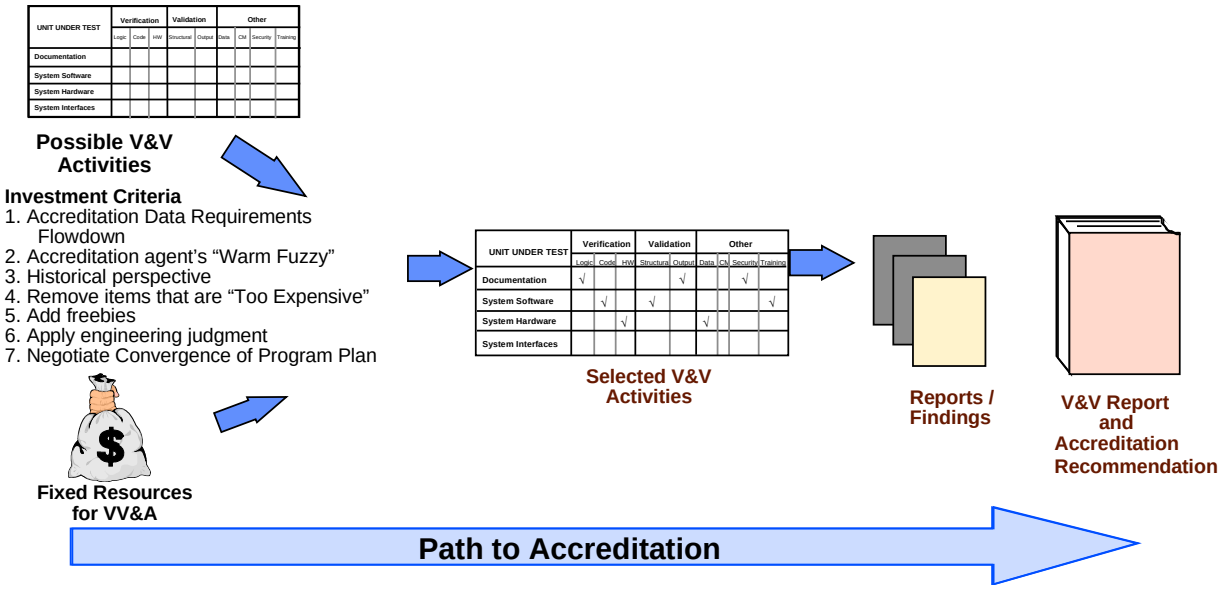

Figure 2.4-2. Managed Investment Strategy For VV&A.

Leveraging JADS Tools and Techniques: The JADS Joint Test Force is also working to answer the central question of technical feasibility. "*Can an Advanced Distributed Simulation (ADS) architecture generate data of test-level fidelity which is both valid and accurate enough for T&E applications?*"

The JADS tools and techniques will be leveraged to assist in answering this question for NMD. For example, the JADS Systems Integration Team analysts have already developed programs to ensure time synchronization between ADS LAN/WAN systems and are using coordinate transformations to convert raw simulation data to usable formats. They have also designed programs that facilitate the quick analysis and synthesis of this data. These tools include various ways to easily capture and display data synchronization, data transformations, data integrity, and latency.

The JADS efforts in the area of VV&A include the development and assessment of a methodology to verify and validate test architecture augmented with ADS. Their approach is to analyze, as it relates to its interaction in the overall network, each component M&S, entity or node for inclusion in the distributed architecture. Next, they assemble, verify and validate the distributed architecture. Before a test proceeds, their accreditation board reviews the V&V effort to ensure that it is adequate to proceed with testing. JADS also plans to assess the current methodologies, such as the nine-step process identified in the Implementation Guide for VV&A for DIS (Reference 4).

JADS began testing these concepts by replicating a live test in an ADS environment. The information presented in their "System Integration Test Linked Simulators Phase" presentation (Reference 5) provides several JADS lessons learned which were relevant to the ISTC distributed test and VV&A planning effort.

- A systematic approach to verifying network performance is necessary.
- A full-up linked architecture is necessary to validate architecture and simulation performance.
- Configuration control is even more critical/difficult in an ADS environment.
- Management is more complex with ADS due to the need to coordinate multiple players and schedule multiple facilities.
- Data collection and management are different from a "standard" test.
- An early integrated team approach is critical and should involve System Under Test (SUT) experts, Simulation Node experts, and Networking experts.
- Networking and analysis tools should be installed early to aid the architecture development process.
- Use of routers from different vendors may cause interoperability problems.
- Transmission latency was predictable and tolerable; processing latency was not.
- Network interface to simulations is critical.
- Synchronization problems can wreak havoc.
- Quantitative comparison of live test and ADS data for validation is difficult.

Incorporating Industry Standard Practices: Mr. Robert O. Lewis, of Boeing Computer Support Services, has put forth to the DIS and ADS communities several notable ideas for defining the VV&A role when models and simulations (M&S) are used for T&E (Reference 6). Importantly, he has identified key products and activities in many phases of ADS development, including the planning and requirements phase, the design and development phase, the preliminary design, the detailed design, construction and assembly, and integration and test.

Concerning the preliminary design phase, Lewis puts forth "*a major objective of V&V at this stage is to confirm and verify the component selection for inclusion in the ADS architecture*." For NMD, a formal review of the proposed ISTC architecture will need to be a key element in the overall V&V process. He also states, "*V&V also focuses on the ability of the preliminary ADS infrastructure to support the overall goals of the test effort with special emphasis on interface standards, including Protocol Data Units (PDU) and data formats, network capabilities, and observed path latencies. As soon as the network is even partially operational, it should be used in early verification testing to confirm path propagation times and performance (bandwidth) and support compliance testing of the components as they become available*". Mr. Lewis correctly notes these types of interactions among components of distributed simulations will require explicit V&V.

Consequently, verification testing of the ISTC distributed test networks as soon as practical is recognized by the development team as key to the timely identification of program and technical risks and necessary for their mediation. Verification tests of the network infrastructure were accomplished early in the ISTC Proof of Principle program, but will continue to be a focus for the near-term program, as additional NMD elements within the ISTC become distributed.

3.0 ISTC V&V ACTION PLAN TO SUPPORT DISTRIBUTED TESTING

The existing, approved ISTC V&V Plan identifies the activities planned and budgeted for execution in FY97, FY98, and FY99 in support of a test resource accreditation decision by the Ballistic Missile Defense Organization (BMDO). It also supports accreditation decisions that may be made by other agencies. This plan was formally staffed and it represents a baseline V&V program of activities for the accreditation decisions associated with utilization of ISTC data to support analyses for an NMD contingency deployment decision in FY00.

To support the emerging distributed test program requirements for NMD, the ISTC VV&A team is developing an ISTC V&V action plan to address the specific issues associated with using the ISTC in a distributed configuration (see Figure 3.0-1, below).

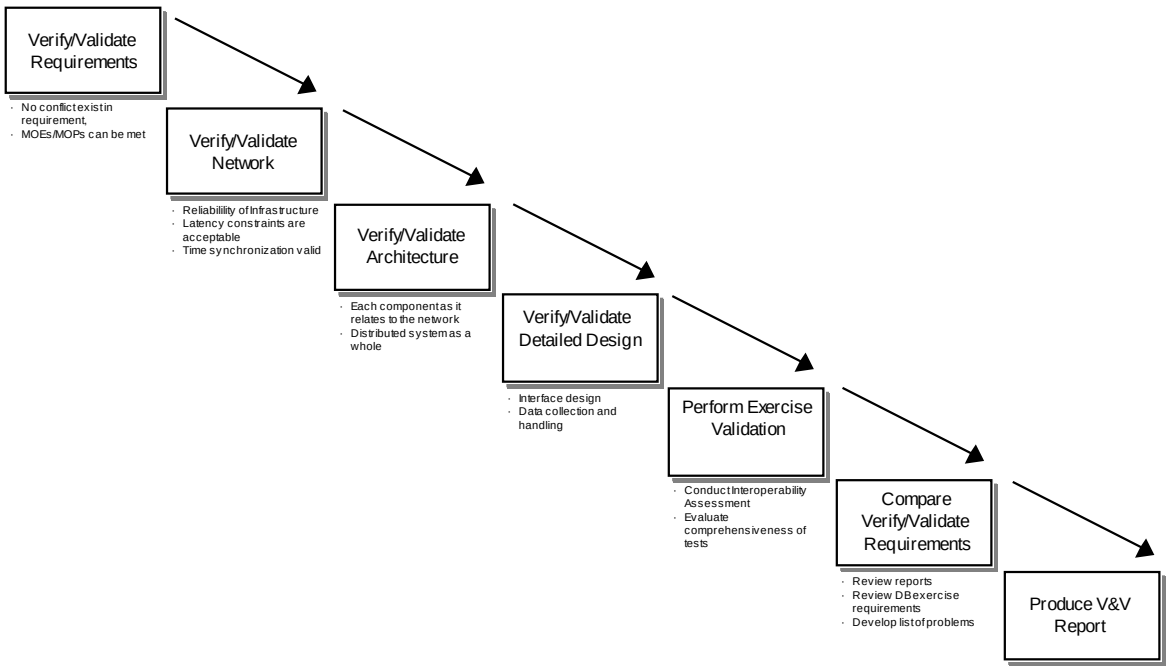

Figure 3.0-1. Proposed Distributed Test VV&A Action Plan For ISTC.

This action plan is an extension of the previously approved baseline ISTC V&V Plan and leverages strongly on the existing VV&A process, previously conducted and on-going V&V efforts, and findings for: concepts, strategic and tactical approaches, procedures, and reporting formats. The objective is to support accreditation of the ISTC for the NMD distributed tests being planned.

The IEEE 1278.4 provides procedures and guidelines for planning and conducting exercise VV&A but the specific tasks and techniques selected depends on the requirements of the exercise and the availability of resources. Utilizing this standard and the other concepts summarized in section 2 of this paper, the ISTC V&V action plan for distributed testing focuses on seven key activities. The objectives for each of these assessment activities is briefly discussed below.

3.1 Verify and Validate Requirements

The objective of this assessment activity is to establish the validity of the test design and exercise requirements with respect to the actual ISTC in terms of:

- Essential environments and scenarios;
- The number and types of element representations;
- Current NMD design increment behaviors, components, attributes (capability increments);
- The battle management and command, control, and communications between elements; and
- Degree of fidelity.

During this activity, the V&V team will evaluate the ISTC completeness, correctness, and appropriateness in terms of end-to-end context, performance objectives, and behavioral requirements for the distributed test. The team will focus on mapping the distributed test requirements against the ISTC design and evaluate the ISTC with respect to completeness, suitability and fidelity for the distributed tests.

3.2 Verify and Validate Network

During this activity, the V&V team will evaluate the robustness and adequacy of the proposed simulation networks terms of end-to-end performance and the throughput requirements for the distributed test. This task will assess the adequacy of the ISTC distributed test network configuration by:

- Evaluating the ability of the network configuration to satisfy the distributed NMD element representations in terms of arrival times, arrival rates, accuracy, latency, and traffic saturation; and,
- Confirming each NMD element representation can receive the network traffic it requires while ignoring the rest.

Supporting activities to be conducted by the V&V team will include:

- Developing independent estimates of the network burden by translating the load estimates (element node and total) provided by the test / network manager into network capacity requirements; and
- Evaluating latency in message and data traffic by examining the hardware and long haul carriers selected to handle the transmissions.

3.3 Verify and Validate Architecture

The objective of this activity is to verify the ISTC design with respect to the distributed test requirements and validate that the ISTC architecture accurately reflects the evolving NMD architecture. Tasks include:

- Examining the allocation of functions from the NMD system-level specification to the ISTC requirements documentation;
- Mapping the distributed test requirements into the emerging test architecture;
- Conducting goodness-of-fit analyses to evaluate suitability of individual element representations;
- Performing consistency analyses of the element representations (HWIL, digital, or hybrid) to determine the best combinations of element representations for the test;
- Reviewing test scenario timelines and estimates of their sequencing; and
- Conducting analyses to address hardware or software modifications needed for the distributed test.

3.4 Verify and Validate Detailed Design

The objective of this assessment activity is to ensure the ISTC detailed design continues to accurately reflect the evolving NMD system design and is adequate to support the anticipated distributed test activities. Distributed test configurations will be incrementally designed by mapping the NMD element representations in ISTC to the functions identified in the NMD architectural design and identifying the means by which element interactions occur. The V&V activities include:

- Evaluating the compatibility of the ISTC element representations and their ability to support the exercise;
- Determining the adequacy and sufficiency of the planned network facilities;
- Assessing the completeness and accuracy of timing estimates in the test and control schema;
- Checking boundary conditions to ensure stable test execution; and
- Verifying data and database usage.

As the detailed distributed test design evolves, the V&V team, within resource constraints, will be responsible for:

- Reviewing component documentation and, if necessary, source code to determine component ability to perform their assigned functions;
- Executing key algorithms to ensure they function appropriately to address the exercise requirements;
- Assessing the proposed interconnections between elements by evaluating the ISTC network; and,
- Analyzing the test design for its rigor and robustness.

3.5 Perform Exercise Validation

The preceding activities concentrated primarily on the functional integrity of the exercise. Exercise validation focuses on evaluation of the operational aspects of the ISTC with respect to the distributed test (e.g., behavioral representations, interoperability, real-time interactions, fidelity of the terrain and environmental representation). This activity should result in validation of the exercise configuration.

The objective of this activity is for the V&V team to assess and document how well the ISTC and its integrated, distributed test results reflect real-world behaviors, performances, fidelity, and interoperability requirements for the NMD by reviewing the results of preceding phases, evaluating results of exercise tests, and executing validation tests, as required.

Key tasks include:

- Analyzing the completeness and structural soundness of the test exercise and the realism of its results in terms of the test requirements;
- Determining if exercise output behavior has the accuracy required for its intended use within the developmental and/or operational test domain; and
- Evaluating the acceptability of each NMD element representation with respect to its operation in the distributed test.

3.6 Compare Verification and Validation Requirements to Requirements

The purpose of this activity is to confirm the appropriateness of the verification and validation effort, affirm the availability of correct data, and lay the foundation for the distributed test verification and validation report. The V&V team will assist in establishing that the scope of the V&V effort for the distributed test configuration of ISTC was adequate and potential shortcomings and limitations were identified.

This assessment activity will include comparisons of distributed testing results to:

- the results of baseline models and simulations;
- real world data, or
- findings and opinions developed via a face validation exercise using subject matter experts (SMEs) to review testing results.

When conducting these comparisons for ISTC, the V&V team will consider underlying assumptions, differences in fidelity, and other constraints and limitations in their evaluation.

This activity will examine:

- Correlation between ISTC distributed test performance and real world behavior and appearance of the represented systems and forces (to the degree required);
- Suitability of the correlation of fidelity among the components;
- Adequacy of the environmental representation; and
- Correlation of live and synthetic targets.

If the distributed test results differ widely from expected values, the testing organization and V&V team will attempt to identify their causes and document them.

3.7 Produce Summary V&V Report

A summary V&V report is the result of a process that begins with the initial development of the V&V plans and ends only when the records of the procedures and results have been properly archived. Every V&V activity involves the collection and evaluation of information. The purposes of the summary V&V report include:

- Documenting the V&V activities to satisfy the planning needs of the exercise manager,
- Facilitating the flow of information during the accreditation decision process, and
- Addressing the V&V and data requirements for future distributed tests for ISTC.

Each of the V&V activities executed will be subject to an eight-step evaluation and reporting process which addresses each of the following items:

1. Name: Identification of the specific V&V activity.

2. UUT: Identification of the system configuration, or the specific part (component), to be evaluated. The unit-under-test (UUT) will be described so that it can be discriminated from other parts of the system. This identification will include identifying UUT characteristics and the rationale for each UUT selection.

3. Process: Identification of each sub-activity which will be performed during this activity. (i.e., measure, dimensions, ...).

4. Criteria: Identification of proposed test measures by which the UUT is determined to be acceptable. These test measures will include the rationale (how the value of criterion is obtained) and justification of the criteria.

5. Product: Identification of each significant data product generated from the V&V activity:
   - Technical Reports
   - Memoranda for Record
   - Database
   - V&V Report
   - Auditable, residual information.

6. Executing Agents: Identification of the lead organization or institution responsible for executing the V&V activity. This also includes identification / coordination of participating agencies and identification of roles and relationships between the V&V activity participants.

7. Resources: Identification of other resources such as:
   - Labor
   - Technical data
   - Computational assets
   - Subject Matter Experts

8. Schedule: Identification of duration, start and stop dates, and illustration of relationships (links) to other activities. This schedule will identify constraints that affected execution.

The findings from the execution of this 8-step evaluation process will be summarized in interim ISTC V&V Reports. These interim V&V reports will be summarized in a final, ISTC Summary V&V Report provided to BMDO, the OTAs, and other government agencies as inputs for their independent accreditation reports. These interim and final V&V reports will be utilized by the various test resource and M&S accreditation authorities (BMDO, OTAs, and others) to support their independent accreditation findings and accreditation decisions.

4.0 SUMMARY AND CONCLUSIONS

Several observations are supported by AEgis Research experience in V&V program planning for ISTC and other similarly complex tools.

4.1 Observations

Certainly, systematic V&V is required for the ISTC and for many similar tools. The technology and management of V&V programs is generally well understood. Based on this understanding, the managed investment approach to deliberate development of V&V programs has been derived and is being used successfully for ISTC and several other major M&S programs.

Within the DoD environment, accreditation data requirements will need to be carefully identified to drive the identification of specific V&V activities, including: UUT, assessment technique, schedule, evaluation criteria, data products, and V&V agents. The special challenges of V&V for distributed test resources and similar M&S resources require early, detailed V&V planning to mitigate program risks and identify the most relevant interoperability issues.

Through on-going DoD programs and activities, several interoperability issues have already been identified in the V&V of a distributed simulation. For example, syntactic consistency, or interoperability is typically enforced by interface specifications. However, semantic consistency, or the interaction's credibility is seldom enforced. Certainly, V&V of distributed simulations of this kind will have to be flexible and may differ in many ways from the V&V utilized for many closed-loop simulations.

4.2 Conclusions

Some conclusions are implicit in furthering the objective of enhancing state-of-practice for V&V of M&S.

First, there is broad guidance available upon which to structure a V&V program for the application of M&S resources like ISTC in distributed tests.

Second, a rigorous management approach to VV&A, and M&S utilization, maintenance, and configuration management of M&S and their associated data is required for early, timely resolution of issues.

Finally, a formal, coordinated V&V program of activity is essential to ensuring:

- Development of a distributed simulation which works well, and can be maintained;
- Availability of simulation-based analyses from accredited tools are available at key design decision points and milestone decision reviews; and
- Design or implementation decisions for major defense programs are correct because credible M&S resources are available to assess performance and identify program alternatives.

5.0 REFERENCES

[1] U. S. Army TRADOC Analysis Center, U.S. Army Space and Strategic Defense Command, Naval Air Warfare Center - Training Systems Division, Army Material Systems Analysis Activity, U.S. Space Command/Center for Aerospace Analysis, U.S. Air Force Wright Laboratory, *"Conduct VV&A of DIS Exercise: IDEF0 Model Specification for Verification, Validation, and Accreditation for Distributed Interactive Simulations"*, 1994 DMSO VV&A of Distributed Simulations Project, September 1994, Huntsville, AL.

[2] IEEE 1278.4 entitled "*Recommended Practice for Distributed Interactive Simulation -- Verification, Validation, and Accreditation*", the Institute of Electrical and Electronics Engineers, Inc.

[3] Waite, William F., and Dr. Nuzman, Dwayne and Phillips, Scott; *"Planning for VV&A: An Example*", The Proceedings of the 1994 Summer Computer Simulation Conference.

[4] JADS Joint Test Force, "*The Big Picture: Finding the Utility of ADS for T&E*".

[5] JADS Joint Test Force, "*ADS & T&E: Gateway to the Virtual Test Environment*".

[6] R.O. Lewis, "*A Generic Model for Verification, Validation and Accreditation (VV&A) of Advanced Distributed Simulations (ADS) Used for Test and Evaluation (T&E)",* Simulation Interoperability Standards (SISO) Workshop, Spring 1997.

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