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SIMULATION, TEST, AND EVALUATION PROCESS

STEP

GUIDELINES

4 DECEMBER 1997

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FOREWORD

On October 3, 1995, Dr. Paul Kaminski, the Under Secretary of Defense for Acquisition and Technology, announced that he was "requiring that the Simulation, Test, and Evaluation Process-let's call it STEP—shall be an integral part of our Test and Evaluation Master Plans. This means our underlying approach will be to model first, simulate, then test, and then iterate the test results back into the model." He emphasized, "Just as we speak now of 'test, fix, test'...we should now plan our development programs so that they 'model, test, model.' My intent is to ensure modeling and simulation truly becomes an integral part of our test and evaluation planning. We must consider all the tools and sources of information available to us in developing and evaluating the performance of our weapon systems."

The Simulation Test and Evaluation Process is one that integrates both simulation and test for the purpose of interactively evaluating and improving the design, performance, joint military worth, survivability, suitability, and effectiveness of systems to be acquired and improving how those systems will be used. STEP significantly reengineers the way modeling and simulation is used with test and evaluation to support acquisition reform. STEP implements the intent of the DoD 5000-series acquisition regulations and is anticipated to contribute to:

- *Substantially reducing the time, resources, and risk associated with the acquisition process,*
- *Increasing the quality, military utility, and supportability of systems developed and fielded, while reducing their total ownership costs, and*
- *Facilitating Integrated Product and Process Development (IPPD) across the full acquisition life cycle.*

We are providing these STEP Guidelines for all those who are involved with the acquisition, fielding, and employment of new military capabilities. We expect engineers, users, support planners, trainers, managers, and executives to use the process and benefit from it. Within T&E, our intent is to ensure that modeling and simulation truly becomes an integral part of our test and evaluation process. We will expect to see this reflected in test planning and conduct and documented in Test and Evaluation Master Plans.

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CHAPTER 1

Introduction to the STEP Concept

1.1 Introduction

The Department of Defense is seeking to streamline ways in which it acquires weapons systems. Evolving modeling and simulation tools have the potential to allow us to reduce the time, resources, and risk associated with the process while improving the quality of the systems produced through a strategy called Simulation Based Acquisition (SBA).

1.2 Acquisition Reform and Integrated Product and Process Development

The DoD is committed to reforming its acquisition system to achieve essential efficiencies. The Department is developing better ways to determine what to buy and better methods of buying what it needs. To determine what it will buy, the DoD is placing considerable emphasis on selecting the most cost-effective mix of individual systems for development and fielding. In order to improve how it buys, the DoD has directed:

> "The PM shall employ the concept of Integrated Product and Process Development (IPPD) throughout the program design process to the maximum extent practicable. The use of Integrated Product Teams (IPTs) is a key tenet of IPPD...The IPPD management process shall integrate all activities from product concept through production and field support, using multi-disciplinary teams to simultaneously optimize the product and its manufacturing and supportability to meet cost and performance objectives. It is critical that the processes used to manage, develop, manufacture, verify, test, deploy, operate, support, train people, and eventually dispose of the system be considered during program design."[1]

Modeling and simulation (M&S) supports the IPPD process and the integration of complex systems and is a key tool of the Integrated Product Teams(IPT). The members of an IPT (i.e., those involved in design engineering, test, manufacturing, logistics, product support) share information and data from tests and simulations and identify needed information from these simulations and tests. Furthermore, technical and operational challenges, which can be identified early in system development through simulation, can be targeted for further testing. Virtual prototypes embedded in realistic synthetic environments can aid in developing a shared vision of the proposed system and provide a means for understanding the complex interactions among the configuration items in the system design. Design, manufacturing, and test engineers can work together in IPTs to

[1] DoD 5000.2-R, Part 4.2.

build a prototype that can be more efficiently manufactured and tested. This efficient use of accredited M&S is required by DoD acquisition regulations:

> "Accredited modeling and simulation shall be applied, as appropriate, throughout the system life-cycle in support of the various acquisition activities: requirements definition; program management; design and engineering; efficient test planning; result prediction; and to supplement actual test and evaluation; manufacturing; and logistics support. PMs shall integrate the use of modeling and simulation within program planning activities, plan for life-cycle application, support, and reuse models and simulations, and integrate modeling and simulation across the functional disciplines."[2]

In addition to increasing the effectiveness of the design, test, and manufacturing functional specialists, modeling and simulation will benefit the product support members of the team (e.g., the logisticians and maintainers) as well as the training and warfighting communities.

Program offices need to support and use modeling and simulation more than ever before and must plan for the funding of program and legacy M&S. Modeling and simulation capability has matured to the point where it can serve as a key facilitator of: (1) development; (2) communication between government and contractor; (3) requirements exploration in the context of cost as an independent variable; (4) demonstrating the significance of features found in component and subcomponent tests; (5) test planning and analysis; (6) communication between engineering, manufacturer, tester and user; (7) logistics management; and (8) training and human factors evaluation during the life-cycle of a system. In other words, modeling and simulation used well in the IPTs can be a key contributor to the Integrated Product and Process Development (IPPD) that the Secretary of Defense has directed.

1.3 Simulation Based Acquisition (SBA)

The Department's vision is to have an acquisition process that is enabled by the robust, collaborative use of simulation technology that is integrated across acquisition phases and programs. The goals of Simulation Based Acquisition are to:

- Substantially reduce the time, resources, and risk associated with the acquisition process;
- Increase the quality, military utility, and supportability of fielded systems while reducing total ownership costs, and

[2] DoD 5000.2-R, Part 3.4.4.

- Enable Integrated Product and Process Development (IPPD) across the full acquisition life cycle.

SBA is an integrator of simulation tools and technology across acquisition functions and program phases and across programs. It is a concept in which M&S as a resource is more efficiently managed in the acquisition process. In a defense environment of decreased funding, SBA addresses both the decreasing availability of resources for system development and the increasing power of M&S tools.

1.4 The Simulation, Test and Evaluation Process - STEP Concept

The Simulation, Test and Evaluation Process (STEP) is a major DoD initiative designed to improve the acquisition process by integrating M&S with T&E. STEP is consistent with the regulations that govern systems acquisition and does not require their modification.

STEP is a move beyond the "test, fix, test" approach to a "model-simulate-fix-test-iterate approach" with problems fixed as they are discovered. This approach, illustrated in Figure 1-1, (model first; simulate; test; fixing after each step and then iterate the test results back into the model) is reiterated throughout system development. There are many iterative loops in this process, for instance, one can model, simulate, fix, simulate, fix, simulate, fix, test, then feed the results into the model. When a need to fix is discovered, the time for each fix can be much shorter when the fix can be verified in the model in hours or days, as opposed to a field test which can take weeks or months to verify a fix.

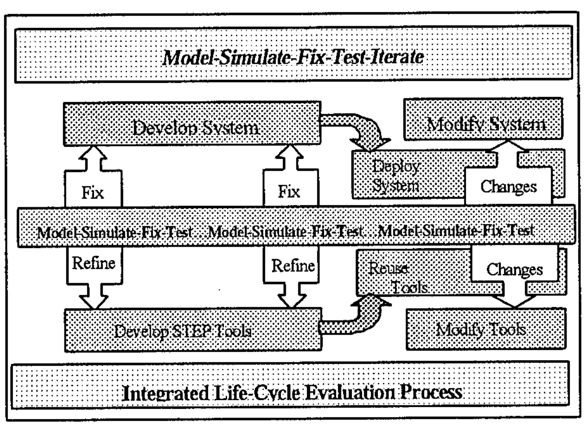

Figure 1-1. STEP Uses a Model-Simulate-Fix-Test-Iterate Approach

With STEP, the set of models matures, culminating in representations of the system, its interfaces, and its environment with an established fidelity. When tests are conducted, the data collected while evaluating the system can be used to refine and validate the models. These models and simulations can then be reused throughout the weapon system's life cycle to further predict and extrapolate performance, operational effectiveness, suitability, and survivability. They will also be available for later modifications to the weapon system and to other programs.

The STEP emphasis is the interdependent manner in which simulation, engineering, management, and test are applied and remain available for reuse throughout the system life cycle. Credible representations of the system and simulations can provide early and continuous insight and projections and predictions about system performance; risk and risk mitigation; operational effectiveness, survivability, and suitability; and to support others in the acquisition, requirements, cost analysis, training, and user communities.

The T&E community will work with the program office through the program IPTs to develop a comprehensive evaluation strategy using STEP and other means. In order to implement this strategy, the program office must invest early to insure that valid models and simulations are available and useable when needed by the contractor and the rest of the IPT.

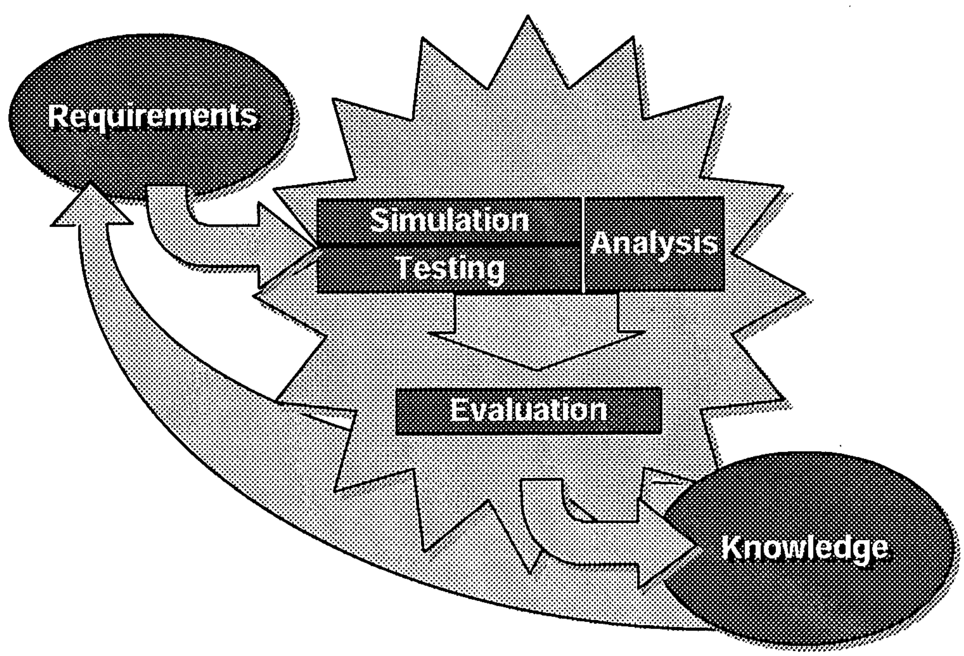

Figure 1-2. STEP is an Evaluation Process

The program office can use the information in the following chapters to assist in developing and implementing an evaluation strategy that will enhance both their program and other acquisition activities.

CHAPTER 2

STEP Strategy

2.1 Definition and Overview

The Simulation Test and Evaluation Process is defined as an iterative process that integrates simulation and test for the purpose of interactively evaluating and improving the design, performance, joint military worth, survivability, suitability, and effectiveness of systems to be acquired and improving how those systems are used.

In STEP, simulation and test are integrated, each one depending on the other to be effective and efficient. Simulations provide predictions of the system's performance and effectiveness, while tests are "part of a strategy to provide information regarding risk and risk mitigation, to provide empirical data to validate models[3] and simulations, to permit an assessment of the attainment of technical performance specification and system maturity, and to determine whether systems are operationally effective, suitable, and survivable for intended use."[4] A byproduct of this process is a set of models and simulations with a known degree of credibility providing the potential for reuse in other efforts.

The product of STEP is information that can be used throughout the system life cycle. By beginning the process early, models and simulations can provide information on failure modes during the early stages of design. This allows for design iterations before hardware is available for test. In addition, throughout the life cycle, information from STEP can support decisions regarding cost-performance trade-offs, technical risk, system maturity, operational effectiveness, suitability, survivability, training, mission planning, and tactical employment. The STEP process does not end with system fielding and deployment; it continues throughout the operational support of the system to the end of its life cycle. STEP results in an efficiently designed and thoroughly understood system with known operational effectiveness, suitability, and survivability characteristics.

The implications of STEP for DoD acquisition are numerous. Decision-makers can use system performance predictions to assess the military worth of the system not only before any physical prototypes are built but also throughout the system life cycle. The development and T&E communities can use predictive simulations to evaluate sys-

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[3] **Model.** *n* A physics, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. *v* To create a representation of a system, entity, phenomenon or process.
Simulation. A method for implementing a model over time.

[4] DoD 5000.2-R, Part 3.4.

tem performance in areas that are not readily testable, or to encourage testing a system to failure to improve reliability. The developmental, operational, and live fire T&E communities can use STEP as a mechanism for test planning, for sharing data for models, simulations, and tests, and for establishing a compatible and consistent basis from which to evaluate performance.

STEP is a sub-process of the overall acquisition process and applies to all acquisition programs, not only Major Defense Acquisition Programs (MDAP) and Major Automated Information Systems (MAIS).

A key ingredient to successfully accomplishing STEP is the development of an interdependent and consistent set of STEP resources. STEP resources are both simulation and test tools that allow the analyst and tester to focus on that which is essential to evaluate, to monitor the activities as they occur, and to consolidate and analyze the results of their activities. Testing tools include live tests, stimulators, and laboratory facilities that have supported testing for many years. Simulation resources include a set of models that together describe the system characteristics and performance at all levels from engineering models to campaign level wargames. They are used in a variety of ways from measuring compliance to design requirements through predicting system performance in an operational environment. Available STEP resources are defined further in Chapter 4.

2.2 STEP Throughout a Weapons Systems Life Cycle Process

As an iterative process extending across a weapon system's life cycle, STEP is integral to an acquisition strategy, interacting with other functions in each phase to provide information needed for acquisition decisions and to ensure that improvements are worked back into the functional areas after each iteration. The involvement of STEP throughout the acquisition process is shown in Figure 2-2. The figure also depicts the developing models and simulations, products of STEP, that are available for continued use throughout the life cycle of the system. As STEP progresses across the acquisition phases, some models and simulations developed for specific applications can be modified, further verified and validated, and made ready for use later in the acquisition process.

During Analysis of Mission Need. Models and simulations offer a way to quantify the shortfalls in number and type of systems for force structure analysis, to quantify the consequences for a wide variety of scenarios, and to identify thresholds of operational significance to the accomplishment of national military objectives.

During Concept Exploration. During this phase, an Analysis of Alternatives (AOA) is developed to aid and document decisionmaking by providing insight into the relative advantages and disadvantages of the options being considered to meet a mission need. Analyses performed show the sensitivity of each alternative to changes in key assumptions (e.g., threat) or major variables (e.g., speed, probability of kill, weight). In addition, the most promising system concepts are defined in terms of broad objectives for cost, schedule, performance, trade-off opportunities, overall acquisition strategy, and T&E strategy.

In implementing STEP, programs should address major information objectives, simulation and test events, resources, and timing. This includes determining how the test objectives will be met and developing plans for the logical progression of events to gather the appropriate data. These plans will integrate the needs of the T&E community with those of other acquisition activities (e.g., design, risk management, trade-off studies) and the training community. When implemented, they should result in the identification of an initial set of interactive models that provide continually maturing and comparable results to support program decisions.

During Program Definition and Risk Reduction. During the Program Definition and Risk Reduction (PDRR) phase, STEP can provide: early insight into the reliability, availability, and maintainability (RAM) of the proposed system; information to support the assessment of risk; information from ergonomic models to support maintainability; information on physics of failure; and data on the human-machine interface.

Predictions from *engineering-level* M&S are also used as the basis for representing the system's performance in *engagement-level* M&S (i.e., the predictions replace the assumed values). *Engagement-level* M&S provides information on the effectiveness of the system against a specific target or enemy threat, which can be used to support MOE projections at the system-on-system level.

Early Operational Assessments (EOAs) in support of Milestone II cannot always be performed on physical prototypes, which are often difficult to acquire at this point in the program. STEP will provide the program manager with an integrated, credible set of models that can be used in simulated test scenarios to allow completion of EOAs when physical prototypes are not available.

During Engineering and Manufacturing Development. During the Engineering and Manufacturing Development (EMD) phase, the most promising design approach is translated into a stable, interoperable, producible, supportable, and cost-effective design. This is when models, simulations and tests are used to: (1) verify the system's design; (2) confirm that design risks have been controlled; (3) certify readiness for operational testing; and (4) evaluate the system's operational effectiveness, suitability, and survivability. The use of models that have been updated with test data increases the understanding of the military worth of the system design.

Feedback from tests to the simulations is not only required for verification, validation, and accreditation (VV&A), but also to allow progressive improvement in the M&S. In this manner M&S can support the tests with performance predictions for use in planning future tests and in risk assessment. Feedback can also highlight areas where additional M&S and test effort may be needed, e.g., gaps in requirements testing, refinement of environmental constraints, and adjustments to modeling logic or algorithms. The final result, when testing is complete and the final M&S updates have been made, will be mature, validated M&S resources, which will support the weapon system throughout its life cycle.

During Production, Fielding/Deployment, and Operational Support. The process of updating models and data sets is critical in resolving design problems after fielding and in making modifications to the system throughout its life cycle. During the last phase of the acquisition process, the entire validated, interdependent set of STEP resources is available for use. Changes introduced during production must also be made in models and data sets to ensure they remain representative and documentation is complete.

STEP can be useful through the entire service life of the system. It can aid in the development of training simulators with the requisite realism and fidelity for system operators and maintainers. Operating specifications and characteristics in manuals and electronic mission planning aids can also be derived from M&S, i.e. projections about maximum range. Records of system usage, failures, and maintenance actions are sometimes incorporated into models of system performance and longevity, permitting the revision of operating procedures and the timing of periodic depot maintenance to reflect actual in-service behavior. Authoritative system representations, developed and matured throughout the acquisition process, can be applied in training exercises from the mission to the campaign level.

Figure 2-2. STEP in the Acquisition Process

(2-page fold out), page 2-5

Second page of Figure 2-2

2.3 Relationship between STEP and the T&E Process

The DoD T&E Process[5] is a five activity iterative process that is repeated many times throughout the acquisition life-cycle. Figure 2-3 shows a flow chart of one iteration of the T&E process with the five major activities, and inputs and outputs to other research, development, and acquisition activities.

A misperception is that STEP uses M&S to support the T&E process, that using STEP is business as usual. In fact, STEP is revolutionary in the ways it extends beyond the T&E stovepipe to use information from across the community to contribute to the evaluation. STEP enhances the T&E process, as well as the other acquisition processes, and provides a mission-centered focus on evaluation.

Another misperception is that STEP uses M&S to replace testing. STEP allows the T&E community to better focus the tests that are done to get critical information for the evaluation. Through IPPD, early involvement of the entire T&E community with the requirements, acquisition, and training communities will help ensure that the mission need and the system are fully understood and described in operational terms.

STEP enhances the T&E process with the application of M&S tools. In addition to the collection of data to support system evaluation, data are collected to refine the models and simulations using the model-test-model approach. Testing produces models and simulations with increased credibility, and allows for the assessment of system performance in areas and under conditions that might not be otherwise available with conventional testing methods.

STEP integrates modeling and simulation into the T&E process by applying analysis and other resources that support the development of an integrated, comprehensive, and flexible evaluation strategy early in the acquisition cycle to insure continual, comprehensive performance evaluations. These performance evaluations serve not only the T&E community and the acquisition community during the acquisition process, but also the requirements community prior to milestone zero, and the training community throughout the system's life.

STEP contributes to refining the requirements in the Operational Requirements Document. Sensitivity analyses using STEP models and simulations identify performance drivers and aid in determining many of the operational issues required by the program such as: critical operational issues (COIs), critical technical issues, and critical system interfaces that must be evaluated. STEP also helps identify evaluation measures—MOEs, MOPs, and CTPs—and where appropriate, the associated threshold and objective criteria. STEP can also be used to analyze data collected to support the performance evaluation. This solid foundation leads to the creation of a comprehensive evaluation plan with clearly defined data and resource requirements, which supports an affordable acquisition strategy and a realistic program schedule.

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[5] The generally accepted DoD T&E process is documented in "*A Description of the DoD Test and Evaluation Process for Electronic Warfare Systems*".

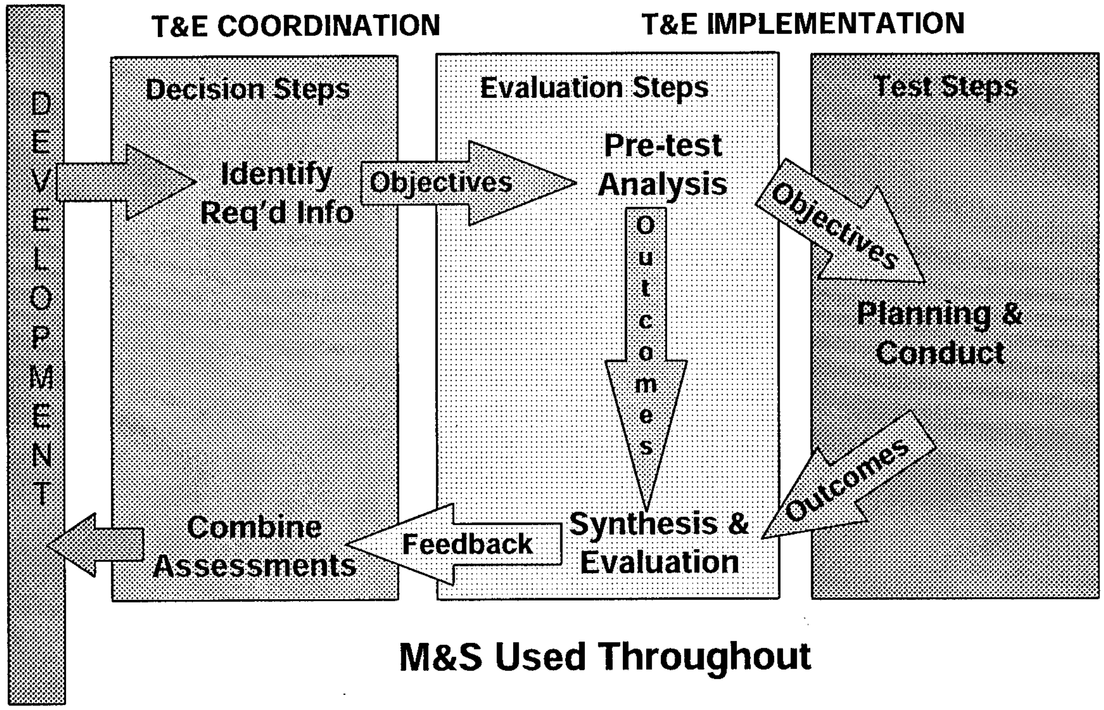

Figure 2-3. The DoD T&E Process

Models and simulations can be used to focus tests on critical missions by identifying the high payoff scenarios from the spectrum of possible mission scenarios. Also, weapon system immaturity can be partially mitigated by increasing crew training using appropriate human-in-the-loop simulators prior to field testing, thereby avoiding wasted time while operators learn how to exploit the new weapon system's unique capabilities and develop effective tactics.

The wise application of STEP will produce objective and more comprehensive information regarding performance than the use of T&E alone. M&S can free costly test assets for use in defining the edges of operating envelopes where confidence may be low but performance is expected to be high. Simulations can also be used to test to failure in order to improve reliability. This evaluation strategy applies the elements of the T&E process to gain knowledge and understanding in order to produce better products without detracting from the test and evaluation process. This kind of evaluation strategy provides better performance information to the warfighters and wisely allocates costly assets to evaluate the most appropriate performance issues.

CHAPTER 3
STEP Implementation

3.1 Introduction

Based upon a thorough understanding of simulation and test capabilities and limitations, the program office must obtain the most cost-effective, objective, and credible performance information possible to adequately evaluate the system under development and its performance in the intended operational environment. Implementation of STEP places the emphasis on an overall evaluation strategy that uses all available data sources efficiently and effectively.

STEP helps explore the best sources of data to support analyses and to provide performance information in time to support decision-makers. Archived data from training exercises, war games, contractors, government agencies, studies, after-action reports, and patrol reports are all potential sources of data. Data from models, simulations, and test events may also be used to augment archived data that is not applicable, available, certified, or complete. In some cases this may require modifications to existing data collection methods or analysis assets. In other cases, new instrumentation and new analysis capabilities may be needed.

The important ingredients in successful implementation of STEP are (1) a thoughtful and thorough evaluation plan that covers the entire life cycle process, (2) early identification of all the tools and resources needed to execute that evaluation plan and timely investment in those resources, (3) assuring the credibility of the tools to be employed, and (4) once testing is accomplished, using the resulting data to improve the efficacy of the models and simulations. The evaluation methodology outlined in the TEMP should incorporate the STEP process.

3.2 Planning for an Evaluation Strategy

The first key is to determine the life-cycle evaluation strategy. This means identifying performance drivers and COI using M&S at the campaign, mission, and engagement levels to help determine what mission critical issues must be evaluated and what methods should be used to make those evaluations.

Planning begins at a macro level and gradually moves to the micro level. STEP is a natural part of the planning process that begins with an analysis of operational mission needs and proceeds through the selection of the most appropriate sources of data (micro level) to provide credible performance information. Planners develop a flexible evaluation strategy, which can be modified if necessary, to support the eventual fielding.

The challenge in developing a comprehensive evaluation strategy is identifying the appropriate data sources and the associated analysis methods that will provide the most credible information in time for each of the information users.

STEP might use validated models and simulations to identify performance expectations in the center of operating envelopes and use valuable test assets to define the edges of those envelopes. In other cases, models and simulations will be used to make performance predictions that will be validated through actual test events. In still other cases, extrapolated results from validated models and simulations will be used when capabilities cannot yet be tested. The T&E community will provide technical expertise regarding the best method of evaluating the mission capabilities required. This truly moves the T&E process to the place where it provides information and understanding of joint military worth to the warfighters.

Engineers and operational evaluators play a key role in evaluating system performance throughout the life cycle. They identify:

- The information needed and when it must be available. This includes understanding the performance drivers and the critical issues to be resolved.
- The exact priority for what must be modeled first, then simulated, and then tested. This includes learning about the subcomponent level, the components, and the system level.
- The analysis method to be used for each issue to be resolved. Timing may have a significant effect on this. The design function can use models before any hardware is available. It will always be more expedient to use models and simulations at the early stage of system design. However, the design itself may be affected by operational considerations that require examination of real tests or exercise data. It will, given the training and logistic information required of systems today, be prudent in the long run to develop appropriate models and simulations.
- The data requirements and format for the analysis chosen. Included in this determination is the availability of instrumentation, not only for collecting performance data, but also for validating appropriate models and simulations.

Evaluation Strategy

The evaluation strategy considers the time, risk, cost, type, and quality of information needed and identifies the analysis methods and resources that can provide the data required. Planners then trade off the sources of data to ensure use of the most cost-effective set of STEP resources. Current trends suggest M&S will play a more important role in providing needed data. Leaders in the acquisition and T&E communities must ensure needed models and simulations are developed and refined as the system under development matures. Furthermore, these leaders must commit to providing the resources needed to develop and refine the models and simulations.

Testing usually provides highly credible data, but safety, environmental, and other constraints can limit operational realism, and range cost and scheduling can be limiting factors. Modeling, especially credible model building, may be very expensive although M&S can be available before hardware is ready to test. A prudent mix of simulation and testing is needed to ensure that some redesign is possible (based on M&S) before manufacturing begins. In the IPPD context, modeling should iteratively examine the design within the mission context and in the combat-simulated environment. The system components that contribute significantly to mission performance require a greater degree of testing than those whose function is not as closely tied to mission performance.

The type of system being developed will influence the evaluation strategy, and availability of M&S resources. For example, developers of strategic systems have long made extensive use of models and simulations because testing was impractical; thus, many of the resources they need already exist. On the other hand, other communities have not made such extensive use of M&S and may have to develop new models. For less complex systems, STEP may reveal that test is the most cost-effective means to evaluate system performance, and the development of models and simulations is not warranted.

Operational requirements (including threat projections) and the information required to support acquisition decisions influence the evaluation strategy. Timing is critical. The acquisition schedule must provide time for engineers, analysts, and decision-makers to gather the data and information they need. At the campaign and mission levels, information will be directed toward resolving macroscopic issues on performance, technical risk, schedule, and cost. Realistic scenarios using models and simulations and based upon MOEs soundly supported by MOPs and CTPs will address these issues in terms of campaign outcomes and mission success.

Models and simulations can be used for sensitivity analyses to identify performance drivers, to obtain a good understanding of the COIs, and to derive the CTPs. Methods for measuring CTPs, MOPs, and MOEs and analyzing the collected data to resolve critical issues must be selected. The analysis methods and the available analysis resources can have a significant impact on the data that needs to be collected. In the case of new technologies, if the existing M&S cannot address the critical issues, then the modification of existing or the development of new analysis resources, instrumentation, and data collection methods may be considered.

Risk reduction must be a key consideration when developing the evaluation strategy. Operational challenges to the technology must be clearly understood. The early evaluation must focus on those areas of the system under development that present the greatest technical risk. The evaluation may involve refining existing or developing new models or simulations. For example, planners may want to provide for an HWIL facility as early as possible for a new seeker technology. This may require modification or development of new STEP resources to provide the facilities, people, and other support needed to evaluate the seeker technology using actual hardware and software with simulated environments and threats. Field tests may be able to accomplish the same goals before the information is required, while models and simulations being developed may not be ready in time to provide the information needed to support the decision. Also, M&S will not identify "unknown unknowns"; laboratory or field tests are needed to accomplish this.

Software development has been shown to be an area of considerable technical risk. When considering the technical risk and timing required for having analyses available to support the information needs of a decision-maker, contingency or alternative options should be considered. The evaluation itself should contain alternatives to be implemented if the STEP resources of choice are not available. Such alternatives should be thoroughly considered to ensure they represent the next best method of providing consistent, comparable, and credible performance information.

The bottom line is that early and thorough planning for the evaluation strategy is essential for effective implementation of STEP.

3.3 Resource Identification and Investment

Program managers and STEP implementers must begin early to plan, budget, and integrate interactive M&S in design, development, acquisition, testing, training, and logistic efforts, starting with currently available models used by the contractor and the government. A key element of an improved acquisition system is the development and maturation of an interdependent, consistent set of models and simulations using test data.

While developing the evaluation strategy, the program office must also develop a plan to identify and fund resources that support the evaluation. In determining the best source of data to support analyses, STEP considers credibility and cost. Resources for simulations and test events are weighed against desired confidence levels and the limitations of both the resources and the analysis methods. The program manager works with the T&E IPT to use STEP to develop a comprehensive evaluation strategy that uses data from the most cost-effective sources; this may be a combination of archived, simulation, and test event data, each one contributing to addressing the issues for which it is best suited.

STEP integrates the use of simulation events with test events, each depending on the other, to add value to the T&E process. *Simulations* are part of a strategy to provide information by *predicting* test results, by *exploring* performance in the testable realm, and by *extrapolating* performance in the non-testable realm. *Tests* provide information from the real world regarding situations and environments and permit an assessment of the attainment of technical performance specifications and system maturity. Tests are used to determine whether systems are operationally effective, suitable, lethal, and survivable in combat.

The reader will find a discussion of the types of STEP resources that can be applied to the evaluation strategy in Chapter 4.

Identification of Models and Simulations

For new systems, planning should begin early enough to influence the initial Request For Proposal (RFP). If government campaign-, mission-, and engagement-level models, simulations, and architecture are specified in the RFP, industry can respond with a proposal that includes the contractor's plan for the development and use of engineering-level models, simulations, that are interoperable with Government models, and the associated preliminary evaluation plan. Such content should be a major proposal evaluation criterion. Contractor models would interface with the models used by the government and specified in the RFP. Thus, common models and simulations would be identified and available at source selection, through EMD, and throughout the life cycle. Further, appropriate models developed by the contractor would be documented, delivered, and maintained to support this integrated evaluation process.

Many models may not be developed by the acquisition program office. Campaign-level and mission-level models and simulations may be the property of other organizations or agencies and in some cases may be owned or at least operated by industry. Major facilities may be owned by other Services. Supported by top-level managers, planners from key organizations should develop an integrated approach that specifies analysis resources, methods, assumptions, types of data, and the data sharing to take place that uses both the resources and facilities specific to the program and other available resources.

The first consideration when using M&S is to conduct an in-depth analysis to define what the M&S is required to do. Before any decisions are made about applying M&S to a given problem, the problem itself must be defined and articulated clearly enough to permit a precise specification of where M&S will play a role in the solution of the problem, and how it will contribute to the solution. Only then can acceptance criteria be developed for candidate M&S.

It is important to define *what* M&S will be required to do (i.e., *functionality*), and it is also necessary to determine *how well* candidate M&S must do those things.

Functional Requirements. Functional requirements are "nonanalytical" requirements in the sense that they do not contribute directly to the resolution of program decisions. Instead, they define such factors as hardware and software compatibility requirements (e.g., the M&S must run on a certain type of workstation under a certain operating system); pre- and post-processing requirements for M&S data (e.g., M&S inputs or outputs must be converted to special file formats); and operations and training support requirements (e.g., M&S cannot have license agreement or operator training requirements because there is no budget for such items, or no time for training).

3.4 M&S Credibility

An integral part of planning is determining the limitations and the degree of credibility of the information derived from use of the models and simulations. Furthermore, it is essential to plan to collect real test data with which to validate the models and simulations as the system under development matures. In some cases, STEP may require the collection of test event data for the sole purpose of validating models or simulations in order to adhere to the established evaluation strategy.

Many of the models needed to support STEP already support the systems acquisition process, both in DoD and industry. Often these models have been developed for a specific function or purpose with little thought to their integration into the entire acquisition process. As dramatic advances in supporting technologies make these models and simulations more powerful and less expensive, and as declining resources and changing priorities make it essential to find better ways to develop and field new systems, the use of M&S and of associated improved processes that exploit their contribution is expanding.

Validated simulation input data is essential for the use of accurate and appropriate M&S resources in STEP. Data repositories are not yet populated for most M&S resources. However, limited validated data for environmental factors, human interaction, and some system performance parameters do exist. It is important that the source of M&S input data be verified and validated. Questionable data can introduce unnecessary risk into the program and obviate test data.

Success with STEP does not come easy, nor is it free. STEP, by integrating M&S with testing, provides additional sources of early data and alternative analysis methods, not generally available in tests by themselves. It seeks the total integration of STEP resources to optimize the evaluation of military worth throughout the life cycle. The central elements of STEP are: the acquisition of information that is credible; avoiding duplication throughout the life cycle; and the reuse of data, tools, and information.

The success of STEP depends greatly upon the credibility of the STEP resources and data which are employed throughout the process. Ensuring that the models, simulations, and data used in, or generated by, STEP have been properly accredited and certified must become a rigid discipline. This section briefly describes verification, validation, and accreditation (VV&A) and verification, validation, and certification (VV&C), the requirement for careful software configuration management, and some of the practical issues involved in the use of M&S tools.[6]

Verification, Validation, Accreditation, and Certification

An effective evaluation strategy must include iterative Verification and Validation (V&V) of models and simulations as the system design matures in order to provide credible information.[7] The credibility of the M&S and supporting data is measured by a structured V&V process. Based upon adequate V&V, the M&S is approved as acceptable for use in a particular application by *accreditation*, with the entire process known as VV&A. Similarly, data used in the M&S are *certified* through a process called VV&C.[8] Ensuring that M&S and data used in STEP have been properly accredited and certified must become a rigid discipline.

The STEP approach involves integrating the data from laboratory and field tests to validate models and simulations as the system matures. This will result in a more complete set of models and simulations with a fidelity that gains credibility as the system under development matures. The V&V aspect of developing models and simulations may be difficult, time-consuming and costly, but it is also absolutely necessary for credibility of the entire process. VV&A is so important to the credibility of models and simulations that all Services require specific VV&A procedures and documentation. These STEP guidelines are not intended to specify VV&A procedures, however Annex C provides references to some additional information.

Verification focuses on M&S *capability* while validation focuses on M&S *credibility*. Verification is the process of determining that model implementation accurately represents the developer's conceptual description and specifications. Validation is the process of determining the degree to which a model is a sufficiently accurate representation of the real world (the subject system and the operating environment) from the perspective of the intended uses of the model.

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[6] The DoD *Verification, Validation and Accreditation (VV&A) Recommended Practices Guide* and DoDI 5000.61 should be reviewed for more detail on this subject.

[7] **Verification**. The process of determining that model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques.

Validation. The process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation.

Accreditation. The official certification that a model or simulation is acceptable for use for a specific purpose.

[8] **Certification.** The determination that data have been verified and validated, and are acceptable for use in the specific application identified.
Also see definitions for Data Validation, Data Verification, Data Certification, and Data VV&C.

Accreditation reflects a decision to use an M&S tool for a specific purpose or application. The decision is supported by the V&V and certain documentation. The process that leads up to an accreditation decision gathers all the information about specific model or simulation capabilities relative to the requirements of a specific application. This information includes the V&V results, but also includes such information as simulation run time, number of simulation operators required, the simulation's history of use, documentation status, and configuration management records. Documentation includes the V&V plan, the accreditation plan, and associated reports.

All M&S are driven by data, either as direct inputs by the user or as embedded constants that drive simulation characteristics. Both the data producer and the data user are involved in data verification, ensuring that data meet specified constraints defined by data standards, and that the data are transformed and formatted properly. Likewise, both are involved in data validation, assessing whether the data are appropriate for use in the intended model within stated criteria and assumptions. There are data V&V processes and procedures which parallel those for M&S V&V described previously. For data, the decision to use data for a specific application lies behind the certification. The configuration management, documentation, and similar issues relevant to M&S V&V also underlie data VV&C.

Software configuration management (CM) is of critical importance to STEP. CM is a development life cycle process through which the integrity and continuity of software development, upgrades, and maintenance are recorded, communicated, and controlled. Without effective CM, a user cannot be assured of what version of the M&S an application is using or what code, hardware, and/or data is being used. Good CM usually implies good documentation. Poor CM leaves any M&S documentation suspect in terms of currency, content, or both.

The reader is referred to the DoD *VV&A Recommended Practices Guide* for more information regarding the VV&A process.

Practical Considerations

The process for selecting V&V tasks rationally within a constrained budget environment revolves around the need for M&S and data credibility balanced by concern for the cost of the V&V activities that contribute to it. Also, while VV&A enhances a simulation's credibility it cannot guarantee that the M&S results will be correct, that the results will be correctly analyzed and interpreted, or that the correct model was chosen to solve the problem. A manager must be confident of the value added by the VV&A and VV&C process.

Although it is generally possible to specify the kind of V&V needed to support a given level of credibility, the amount of V&V required to establish credibility for a particular application will still be dependent on a clear definition of how program decisions are affected by M&S outputs.

Ongoing VV&A activities are the price one should expect to pay for ascertaining and maintaining the credibility of the M&S tools. When a simulation is modified, it is usually done with the intent of improving its operation, accuracy or scope. These changes may affect the simulation's suitability for particular applications. The changes must be compared against the user's intent (verification), and the impact of the changes on simulation output must also be compared against the real-world system or process to measure the increase or decrease in fidelity (validation). Additionally, when the real world changes, or the M&S is used for a purpose different from that originally intended, previous VV&A results should be reviewed to determine the impact of these changes on the credibility of the simulation. Since the real world is rarely static over any length of time, it is useful to review the VV&A status of an M&S periodically to ensure consistency with the real world.

3.5 Enabling legacy value of M&S through STEP

When planning for resources to support the evaluation strategy, the system developer will need to identify resources to mature the models and simulations, and plan for the test data to verify and validate the performance of those M&S. This is a critical to insuring that M&S used by the system have a long term legacy value and is fundamental to the reuse focus of STEP.

The M&S verified and validated during development and testing have wide use during fielding and deployment. Training simulators for system operators and maintainers must produce as realistic an environment and reproduction of system functions as possible. This will most likely be based upon or made up of subsets of the earlier M&S resources. Some operating specifications and characteristics presented in manuals and electronic mission planning aids are also derived from such M&S assets. Models of system durability and longevity will be used in determining timing of servicing, planning for parts availability, and other logistical support requirements. Records of system usage, failures and maintenance actions are folded into certain models of system performance and longevity. This allows necessary adjustments to operating procedures and limitations, plus periodic depot maintenance timing and planned work, to meet actual in-service behavior. Data sets or M&S are also rolled up as increasingly simplified, but authentic, representations of the system in wargame exercises from the mission to the campaign level.

The process of updating models and data sets is important in resolving design problems after fielding and in making modifications to the system throughout its life cycle. Changes introduced during production must also be made in models and data sets to ensure they remain representative.

The M&S verified and validated during development and testing have wide use during fielding and deployment. Training simulators for system operators and maintain-

ers must produce as realistic an environment and reproduction of system representations as possible.

Test design should allow for data collection to update models and to support the continuous V&V process to ensure that the most credible M&S resources will be available for use for future program endeavors, as well as by other program offices and acquisition functions.

3.6 Documenting STEP in the Test and Evaluation Master Plan (TEMP)

"A TEMP shall provide a road map for integrated simulation, test, and evaluation plans, schedules, and resource requirements necessary to accomplish the test and evaluation program."[9] Above all, STEP should increase the focus in the TEMP on developing and documenting a robust and comprehensive evaluation strategy. Additionally, the TEMP addresses how credible data will be obtained to support the evaluation strategy by integrating the use of models and simulations with test events. The TEMP remains a "living" document that must respond to, and reflect changes in, the state of the program and its previous testing results, requirements, models and simulations, analyses, and acquisition strategy, schedule, and funding.

The TEMP documents a comprehensive evaluation strategy that integrates the use of M&S with test events through STEP. The integration of STEP into the individual parts of the TEMP is described below.

Part I System Introduction

Part I of the TEMP addresses the evaluation measures and criteria derived from system requirements to be used in the evaluation strategy. Evaluation measures include operational Measures of Effectiveness (MOEs), and supporting Measures of Performance (MOPs) and Critical Technical Parameters (CTPs), derived from operational requirements. Measures of effectiveness include measures of suitability and, where appropriate, measures of lethality and survivability (susceptibility and vulnerability).

Prior to drafting the TEMP, M&S tools should help identify performance drivers to aid in defining Critical Operational Issues (COIs), MOEs, MOPs, CTPs, and critical system interfaces that must be evaluated. These same M&S tools should also help determine the quantifiable criteria (i.e., appropriate thresholds and objectives) for these measurable parameters. This solid foundation leads to a comprehensive evaluation strategy with clearly defined, measurable parameters and the associated quantifiable criteria that will be recorded in Part I of the TEMP.

[9] DoD 5000.2-R, Part 3.4.11.

The ability to trace evaluation results to requirements is vital to demonstrating the degree to which the system performance satisfies the requirements. The iterative nature of STEP permits linking operational performance measures and the derived technical parameters back to the operational requirements. Evaluation measures may be specified in the MNS, the ORD, or the RFP, or they may be developed based upon COIs identified using M&S tools.

Part II Integrated Test Program Summary

Part II addresses the schedule and management of the models, simulations, test events, resources, time, and funding to carry out the evaluation strategy. STEP affects the integrated schedule by calling for M&S throughout the evaluation process.

Key development or modification milestones of any simulations needed to support the evaluation strategy should be included in the integrated schedule to ensure appropriate visibility and the allocation of adequate time and resources. The details of developing or modifying the models and simulations need not be addressed in the TEMP. However, site installation schedules and configuration releases should be depicted on the Integrated Test Program Schedule and addressed in Part II of the TEMP. This will indicate the STEP resources that will be provided and when they will be available to support the evaluation strategy.

Part III Developmental Test and Evaluation Outline

Part III addresses the evaluation strategy, which examines the degree to which the system meets requirements as both the system and the requirements mature. The majority of the iterative work of STEP is accomplished during the DT program. It is here that STEP is employed to incrementally develop and test the system, making refinements to the system as well as the M&S tools. A key element of STEP is the concurrent growth and maturation of capabilities in both the system under development and STEP resources.

Early application of STEP that helps refine the system requirements will also examine the applicability of existing M&S to support the evaluation strategy. M&S should be used during the early phases of system development to provide information on performance drivers, CTPs, and technical risk areas such as system integration and system interfaces. This information should be used to conduct informed cost-performance trade studies.

The TEMP should also document how the early use of M&S will aid in assessing vulnerability and lethality. Documentation relating to statutory lethality and vulnerability (LFT&E) should be included in Part IV. LFT&E differs from OT&E in that live fire tests result in some degree of damage to the target system. Legislation and DoD 5000.2-R recognize that both modeling and component level testing should have an impact on the program early enough to correct design deficiencies before LRIP. Models based upon the understanding of underlying physical phenomena offer the greatest potential to assess vulnerability and lethality interactions. Fire, explosion, hydrodynamic ram, dynamic instabilities, and hypervelocity interactions are possible candidates for physics-based modeling.

The TEMP should address STEP resources that will help identify areas where data is needed and where M&S development is needed. The TEMP should be updated to reflect the results of trade studies that affect the evaluation strategy, the test strategy, and the test and evaluation resources. The TEMP should also identify areas where actual testing either can be augmented by M&S or used to validate the models and simulations. The program offices should use this information to help determine and document in Part III of the TEMP the appropriate analysis methods, instrumentation needs (particularly with new technology), and data sources to support the evaluation strategy.

Validation of the models and simulations and data certification are integral parts of the evaluation strategy and much of the information gathered during the early application of M&S can provide the required justification for subsequent use of M&S. The TEMP should summarize the M&S VV&A and the data certification to be conducted. If the VV&A and certification methods or the number of M&S assets to be validated is extensive, this information may be contained in a separate document with a summary and a reference in the TEMP.

Part IV Operational Test and Evaluation Outline

Part IV addresses the evaluation used to determine if the system is operationally effective and operationally suitable. STEP permits the evaluation strategy to include an examination of operational issues early in development. Using M&S, analysts should examine system performance from previously unavailable perspectives. Using M&S analysts can control introduction of unique variables to examine "what if" performance issues.

The TEMP should reflect the results of these initial operational insights and the invaluable information on the data collection requirements, performance requirements, thresholds, and objectives as well as on the appropriateness of evaluation measures and criteria. As the system and STEP resources mature, such information increases confidence that the system can be certified ready for IOT&E. The TEMP should reflect the integration of models, simulations, and test events to obtain the most credible data with which to conduct a comprehensive evaluation of performance.

The TEMP documents an evaluation plan that carefully considers the selection of appropriate evaluation measures and the ability to obtain and compare credible data collected from both simulations and test events. The TEMP should include a discussion of the mission-level and engagement-level models and simulations, that will be used to identify COIs and the operationally significant MOEs and MOPs, so CTPs can be derived.

STEP facilitates defining the COIs and conducting OAs of system capabilities throughout system development. The TEMP should document how these OAs will be supported with the iterative application and maturation of models and simulations. This process will provide the confidence and the data to develop operational concepts early, to evaluate software functional maturity, to evaluate component, sub system and system interface performance, to evaluate human factors, and to certify system readiness for dedicated IOT&E. The TEMP should also document how the early use of M&S will aid in assessing the operational impact of suitability issues (the "ilities") and logistics, and in determining initial tactics, training, and procedures.

Part IV of the TEMP should document the integrated use of accredited models and simulations with OT to increase the knowledge and understanding of the capabilities and the limitations of the system as it will be employed. Knowing the limitations of a system from models, simulation, and tests is important to the effective employment of the system. The final tactics, training, and procedures for employment will ultimately be based upon a thorough understanding of the system capabilities and limitations determined from the comprehensive and integrated use of models, simulations, and operational tests.

Part V Test and Evaluation Resource Summary

Part V addresses the resources needed to ensure the evaluation strategy can be carried out effectively, and is adequate to determine the system under development is operationally effective, suitable, and survivable. STEP requires greater emphasis in identifying, in the TEMP, the models and simulations, and the associated VV&A information that will be integrated with real test events to obtain credible data for evaluating performance. Step resources that should be integrated into Part V of the TEMP include:

- Facilities (government, industrial and academic),
- Threat representations including simulations,
- Specific existing models and simulations,
- Specific models and simulations to be developed, and
- Resources to conduct VV&A, including instrumentation needs.

STEP alters the focus of the types of resources required to develop and carry out a comprehensive evaluation strategy. Early and iterative use of M&S during development can identify critical test issues and focus the expenditure of test assets on critical test events. M&S may be used to increase the efficiency of test events by conducting "dry runs" that can identify procedural, data collection, and analytical difficulties before expending valuable test assets. This approach and the associated resources should be documented in the TEMP.

The STEP resources used in each phase of acquisition may differ as the program matures. The STEP resources, the data generated by simulations, and the data (from real test events) used to validate the M&S should be archived for future use. Such use may occur later in the life cycle of the program or may be used by other programs. The resources required to VV&A the models and simulations; the resources required to obtain, maintain, and M&S; and the resources required to archive data for the M&S should be included in Part V of the TEMP.

Annex A—Bibliography

The TEMP should not duplicate information contained in other sources (e.g., simulation support documents or VV&A documents). The TEMP should summarize such information and refer to the source documents. Verification documents, validation documents, and accreditation documents for each model and simulation used in STEP should be included in the bibliography.

CHAPTER 4

STEP Tools, Standards, and Resources

4.1 Introduction

Many of the tools needed for STEP already support the systems acquisition process, both in DoD and industry. Often these tools have been developed for a specific function or purpose with little thought to their integration with the entire acquisition process. As dramatic advances in supporting technologies make these tools more powerful and less expensive, and as declining resources and changing priorities make it essential to find better ways to develop and field new systems, the use of these tools, and of improved processes that exploit their contribution, is expanding rapidly.

4.2 Tools

The descriptions of STEP tools that follow are not all-inclusive, but are provided to show the range of types that exist and illustrate potential applications to STEP. What is desired is the effective integration of productive STEP tools and the reuse of many of these tools throughout the acquisition process. These can be viewed in the context of the activities detailed in the acquisition strategy, some examples of which are noted in Figure 2-1. When planning the evaluation strategy, it is advantageous to begin planning for funding and consider integration across the functional areas as early in the process as possible.

Models and Simulations

Models and simulations underlie all other STEP tools. M&S supports early involvement of the tester and evaluator in the system concept development stage to help formulate functional requirements in a testable manner. STEP resources in an evaluation strategy include authoritative and validated representations of the threat, e.g., both radio frequency (RF) and infrared (IR) missiles, threat radars, aircraft, and the associated command and control. Other important resources are models or simulations of the environment, including terrain, atmosphere, space, and ocean. These and other simulation tools are used to plan, rehearse, extend and evaluate live testing activities.

M&S includes a wide range of computationally based activities such as mathematical models exercised on digital computers. As discussed in Figure 4-1, models can be viewed in a hierarchy from engineering and engagement level models to mission and campaign level models. When planning the evaluation strategy, the program office should consider which types of models fit the needs for the developing system.

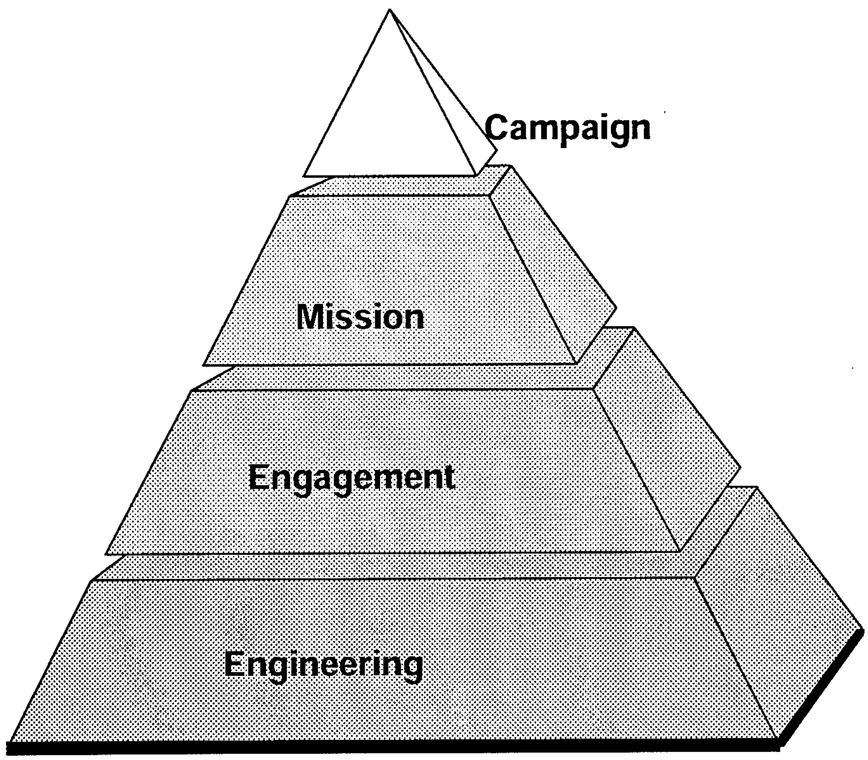

Figure 4-1. Hierarchy of Modeling and Simulation

Figure 4-1 illustrates the different levels of models and simulations required, and depicts how they form a hierarchy.

- **Engineering-level models** often involve the use of three-dimensional CAD/CAM/ CAE, or computational fluid dynamics or other computational approaches to consider such effects as signatures, extreme environments, mobility, and fatigue.
- **Engagement-level models** are used to explore such issues as end-game lethality, fire-power, manufacturing, and producibility.
- **Mission/battle-level, system-on-system models** support analyses of system performance, platform engagement, survivability, and mobility.
- **Theater/campaign-level, force-on-force models** provide insights into a system's contribution to force effectiveness, as well as force structure and logistics requirements.

M&S also includes physical representations as system models, and large computer-based simulations that predict system performance. The development of the models that describe a system, and the M&S that predict its performance, should be driven by the identification and refinement of system requirements. For example, the MNS for a major weapon system initiates the selection or development of models and simulations to assess the performance of the proposed system in theater/campaign, mission/battle, and engagement-level conflicts. The top-level system requirements of automated information systems (AIS) drive the development of top-level models of computer hardware and software, data, and telecommunication systems that can be used in simulations to predict functions such as collecting, processing, transmitting, and displaying information.

M&S can be used to design a better test program, add realism to test scenarios, extrapolate results of live testing, and understand aspects of system performance observed during live testing. This can reduce time, resources, and risk to an acquisition program. In some cases, M&S is the only way to conduct system assessment and is the only way to generate "reproducible" scenarios and conditions. The major limitation associated with models and simulations is credibility, which is addressed in more detail in Section 4.5. A technical challenge is linking or aggregating results from engineering models into higher level models. Additionally, many existing models and computer simulations are based on empirical data rather than physical principles. M&S output may be more readily accepted if M&S tools are based on proven principles of physics, validated by experimental data.

Advanced Distributed Simulation (ADS). ADS is an environment in which simulations are linked to produce large synthetic environments within which large numbers of subjects can interact in real time. The principal characteristics of ADS are that participating simulations are physically separated, are linked electronically, and share a common view of their electronic environment. The responses elicited from each simulation are seen, interpreted, and acted upon by the other simulations in near real time.

ADS offers the potential to link multiple non-collocated T&E for an evaluation. This could include multiple systems being linked and operating within a realistic synthetic environment, thus creating a virtual system. The benefits of this linkage are early interoperability and compatibility evaluation, and early user input to the system operating in concert with other new systems in a synthetic environment. Cost savings could be realized through early testing, reduced need for transportation and repositioning, and reduced acquisition cycle time. Limitations of ADS include latency, or the communication delay between participants, and the immaturity of the technology. The challenges of VV&A are compounded by the distributed nature of the ADS network; the linked network will require VV&A in addition to each stand-alone M&S participant.

Computational Fluid Dynamics (CFD). CFD is a numerical approach for modeling the dynamics of a fluid flow in and around solid objects. In aircraft applications, it can be applied to model stores separation to analyze aircraft-store loading, safe carriage and separation, safe escape and ballistic accuracy. The cost associated with certification of stores for release from an aircraft is very high. CFD is often used as a tool in direct support of wind tunnel and flight testing. Integrating the modeling tools directly with ground and flight tests enables the tester to design a better test program, validate and/or extrapolate the results, and assist in decision making for a more efficient or effective test. CFD can be applied to investigate anomalies observed during wind tunnel testing at significantly reduced cost over repeat wind tunnel trials. The principal limitation of

CFD is credibility. Optimal application of CFD is in conjunction with wind tunnel and flight test/analysis effort employing the model-test-model approach.

Simulators. The word "simulator" has a number of meanings:

> (1) *A family of equipment used to represent threat systems in testing and training. A threat simulator has one or more characteristics which, when detected by human senses or man-made sensors, provide the appearance of an actual threat system within a known degree of realism.*

Threat simulators are particularly useful to testers in creating realistic environments and as a means to mitigate limitations to the scope of testing because actual threat systems operated by trained "enemy" personnel may not be available for realistic testing. Threat simulators can be emissions, signatures or radar returns synthetically injected into a controlled laboratory environment, or they could be friendly units playing the role of threat forces in doctrine or performance. In some cases, threat hardware is used. M&S "simulators" may produce their greatest utility in providing the electronic means to generate sufficient numbers of threat forces to provide a meaningful evaluation of new system capability.

> (2) *A human-in-the-loop device that provides the conditions and environment of a system to accurately produce aspects of system performance and operation to estimate human performance associated with the system and to conduct training and develop tactics, techniques, and procedures.*

Simulators in this second meaning are commonly employed as training devices, but have numerous applications in support of testing, system operation, and tactics. Simulators developed concurrently with the system provide the means to obtain user feedback on operational and human factors issues. When integrated with other systems via ADS, great insight into the operational aspects of the system can be obtained.

> (3) *A physical representation of a system which can demonstrate certain aspects of system operation.*

An example of this third type of simulator is the Army's Firing Impulse Simulator. This device mechanically duplicates the recoil shock of firing large caliber weapons without actual firing. Environment effects (e.g., blast overpressure and noise) and ammunition cost are avoided while representative dynamic firing impulses are produced.

Stimulators. A stimulator is a simulation used to provide an external stimulus to a system or subsystem. The output of the simulation is used to "stimulate" the system (hardware and/or software) being evaluated for purposes of analysis. The unit under test may be in a HWIL configuration, test stand, or live field conditions. Limitations include the degree of realism of the stimulator, lack of tactics applied, and total threat system representation in fit, form and function to replicate the threat.

Measurement Facilities

Measurement facilities are used to quantify or measure parameters (such as thrust, radar cross section (RCS), and drag) of a test article in precise terms. Types of such facilities are wind tunnels, anechoic chambers, captive carry systems, RCS facilities, antennae pattern ranges, and engine thrust stands. Test articles may be scale models, mockups, or actual hardware. Examples of measurement facilities are wind tunnels, anechoic chambers, and captive carry facilities.

Wind Tunnel. A wind tunnel is a chamber through which air is forced at controlled speeds so that its effect on an object can be studied. A wind tunnel can be used at different times in a system's development to analyze air stream effects. This testing is especially relevant for flight safety evaluation and issue resolution. This evaluation can be augmented with computational fluid dynamics (CFD), flight testing, and captive carry evaluation. Limitation of wind tunnel use are the cost and availability of the facility and limitations on the size of the weapon that can be accommodated. Due to the cost of development and operation, most wind tunnels cannot accommodate full-scale systems. This forces the scaling down of systems to less than full-scale models for testing and imposes limitations on conclusions drawn from wind tunnel tests.

Anechoic Chamber. An anechoic chamber is a facility that provides an essentially echo-free environment at various electromagnetic frequencies for laboratory measurements including RCS, antenna pattern, and passive radar augmentation. Anechoic chambers provide a "pure" environment for testing, and the additional benefit of secure testing with no external emissions which can be monitored by unauthorized personnel. Weapons system size limitations may preclude some types of testing.

Captive Carry. Captive carry of stores or vehicles is a nondestructive means of obtaining data on air-capable vehicles. Instead of free-flying the vehicle, it is mounted on a parent aircraft. This "host" aircraft provides the motion, power, and support services required to operate the "guest." Additionally, the host aircraft often collects the data obtained for later analysis. A captive carry store or vehicle is normally not damaged and can be examined, analyzed, evaluated, and reused.

Hardware/Software in the Loop

Hardware/Software In the Loop (HWIL/SWIL) is a hybrid simulation that includes actual system (prototype or production) hardware or software in conjunction with digital models and external stimuli to demonstrate the operation and function of the hardware/software within an environment simulating actual operating conditions. HWIL/SWIL can be used to demonstrate new technology; evaluate designs, concepts, and prototypes; and show the integration of hardware and software. It allows early evaluation without the expenditure of live test resources, facilitates live test development by identifying critical test conditions, and can be used for development of data collection plans. The laboratory environment may provide for easier data collection as a result of better access to components.

SWIL may provide the only method to examine complex software and the algorithms and logic flow of programming in adequate detail. If the operational conditions or environment of live testing are such that conditions necessary to manifest a fault do not occur, the fault may not be detected. If undetected, the fault can be duplicated or promulgated across other interfacing systems. Correction of faults after software release and integration in deployed systems is difficult and expensive. SWIL is the best opportunity for fault detection and software risk reduction prior to release, and is one of the most cost-effective methods of fault correction.

For early phases of operational testing, HWIL can demonstrate potential effectiveness and suitability for designs that exist in a pre-production or breadboard stage of development. User feedback on HWIL/SWIL performance can be used to improve the design early in the process. The reduction in risk by early system integration can be of significant value to the program manager. In some programs, complete HWIL simulations housed in elaborate system integration laboratories have provided fully integrated system testing prior to platform installation and offer the additional benefit of crew performance evaluation. The principal limitation to HWIL/SWIL simulation is realism in the operating environment and credibility of the system representation. Use of ADS to bring realistic synthetic environments into the testing loop and robust VV&A of the system representation can mitigate these problems.

System/Software Integration Laboratory

A System/Software Integration Laboratory (SIL) is a facility that supports the integration of system components and/or software in a laboratory environment for development, experiments, and testing. The integration laboratory "simulates" (or replicates) a system to a known extent and allows the modification/addition of component hardware/software for use without many of the restrictions or difficulties that would be encountered using actual system hardware or host platforms. The SIL is the physical support structure and components that make HWIL/SWIL testing and evaluation possible.

SILs can be used by prime contractors to evaluate the compatibility and interoperability of subsystems and components developed by various subcontractors. A variety of computer simulations, real-world equipment, and images generate scenarios and environments to test component interaction while performing mission tasks.

Installed System Test Facilities

An Installed System Test Facility (ISTF) is a facility where entire systems or subsystems get their first workout in the environment in which they will operate (e.g., inside an aircraft). A full capability ISTF has the ability to mix a complete spectrum of players from synthetic (digital models) to real (actual hardware) to hybrid (a combination of both). It has the ability to provide multilevel threat simulations (open-loop and closed-loop signal simulators, including actual or simulated threat system hardware). It also has the ability to provide simulations of all C^3 elements a system would be expected to operate in the real world. The Navy's Air Combat Environment Test and Evaluation Facility (ACETEF) at Patuxent River, Maryland, is an example of an ISTF.

Live Test Ranges

Instrumented test ranges permit system-level tests in a real-world, dynamic environment. The Major Range and Test Facility Base (MRTFB) is a set of test installations, facilities, and ranges which are regarded as "national assets." MRTFB assets are sized, operated, and maintained primarily for DoD T&E missions. A variety of ranges are available which can facilitate fully operational, system-level testing. They are instrumented for data collection, time-space-position information, positive control, and safety. Typically, both real or simulated targets and interactive threats are available. The ranges employ actual and simulated systems to achieve high levels of credibility approaching representation of combat operations. Examples of live test ranges are listed below:

- **Air Force**: Utah Test and Training Range, Nellis AFB Range Complex, and Armament Systems Test Environment and Gulf Range

- **Navy**: Atlantic Underwater Test & Evaluation Center, and Naval Air Warfare Center Weapons Division-China Lake

- **Army**: Kwajalein Missile Range, White Sands Missile Range, and Electronic Proving Ground.

4.3 High Performance Computing

High performance computing (HPC) is a key enabling technology whose use continues to increase rapidly throughout the DoD. High performance computing, as defined here, refers to computer system capabilities, typically in terms of speed and size, that are within two or three orders of magnitude of the very best computers available. The increasing fidelity of evolving modeling and simulation, including interacting physical and engineering principles, requires HPC capabilities to estimate performance and effectiveness, especially in areas where environmental, legal, safety, or technical restrictions affect actual testing.

High performance computing capabilities are needed in three major T&E areas:

1. *System Modeling and Simulation* – to execute complex, high-fidelity models and simulations representing the system under test, the natural environment, and the threat environment.

2. *High Performance Range Instrumentation*—to allow range instrumentation systems to perform "intelligent' data processing, such as machine vision techniques, automating and refining data collection and analysis.

3. *High Performance Databases*—to manage, process, and analyze large data sets.

Information on the availability of HPC resources, their capabilities and employment, can be found in the *DoD Test and Evaluation High Performance Computing Modernization Plan.*

4.4 Standards

Interoperability of STEP tools is essential to assure proper evaluation of subsystems, systems, and systems of systems. A proliferation of M&S that cannot exchange data, or that require extensive modifications to interoperate, is counterproductive. Initiatives are in process to facilitate interoperability. Standards are also useful in facilitating reuse of STEP tools across weapons systems programs.

Common Technical Framework

A Common Technical Framework (CTF) is the first objective cited in the DOD M&S Master Plan. Its purpose is to facilitate reuse and interoperability of M&S by providing some pillars of commonality; an architecture to which M&S must conform, a basis for the development of consistent and authoritative simulation representations, and data standards to provide common representation of data across M&S. Principal components of the CTF are a High Level Architecture, a Conceptual Model of the Mission Space, and Common Database Standards.

High Level Architecture. The High Level Architecture (HLA) has been designated the standard architecture for M&S throughout DoD. HLA provides a common architecture for reuse of simulations. It is based on the premise that no single model or simulation can satisfy all uses and users in DoD at all levels of resolution. An individual simulation or set of simulations developed for one purpose can be applied to another application under the HLA federation concept that calls for a selectable set of interacting simulations. The intent of the HLA is to provide a structure that will support reuse of capabilities available in different simulations, ultimately reducing the cost and time required to create a synthetic operating environment for a new purpose.

Common Model of the Mission Space. The Common Model of the Mission Space (CMMS) is a simulation-neutral view of the real world, and acts as a bridging function between the warfighter, who owns the combat process and serves as the authoritative source for validating CMMS content, and simulation developers. Additionally, the CMMS provides a common viewpoint and serves as a vehicle for communications among warfighters, doctrine developers, trainers, C4I developers, analysts, and simulation developers. Such a foundation allows all concerned parties to be confident that DoD simulations are founded in operational realism. The CMMS will require reliance on authoritative sources and serve as the means for capturing, sharing, and evolving information.

Common Database Standards. The overarching objective is to enable data suppliers to provide the community affordable, timely, verified, and validated data to promote reuse and sharing of data, interoperability of models and simulations, and improved credibility of M&S results. The policies, procedures, and methodologies for data standards form general guidance for data used in environmental, systems and human behavior representations.

Joint Technical Architecture

The DoD Joint Technical Architecture (JTA) is a key piece of the Department's overall strategy to achieve interoperability. The JTA specifies a set of performance-based, primarily commercial, information processing, transfer, content, format and security standards. These standards specify the logical interfaces in command, control, and intelligence systems and the communications and computers (C4I) that directly support them. The JTA is a practical document, identifying standards where products are available today. JTA (Version 1.0) is mandatory for all emerging systems and system upgrades. HLA is being included along with other M&S standards in the JTA.

Joint Modeling and Simulation System

The Joint Modeling And Simulation System (JMASS) is a program to develop and deliver a distributed, object-oriented M&S architecture and system focused on the tactical level of war (mission- and engagement-level simulation). It is designed to provide a flexible, standardized M&S tool to support a wide range of simulation requirements throughout the life cycle of a weapon system. It supports concept design, trade studies, performance evaluations, and tactics analysis and development.

4.5 Support Activities

M&S Operational Support Activity

The M&S Operational Support Activity (MSOSA) is chartered to supply M&S resource information to DoD customers. It catalogues M&S resources, databases, exercises, capabilities, and points of contact and makes this information available to the DoD community. MSOSA resources link to each of the Services, the Information Analysis Centers, and other specific M&S sources. Through an on-line database, information is readily available. MSOSA also provides M&S expertise and direct access to the DoD M&S "corporate knowledge base."

MSOSA users may be able to benefit from the reuse of existing M&S products and databases; obtain easy access to information on M&S policies, activities, and initiatives; coordinate with ongoing M&S "events"; and experience cost savings through asset sharing. MSOSA builds databases based upon the needs of the community, and expands its capability based on contacts made and requests for services. MSOSA provides a staffed, help desk and 24-hour, on-line service via the Internet.

Modeling and Simulation Resource Repository

The Modeling and Simulation Resource Repository (MSRR) Web page provides several M&S informational services such as the M&S Digital Library, the M&S Exercise and Event Calendar, and an M&S search engine called the Intelligent Mission Support System. A linked system of resources (servers, classified as nodes) allow connectivity, reuse, and sharing of M&S resources to support communication and information exchange. A prototype MSRR, leveraging the existing technologies of internetworking is established to provide a number of useful services, including software tools, electronic documents, government off-the-shelf applications, a repository of M&S data models, and directories and catalogs.

M&S Executive Agents

M&S Executive Agents (MSEA) are DoD Components or Agencies who have been assigned management responsibility by the Under Secretary of Defense (Acquisition and Technology) for the development and maintenance of a specific area of M&S application, including relevant standards and data bases, used by or common to many models and simulations. The current MSEA are shown in Table 4-1.

Table 4-1. M&S Executive Agents

Area	Executive Agent
Air and Space	Air Force AFCCC
Ocean	NRL Code 7306
Terrain	Defense Mapping Agency, Terrain Modeling Project Office
Threat/Intelligence	Defense Intelligence Agency

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CHAPTER 5

Summary

The DoD is placing emphasis on the use of Integrated Product and Process Development (IPPD) and Integrated Product Teams (IPTs) as it develops better ways to determine what to buy and better methods of buying what it needs.

Simulation based acquisition (SBA) promotes the robust, collaborative use of simulation technology integrated across acquisition phases and programs. It is envisioned to substantially reduce the time, resources, and risk associated with the acquisition process and to increase the quality, military utility, and supportability of systems developed and fielded. SBA may involve an initial investment but is expected to save resources over the lifecycle of the system.

The Simulation, Test, and Evaluation Process is a test and evaluation answer to the DoD challenges of implementing IPPD and SBA. STEP, as the participation of T&E in SBA, focuses on reusability and interoperability, enabling the acquisition community to take a measured approach in realizing the objectives of SBA.

Modeling and simulation used collaboratively can reduce the lifecycle costs associated with the integration of complex systems, by helping the members of an IPT identify a program's technical and operational challenges as early as possible and plan for resolution of the issues. Commercial computer hardware and software, virtual prototypes, and simulations can aid in developing a shared vision of the proposed system and provide a means for understanding the complex interactions among the configuration items in the system design. In other words, modeling and simulation can be a key contributor to the Integrated Product and Process Development (IPPD) that the Secretary of Defense has directed.

Substantial evidence has already accumulated as to the value of modeling and simulation in acquisition. Both commercial and military system development programs provide pervasive evidence of tangible results that can be measured in improvements in cost, schedule, productivity, and quality/performance. STEP is not merely an incremental step beyond current system engineering methods and tools—it represents a major shift toward a comprehensive, integrated environment of M&S within the acquisition process.

Key in STEP is the integrated simulation, engineering management and test focused on program area success. The product from STEP then becomes information and insight that can be shared concurrently across functional areas and the acquisition community in the spirit of IPPD.

STEP enhances the acquisition process, fully integrating the use of models, simulations, and test events, and implements the intent of DoD 5000.2. It provides early and continuous information on the joint military worth of a system so that the total life cycle is more effective and efficient. STEP begins by focusing on the mission level, collecting models and simulations that can be used to understand how the new system might affect the mission; identifying and prioritizing critical information needs for the operational concept developers and engineers; and integrating the use of models, simulations, and tests to provide that information. STEP can be applied throughout the system life cycle, and can provide consistent, comparable performance information for the requirements, acquisition, test and evaluation, and training communities.

In order for this process to be fully realized, the program office must work with the T&E community to develop an effective evaluation strategy which will use simulation and test resources. Accreditation and certification are essential and must be included in an effective evaluation strategy. The program must resource these efforts to realize the benefits of STEP. To be successful, it is imperative that the program identify and fund STEP resources early while considering credibility and cost in order to best allocate assets to the most appropriate issues. The wise application of STEP will produce objective and more comprehensive information regarding performance, suitability, and survivability than would T&E alone.

STEP does not end with the fielding and deployment of the system, but continues throughout the operational support of the system to the end of its life cycle. STEP results in a thoroughly evaluated system with better understood operational effectiveness, suitability and survivability. STEP also results in a set of models and simulations of known fidelity, capable of reuse in other efforts.

ANNEX A

Acronyms and Definitions

ADS	Advanced Distributed Simulation
AFCCC	Air Force Combat Climatology Center
AOA	Analysis Of Alternatives
BMD	Ballistic Missile Defense
CE	Concept Exploration
CM	Configuration Management
COI	Critical Operational Issue
CTP	Critical Technical Parameter
DIS	Distributed Interactive Simulations
DMSO	Defense Modeling and Simulation Office
DMSTTIAC	Defense Modeling, Simulation, and Tactical Technology Information Analysis Center
DoD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DSMC	Defense Systems Management College
DT	Developmental Test; Developmental Testing
DT&E	Developmental Test and Evaluation
EMD	Engineering and Manufacturing Development
EOA	Early Operational Assessments
FLIR	Forward Looking Infrared Radar
FOT&E	Follow-on Operational Test and Evaluation
HITL	Human-In-The-Loop
HLA	High Level Architecture
HWIL	Hardware-in-The-Loop
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
ISTF	Installed System Test Facility
ITAS	Improved Target Acquisition System
JADS	Joint Advanced Distributed Simulation
JDBE	Joint Data Base Elements for M&S
JMASS	Joint Modeling And Simulation System
LFT&E	Live Fire Test and Evaluation
LRIP	Low-Rate Initial Production
LUT	Limited User Test
M&S	Modeling and Simulation

MNS	Mission Need Statement
MOE	Measures Of Effectiveness
MOP	Measures Of Performance
MRTFB	Major Range and Test Facilities Base
MSEA	Modeling and Simulation Executive Agent
MSOSA	M&S Operational Support Activity
MSRR	Modeling and Simulation Resource Repository
MSTI	Model-Simulate-Test-Iterate
NPS	Naval Postgraduate School
OA	Operational Assessment
ORD	Operational Requirements Document
OT	Operational Test; Operational Testing
OT&E	Operational Test and Evaluation
RAM	Reliability, Availability, and Maintainability
RCS	Radar Cross Section
RFP	Request For Proposal
SAFOR	Semi-Automated Forces
SIL	System/Software Integration Laboratory
STEP	Simulation, Test, and Evaluation Process
SWIL	Software-In-The-Loop
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TENA	Test and Training ENabling Architecture
TMD	Theater Missile Defense
V&V	Verification and Validation
VV&A	Verification, Validation, and Accreditation
VV&C	Verification, Validation, and Certification

Definitions

Accreditation. The official certification that a model or simulation is acceptable for use for a specific purpose. [DoDD 5000.59; DoD 5000.59-P]

Architecture. The structure of components in a program/system, their interrelationships, and the principles and guidelines governing their design and evolution over time. [DoD 5000.59-P]

Battlespace. The physical environment in which the simulated warfare will take place and the forces that will conduct the simulated warfare. [DoD 5000.59-P]

Computer Simulation. A dynamic representation of a model, often involving some combination of executing code, control/display interface hardware, and interfaces to real-world equipment. [DMSO Glossary of M&S Terms]

Data Certification. The determination that data have been verified and validated. Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage. Data producer certification is the determination by the data producer that data have been verified and validated against documented standards or criteria. [MSMP]

Data Validation. The documented assessment of data by subject area experts and its comparison to known values. Data user validation is an assessment as appropriate for use in an intended model. Data producer validation is an assessment within stated criteria and assumptions. [DIS; MSMP]

Data Verification. Data producer verification is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. Data user verification is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly. [MSMP]

Data Verification, Validation & Certification (VV&C). The process of verifying the internal consistency and correctness of data, validating that it represents real world entities appropriate for its intended purpose or an expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives: producer and user process. [MSMP]

Distributed Interactive Simulation (DIS). (1) Program to electronically link organizations operating in the four domains: advanced concepts and requirements; military operations; research, development, and acquisition; and training. (2) A synthetic environment within which humans may interact through simulation(s) at multiple sites networked using compliant architecture, modeling, protocols, standards, and databases. [DoD 5000.59-P]

Fidelity. (1) The similarity, both physical and functional, between the simulation and that which it simulates. (2) A measure of the realism of the simulation. (3) The degree to which the representation within a simulation is similar to a real world object, feature, or condition in a measurable or perceivable manner. [DMSO Glossary of M&S Terms, DIS Glossary]

High Level Architecture (HLA). Major functional elements, interfaces, and design rules, pertaining as feasible to all DoD simulation applications, and providing common framework within which specific system architectures can be defined. [DMSO Glossary of M&S Terms]

Human-In-The-Loop (HITL). A model that requires human participation. [DMSO Glossary of M&S Terms; DIS Glossary].

Measure of Effectiveness (MOE). A measure of operational success that must be closely related to the objective of the mission or operation being evaluated. Examples are kills per shot, probability of kill, and effective range. A meaningful MOE must be quantifiable and a measure to what degree the real objective is achieved.

Measure of Performance (MOP). Measure of lowest level of performance representing subsets of MOEs. Examples are speed, payload, range, time on station, frequency, or other distinctly quantifiable performance features.

Model. *n* A physics, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. [DIS Glossary; DoD 5000.59-P] *v* To create a representation of a system, entity, phenomenon or process.

Modeling and Simulation (M&S). The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably. [DMSO Glossary of M&S Terms]

Simulate. To represent a system by a model that behaves or operates like the system. [DMSO Glossary of M&S Terms; DIS Glossary]

Simulation. A method for implementing a model over time. [DoDD 5000.59]

a. Live Simulation. A simulation involving real people operating real systems.

b. Virtual Simulation. A simulation involving real people operating simulated systems. Virtual simulations inject HITL in a central role by exercising motor control skills (e.g., flying an airplane), decision skills (e.g., committing fire control resources to action), or communications skills (e.g., as members of a C^4I team).

c. **Constructive Model or Simulation.** Models or simulations that involve real people making inputs into a simulation that carries out those inputs by simulated people operating simulated systems.[DoD 5000.59-P]

Simulator. (1) A device, computer program, or system that performs a simulation. (2) For training, a device which duplicates the essential features of a task situation and provides for direct practice. (3) For DIS, a physical model or simulation of a weapons system, set of weapons systems, or piece of equipment which represented some major aspects of the equipment's operation. [DMSO Glossary of M&S Terms; DIS Glossary]

Stimulate. To provide input to a system in order to observe or evaluate the system's response. [DMSO Glossary of M&S Terms; DIS Glossary]

Synthetic Environments. Internetted simulations that represent activities at a high level of realism from simulations of theaters of war to factories and manufacturing processes. These environments may be created within a single computer or a vast distributed network connected by local and wide area networks and augmented by super-realistic special effects and accurate behavioral models. They allow complete visualization of and total immersion into the environment being simulated. [DoD 5000.59-P]

Validation. The process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation. [DoDD 5000.59]

Verification. The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques. [DoDD 5000.59]

Virtual Prototype. A computer-based simulation of systems and subsystems which exhibits both geometric and functional realism. This three-dimensional virtual mockup may be used to evaluate prototypes or concepts and provides a common platform which all functional disciplines (design, test, manufacturing, logistics, training, operations, etc.) can work. [DMSO Glossary of M&S Terms; DSMC Guidebook on M&S]

Virtual Prototyping. The process of using a virtual prototype, in lieu of a physical prototype, for test and evaluation of specific characteristics of a candidate design. [DSMC *Virtual Prototyping*]

ANNEX B

Some Helpful Internet Sites

Site	*URL Address*
DTSE&E	http://www.acq.osd.mil/te/
• STEP Guidelines	http://www.acq.osd.mil/te/programs/tfr/step.htm
DOT&E	http://www.dote.osd.mil/
DD, LFT&E	http://www.dote.osd.mil/lfte/INDEX.HTML
DMSO	http://www.dmso.mil/
• DoD M&S Master Plan	http://www.dmso.mil/docslib/#mspolicy/
• HLA	http://www.dmso.mil/projects/hla/
• VV&A	http://www.dmso.mil/projects/vva/
DMSTTIAC	http://dmsttiac.hq.iitri.com/
JADS JTF	http://jadsweb.kirtland.af.mil/
JITC	http://138.27.8.2/ot&e/otande.htm
JMASS	http://www.jmass.wpafb.af.mil/
JSIMS Joint Program Office	http://www.jsims.mil/
JWARS Office	http://www.dtic.mil/defenselink/jwars/
MSOSA	http://www.msosa.mil.inter.net/
MSRR	http://mercury-www4.nosc.mil/msrr/
Software Technology Support Center	http://stscols.hill.af.mil/
TENA	http://c38.npt.nuwc.navy.mil/TENA/home.html
AF Directorate for M&S and Analysis	http://xom.hq.af.mil/
AF M&S Resource Repository	http://afmsrr.sc.ist.ucf.edu/
AFMC M&S TPIPT	http://www.afbmd.laafb.af.mil/xre/m&s/
AFOTEC	http://www.afotec.af.mil/
Army OPTEC	http://
Army M&S Office	http://www.misma.army.mil/
• Army M&S Master Plan	http://www.misma.army.mil/
• Army M&S Resource Repository	http://www.misma.army.mil/armymsrr/
M&S Army Integrated Catalog	http://hp01.arc.iquest.com/mosaic/mosaic.html
Navy M&S Management Office	http://sneezy.nosc.mil:80/donmsmo/navmsmo/
Navy M&S Resource Repository	http://navmsmo.nosc.mil/msrr/
Navy COMOPTEVFOR	http://tecnet0.jcte.jcs.mil:9000/COTFOTD/
Navy T&E M&S Management Office	http://www.nawcad.navy.mil/tems/index.html
Navy T&E Repository for M&S	http://nterms.mugu.navy.mil/
USMC M&S Management Office	http://mcmsmo.usmc.mil/

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ANNEX C

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