# AEROSPACE SYSTEMS SURVIVABILITY HANDBOOK SERIES

# Volume 6. Survivability Test and Evaluation

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# FOREWORD

This Aerospace Systems Survivability Handbook Series is designed to provide its users with insight into the key activities performed by survivability personnel in support of aerospace systems acquisition. The series is not a specification or standard but rather a "how-to" guide for all survivability managers, engineers, and analysts associated with survivability activities likely to be needed on any program, government or commercial.

Some of the material used in the handbook series has been adapted from various sections of the Department of Defense (DoD) Deskbook, Internet links, and survivability documents produced by the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS), under the sponsorship of the Joint Aeronautical Commanders' Group (JACG). The service laboratories and centers also produced source documents. This handbook series emphasizes the requirement for integrated teamwork of survivability management, engineering, test and evaluation, and systems analysis in order to accomplish a successful systems acquisition.

The handbook series (JTCG/AS Project A-8-01, Acquisition Deskbook Survivability Section Rewrite) was prepared for the JTCG/AS under the sponsorship of the Principal Members Steering Group (PMSG) and directed by LTC Charles R. Schwarz, Director, JTCG/AS. The handbooks were drafted by Hubert (Hugh) Drake, SRS Technologies, under contract to the Naval Air Warfare Center Weapons Division, China Lake, CA. As the Contract Technical Monitor, Dave Hall provided guidance and initial review. The following working group members provided oversight:

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACAT | Acquisition Category |
| ACTD | Advanced Concept Technology Demonstration |
| AoA | Analysis of Alternatives |
| APA | Analysis Plan for Assessment |
| APB | Acquisition Program Baseline |
| ATPS | Automated Test Planning System |
| AWE | Advanced Warfighting Experiment |
| BMDO | Ballistic Missile Defense Organization |
| BOS | Base Operations Support |
| C4I | Command, Control, Communication, Computers, and Intelligence |
| CAE | Component Acquisition Executive |
| CAIV | Cost as an Independent Variable |
| CIM | Corporate Information Management |
| CINC | Commander-in-Chief |
| COI | Critical Operational Issue |
| COTS | Commercial Off-the-Shelf |
| CTEIP | Central Test and Evaluation Investment Program |
| CTF | Combined Test Force |
| D, S&TS | Director, Strategic and Tactical Systems |
| DAC | Designated Acquisition Commander |
| DD, DT&E/ S&TS | Deputy Director, Developmental Test and Evaluation/Strategic and Tactical Systems |
| DISA | Defense Information Systems Agency |
| DMSO | Defense Modeling and Simuation Office |
| DoD | Department of Defense |
| DOT&E | Director, Operational Test and Evaluation |
| DSM | Digital System Model |
| DT | Developmental Testing |
| DT&E | Developmental Test and Evaluation |
| DT&E/S&TS | Developmental Test and Evaluation/Strategic and Tactical Systems |
| DTIC | Defense Technical Information Center |
| E3 | Electromagnetic Environmental Effects |
| ECM/LO | Electronic Countermeasures/Low Observables |
| EOA | Early Operational Assessment |
| EW | Electronic Warfare |
| FACITT | Facility and Capability for Test and Training |
| FOT&E | Follow-on Operational Test and Evaluation |

| | |
|---|---|
| HITL | Hardware-in-the-Loop |
| ILSP | Integrated Logistics Support Plan |
| IOT&E | Initial Operational Test and Evaluation |
| IPPD | Integrated Product and Process Development |
| IPT | Integrated Product Team |
| ISTF | Installed System Test Facility |
| ITP | Integrated Test Program |
| | |
| JFS | Joint Feasibility Study |
| JITC | Joint Interoperability Test Command |
| JPO(T&E) | Joint Program Office for Test and Evaluation |
| JT&E PC | Joint Test and Evaluation Planning Committee |
| JTCG/AS | Joint Technical Coordinating Group on Aircraft Survivability |
| JTF | Joint Test Force |
| LFT&E | Live-Fire Test and Evaluation |
| LRIP | Low-Rate Initial Production |
| | |
| M&S | Modeling and Simulation |
| MDA | Milestone Decision Authority |
| MDAP | Major Defense Acquisition Program |
| MILCON | Military Construction |
| MNS | Mission Need Statement |
| MOE | Measure of Effectiveness |
| MOO | Measure of Outcome |
| MOP | Measure of Performance |
| MOS | Measure of Operational Suitability |
| MOT&E | Multiservice Operational Test and Evaluation |
| MRTFB | Major Range and Test Facility Base |
| | |
| NDI | Non-Developmental Item |
| OA | Operational Assessment |
| OPR | Office of Primary Responsibility |
| ORD | Operational Requirements Document |
| OSD | Office of the Secretary of Defense |
| OT | Operational Testing |
| OT&E | Operational Test and Evaluation |
| OTA | Operational Test Agency |
| OTRR | Operational Test Readiness Review |
| OUE | Operational Utility Evaluations |
| OUSD(AT&L) | Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics) |
| | |
| P3I | Preplanned Product Improvement |
| PEO | Program Executive Officer |

| | |
|---|---|
| PM | Program Manager |
| PO | Program Office |
| POM | Program Objectives Memorandum |
| PPBS | Planning, Programming, and Budgeting System |
| PTD | Program Test Document |
| QOT&E | Qualification Operational Test and Evaluation |
| RDT&E | Research, Development, Test, and Evaluation |
| RFP | Request for Proposal |
| RTO | Responsible Test Organization |
| S&T | Science and Technology |
| S&TS | Strategic and Tactical Systems |
| SAC | Senior Advisory Council |
| SECDEF | Secretary of Defense |
| SEMP | Systems Engineering Management Plan |
| SIL | System Integration Laboratory |
| SOO | Statement of Objectives |
| SOW | Statement of Work |
| STEP | Simulation Test and Evaluation Process |
| T&E | Test and Evaluation |
| TEMP | Test and Evaluation Master Plan |
| TPWG | Test Planning Working Group |
| USD(AT&L) | Under Secretary of Defense (Acquisition, Technology, and Logistics) |
| V&V | Verification and Validation |
| VV&A | Verification, Validation, and Accreditation |
| WIPT | Working-Level Integrated Product Team |

# EXECUTIVE SUMMARY

Department of Defense (DoD) policy states that “To assess and manage risk, PMs and other acquisition managers shall use a variety of techniques, including technology demonstrations, prototyping, and test and evaluation.” This statement implies a continuum from technology through acquisition. But one person’s T&E might not equate to another person’s T&E.

An issue in pursuing T&E and associated M&S for survivability is identification of the elements that make up T&E and how those elements relate to potential customers, including those who develop requirements, plans, guidance, and policy. This volume discusses those elements and customers, with the intent of helping survivability managers, engineers, and analysts manage and conduct their survivability test and evaluation (T&E) efforts in a disciplined, scientific, and cost-effective manner.

DoD establishes requirements for the acquisition process and develops policy and guidance for the individual services, associated agencies (Centers and Laboratories), and contractors in the performance of defense-related T&E to meet the acquisition strategy. Contractors involved in the acquisition process include the prime contractor, his or her subs, and those involved in independent verification and validation (V&V) and assessment. Prior to Milestone A, DoD coordinates with military departments and the defense agencies to orchestrate the Science and Technology (S&T) program, which develops options for future decisive military capabilities based on superior technology. Contractor participation can take a number of different forms in these S&T activities.

The T&E process described herein has been developed to help the user of this volume think through the steps necessary to plan and execute a system T&E effort that meets the needs of the military services for mature, usable, operationally effective, and suitable survivability hardware and software. Diagrams are provided to show the time-phased relationship of T&E to the rest of the acquisition process and the activities that need to take place to ensure scientific rigor and valid results.

Tests and evaluations involve deliberate and rational generation of data about the nature of the emerging system, as well as creation of information useful to the technical and managerial personnel controlling the system’s development. To generate that information in a cost-effective manner, T&E processes and procedures increasingly involve modeling and simulation (M&S). Four such processes discussed in this volume and its appendixes are (1) the simulation T&E (STEP) process, (2) the DoD T&E process for electronic warfare systems, (3) the Air Force T&E process, and (4) test procedures for DoD ranges and facilities. A discussion of the test planning process takes into account special aspects related to component and subcomponent testing, full-system testing, behind-the-plate testing, and live-fire testing. In addition, pretest predictions and their relationship to the planning process are discussed.

A discussion of uses of M&S technology during pre-Milestone-A T&E introduces the concept of the Logical Range, which can be described as a layered profile of functionality, with the layers including the system under test and/or its operators, a test environment, data acquisition, data transmission, data processing, information presentation, and operational control. A common architecture enables seamless interoperability of the Logical Range.

A section on Post-Milestone-A covers the uses of both developmental and operational testing, DT&E as an engineering tool to reduce risk throughout the defense acquisition cycle and OT&E as a means of assessing the success of actual or simulated employment by typical users under realistic operational conditions.

Information is also provided on survivability and lethality testing, including the process necessary to attain waivers to live fire testing requirement if pursuing the requirements would be unreasonably expensive and impractical.

# 1.0 INTRODUCTION

Acquisition is an ever-changing activity where requirements, plans, guidance, and policy are in constant flux and organizations, personnel, and associated relationships come and go. This fluidity makes any specific element perishable or subject to change. T&E, which has the fundamental purpose of identifying areas of risk to be reduced or eliminated, is thus an essential part of the process. An understanding of the many phases of T&E and how they fit into the acquisition process can help survivability engineers, analysts, and managers manage and conduct their survivability T&E efforts.

## T&E Description and Strategy

The DoD 5000.2R Test and Evaluation Overview gives the following description of T&E:

> T&E reveals information about the program and measures performance of the system against established requirements. The program manager (PM), in concert with the user and test communities, shall coordinate development test and evaluation (DT&E), operational test and evaluation (OT&E), live fire test and evaluation (LFT&E), family-of-systems interoperability testing, and M&S activities, into an efficient continuum, closely integrated with requirements definition and systems design and development. The T&E strategy shall provide information about risk and risk mitigation, provide empirical data to validate models and simulations, evaluate technical performance and system maturity, and determine whether systems are operationally effective, suitable, and survivable against the threat detailed in the System Threat Assessment. The T&E strategy shall also address development and assessment of the weapons support test systems during the System Development and Demonstration Phase, and into production, to ensure satisfactory test system measurement performance, calibration traceability and support, required diagnostics, safety, and correct test requirements implementation. Adequate time and resources shall be planned to support pre-test predictions and post-test reconciliation of models and test results for all major test events.
>
> The PM shall design DT&E objectives appropriate to each phase and milestone of an acquisition program. The Operational Test Agency (OTA) shall design OT&E objectives appropriate to each phase and milestone of a program, and submit them to the PM for inclusion in the Test and Evaluation Master Plan (TEMP). Completed, independent OT&E and completed LFT&E shall support a beyond low-rate initial production (LRIP) decision for acquisition category (ACAT) I and II programs for conventional weapons systems designed for use in combat. For this purpose, OT&E shall require more than an operational assessment (OA) based exclusively on computer modeling, simulation, or an analysis of system requirements, engineering proposals, design specifications, or any other information contained in program documents.

In a broad sense, T&E may be defined as all physical testing, modeling, simulation, experimentation, and related analyses performed during research, development, introduction, and employment of a weapon system or subsystem.

## Changes Caused by Simulation-Based Acquisition

Some rethinking by DoD is dramatically changing the landscapes of T&E and training. DoD has organizationally combined developmental testing (DT), operational testing (OT), and the evaluation mission under the Director, Operational Test and Evaluation (DOT&E). Training is increasingly combined with experimentation, as happens with Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs).

The movement toward simulation-based acquisition makes the practice of data acquisition more extensive (albeit over a shorter duration) and drives the system developer's need for interactive engineering. The movement toward rapid acquisition and deployment requires increased continuity of system performance, reliability, and safety information across the testing, modeling and simulation (M&S), training, and operational environments. The requirement for total asset visibility, with its dependence on the knowledge of weapon systems' "state vectors," also generates the need to collect testlike information in deployed situations. See Volume 2, *Survivability and Acquisition*, for additional information about acquisition.

## Use of T&E in the Acquisition Process

T&E provides information to many customers: developers responsible for identifying and resolving technical difficulties, decision-makers responsible for procuring new systems and for making the best use of limited resources, and operational users responsible for refining requirements and supporting development of effective tactics, doctrine, and procedures.

The following five guidelines for incorporating T&E into the acquisition process have been identified as important to effective system development:

- Involve testers early.
- Make better use of M&S.
- Combine DT and OT.
- Combine training and OT&E.
- Do 1 through 4 for ACTDs.

During the early phases of development, tests and evaluations are conducted to demonstrate the feasibility of conceptual approaches, evaluate design risk, identify design alternatives, compare and analyze trade-offs, and estimate satisfaction of operational requirements. During this process, participants need to consider the following aspects of T&E:

- Where experiments and exercises fit into the continuum.
- How JT&E is funded and who's in charge.

- What roles JTCGs play.
- How the laboratories and centers can get involved.
- How JTCG/AS can leverage the activities we are already involved in.
- How changes in the OSD structure are apt to affect T&E.
- Where central T&E investment programs (CTEIP) are in the continuum.
- Where the Ballistic Missile Defense Organization (BMDO) is organizationally and how it is involved.
- How we can collectively accomplish our T&E responsibilities in a cost-effective manner.
- What we can do to help.

As T&E programs are developed through the S&T and the Integrated Product and Process Development (IPPD)/Integrated Product Team (IPT) process, these guidelines should be incorporated to the extent they make sense under the particular conditions of the program.

## Key Test Issues and Events During Early Acquisition Phases

Early in the life of the acquisition program, the Test and Evaluation Master Plan (TEMP) is developed, as discussed in Appendix A. The TEMP is also discussed in detail in Volume 2, Appendix B.

As the program matures, the TEMP is updated to reflect an increasing level of detail. Concept and Technology Development and System Development and Demonstration Phase activities may include significant M&S activities in order to better define system operational requirements and support Analysis of Alternatives (AoA) by clarifying the characteristics of competing alternative approaches. Each alternative also has its own set of risks and challenges, the management of which should be reflected in the TEMP. When a contract is used, the contractor's M&S, analysis, and T&E activities are essential to successful completion of phase activities.

The Mission Need Statement (MNS), validated by Milestone A and updated in each phase, and the Operational Requirements Document, initially developed early in the acquisition process, contain the initial information the tester needs to identify critical issues that need to be addressed in the test program. The System Threat Assessment Report contains information regarding the threat system that will be faced by the new product; this information must also be reflected in the TEMP.

## Oversight for Defense-Related T&E

DoD establishes requirements for the acquisition process and develops policy and guidance for the individual services, associated agencies (Centers and Laboratories), and contractors in the performance of defense-related T&E to meet the acquisition strategy. DOT&E and the Deputy Director, DT&E, within the Office of Strategic and Tactical Systems, Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics) (DD, DT&E/S&TS,

OUSD(AT&L)) must have full and timely access to all available developmental, operational, and live-fire T&E information.

DOT&E and Director, Strategic and Tactical Systems (D, S&TS) are required to publish jointly, and in consultation with the T&E executives of the cognizant DoD components, an annual list of programs designated for OSD T&E oversight. This oversight list identifies programs on DT, OT, and/or LF oversight, with each program listed in one or more of the three areas. This list is contained in the DoD memorandum entitled "Designation of Programs for OSD Test and Evaluation (T&E) Oversight."

## Government and Contractor Teaming

The roles government and contractor personnel perform during T&E are important to the success or failure of a test program. Generally, successful government and contractor teaming, especially during DT&E, results in more effective and suitable systems being delivered to the user. The level of T&E teaming depends upon what T&E phase the program is in and the associated level of government test involvement. T&E teaming occurs across various facets and tasks: managing, planning, conducting, analyzing, and reporting. The tester's specific duties (and teaming implementation) at a given time are dictated by these facets and test phases.

Contractors involved in the acquisition process include the prime contractor, his or her subs, and those involved in independent verification and validation (V&V) and assessment. Prior to Milestone A, DoD coordinates with military departments and the defense agencies to orchestrate the Science and Technology (S&T) program, which develops options for future decisive military capabilities based on superior technology. Contractor participation can take a number of different forms in these S&T activities.

# 2.0 THE TEST AND EVALUATION PROCESS

If you are starting to plan, manage, or conduct a survivability T&E effort, this handbook will help you do it in a disciplined, scientific, and cost-effective manner. The T&E process described herein has been developed to help you think through the steps you and others should take to plan and execute a system T&E effort that meets the needs of the military services for mature, usable, operationally effective, and suitable survivability hardware and software.

The goal of T&E is to find and fix problems early. Correct test implementation requires proper planning of the necessary ground, logistics, or flight tests to optimize the tradeoffs between cost, schedule, test content, and risk. T&E resource requirements should be smartly tailored during each phase of a system's development, and the test results obtained from these T&E resources should be used as building blocks for future tests. Each test should stress the component or subsystem against its requirements enough to ensure that performance is adequate before the system progresses to the next development step.

In general, maximizing the use of digital pilot-in-the-loop M&S and in-flight simulation and ground testing (in system integration laboratories (SILs), hardware-in-the-loop facilities (HITLs) and installed system test facilities (ISTFs)) prior to and during flight tests reduces overall test costs, since open-environment flight tests are the most costly of the T&E resource categories.

The T&E process is a critical one, based on the scientific method. The process involves analyzing a system and gathering information and data to predict, establish and verify operational performance characteristics and safe operating parameters. Also examined are life-cycle effectiveness, suitability, and supportability to ensure that user mission requirements are met. Additionally, the processes and technologies involved in the development, design, and manufacturing of the product are tested and evaluated for suitability, variability, and conformance to the program's technical requirements. Figure 1 illustrates the top-level T&E process.

*Figure 1. Top-Level T&E Process*

T&E activities begin early in the system acquisition cycle and are time phased to provide essential information to decision-makers who have reached program milestone points. Figure 2 illustrates the time-phased relationship of T&E activities to the rest of the acquisition process.

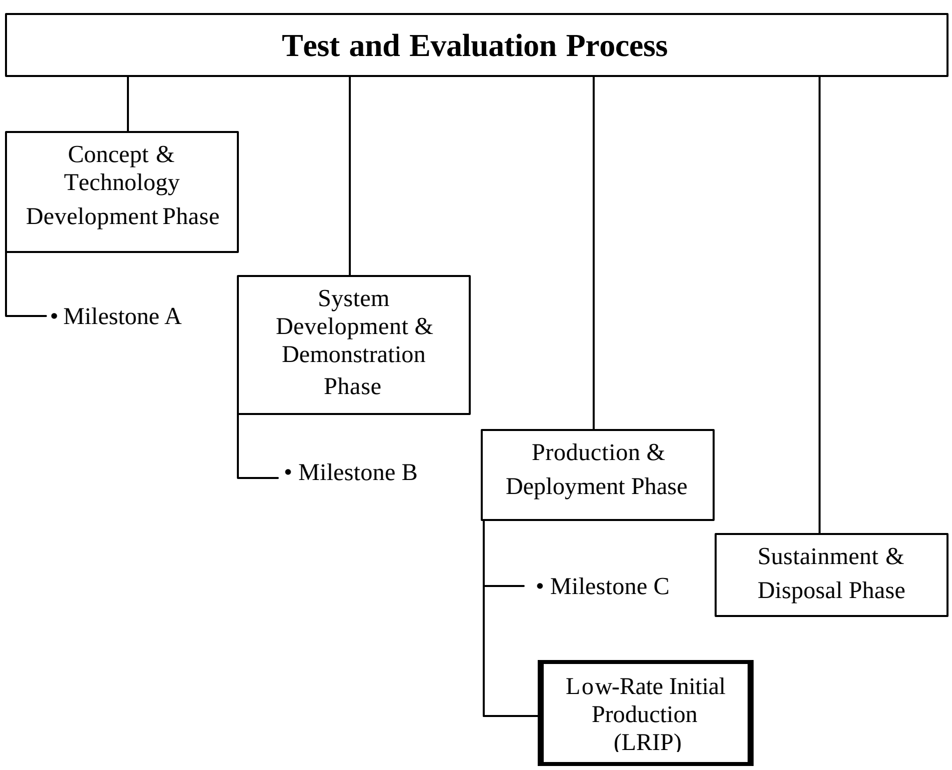



*Figure 2. Relationship of T&E to System Acquisition*

In the Concept and Technology Development Phase, the T&E process involves Integrated Product Teams (IPTs) that assist in the evaluation of the various candidates to provide essential and critical information for selection of the most suitable approach. Short-term paper studies, laboratory testing, and M&S are used to assess the proposed concepts, technologies, and designs. Test requirements are validated and resources identified and planned with emphasis on using existing, proven industrial and government technology, facilities, and equipment.

Externally, the contractor's T&E process cooperates with independent V&V contractors and assists the government's Test Planning Working Groups (TPWG) to ensure that drafting of the government TEMP is accurate, consistent, and traceable to system requirements. Early participation and involvement in the T&E process by government DT&E and OT&E organizations are also important. DT&E serves as an active participant in the T&E process while OT&E observes and reviews test data to establish an information base for future operational inputs. These early efforts toward cross-pollination and cooperation are important to a fruitful result for any involved program.

Tests and evaluations involve deliberate and rational generation of data about the nature of the emerging system, as well as creation of information useful to the technical and managerial personnel controlling the system's development. Because of the attention given T&E and M&S during acquisition reform, numerous processes and procedures are in existence, including the following:

- Simulation T&E process
- DoD T&E process for electronic warfare systems
- Air Force T&E process
- Test procedures for DoD ranges and facilities

These processes and procedures are discussed in the following subsections.

## Simulation T&E Process

The OSD simulation test and evaluation process (STEP) is integrally involved in five areas of the acquisition process: (1) as requirements and system specifications are refined; (2) as the design is developed; (3) in support of testing; (4) as a link between the developing system and its operational environment, permitting a recurring assessments of the system's military worth; and (5) after fielding, as a means of evaluating deficiencies and new requirements. Figure 3 depicts STEP and its role in the acquisition process; Appendix B contains additional information on STEP.

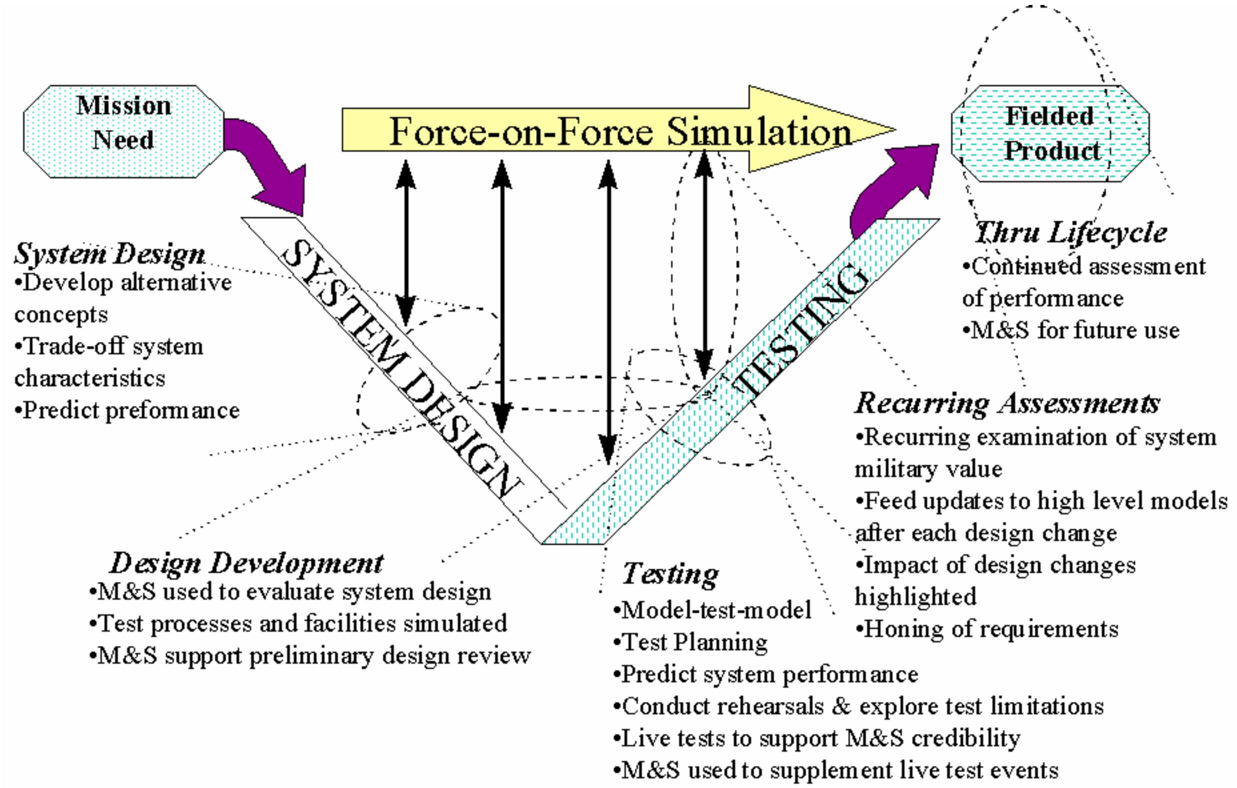



*Figure 3. The STEP Concept*

## DoD T&E Process for Electronic Warfare

The foreword to DTIC ADA-282514, *A Description of the DoD Test and Evaluation Process for Electronic Warfare Systems*, states: "The effectiveness of EW is difficult to measure but can be tied directly to the survivability of the assets it is intended to protect."

Public Law 103-160 requires the Secretary of Defense to develop a DoD T&E process for electronic warfare (EW) systems and to report annually on progress toward meeting the requirements of this process. An annual DoD memorandum, "Designation of Programs for OSD Test and Evaluation (T&E) Oversight," promulgates the list of EW programs from which reports are required, as well as the reporting procedure and format. Each designated program is required to submit a one-page status report through service channels to DD, DT&E/S&TS by 15 November each year. Appendix C contains background on the process.

Appendix D describe the kinds of resources required for EW T&E. The EW example given in the appendix is typical of most susceptibility testing.

## Air Force T&E Process

The Air Force T&E process is intended to be universal, for use by both government and contractors in any phase of the DoD system acquisition cycle, whether the T&E program is developmental, operational, or combined. The Air Force process implements a plan-predict-test-compare philosophy and stresses adequate ground testing. Appendix E contains additional information about this process.

## Test Procedures for DoD Ranges and Facilities

DoD directs that "testing shall be planned and conducted to take full advantage of existing investment in DoD ranges, facilities, and other resources, wherever practical, unless otherwise justified in the TEMP." T&E planning is accomplished using the planning procedures associated with the test facilities to be used. Such procedures are generally unique to their facilities. At each facility, plans are prepared and processes fulfilled by the facility personnel and the tester. Appendix F provides information about the ranges and facilities supported by the Major Range and Test Facility Base (MRTFB).

# 3.0 T&E PLANNING AND RESOURCES

## Test Strategy

The test planner needs to develop a robust test strategy that includes numerous fallback options in the event that the test has undesirable or unpredicted results. The strategy should be designed to support the decision-maker's needs; identify and correct deficiencies early in development; and include the T&E necessary to support evaluation of the user's key parameters, critical system characteristics, AoA-identified sensitive parameters, and parameters considered risky.

As part of the test strategy, the critical path should be identified, as should options dependent on test results. The critical path links tests that directly support fixed milestone decisions (for example, data that support a fixed-schedule budget decision), programmatically risky tests (schedule, cost, performance, etc.), and key decision-point tests, including those supporting acquisition milestones, choice of one technology implementation versus another, or key parameter demonstrations. Your test strategy will be most useful if it addresses issues such as whether to conduct a series of small tests designed to obtain early results quickly or one big test late in the acquisition with a limited or no fallback position.

## Sources of Information on Test Concept Development

Research at the Defense Technical Information Center (DTIC) and in other available sources will turn up information helpful to the task of defining DT&E requirements and outlining the DT&E test concept. Such information will help efforts to clarify the following:

- The program's overarching acquisition strategy and T&E strategy.
- Changes to the acquisition strategy.
- Information on T&E of comparable systems.
- Lessons learned by previous acquisition personnel.

Sources of information should also include the test centers, the users, and the services' OT&E Centers.

## Test Planning

Test planning takes into account everything necessary to develop and document the actions required to execute a test and report on its results. The survivability test planning process must be flexible and allow for changes at all stages. A written test plan should result.

The following presents a discussion of the test planning process, including special aspects related to component and subcomponent testing, full-system testing, behind-the-plate testing, and live-fire testing. In addition, pretest predictions and their relationship to the planning process are discussed.

DOT&E establishes DoD policies and procedures for operational and live-fire T&E. Test planning should begin during the Concept and Technology Development Phase when the PM forms a T&E Working-Level Integrated Product Team (WIPT). Representatives from DT&E (contractor and government), OT&E, LFT&E, and intelligence communities support the WIPT. If a project or program enters the acquisition process later than the Concept and Technology Development Phase, the PM forms the WIPT prior to entering the acquisition process. Both developmental and operational testers should be involved early to ensure that the test program for the most promising alternative can support the acquisition strategy. These testers should also ensure that objectives, thresholds, and measures of effectiveness (MOEs) are harmonized in the operational requirements document (ORD) and the TEMP.

Test planning should address MOEs and measures of performance (MOPs) with identification of appropriate quantitative criteria, test events or scenarios, resource requirements (e.g., special instrumentation, test articles, validated threat targets, validated threat simulators and simulations, actual threat systems or surrogates, and personnel), and test limitations. The following are required:

- Test planning, at a minimum, must address all system components (hardware, software, and human interfaces) critical to the achievement and demonstration of contract technical performance specifications and operational effectiveness and suitability requirements from the ORD.

- Quantitative criteria must be phased to provide substantive evidence for analysis of hardware, software, and system maturity, as well as readiness to proceed through the acquisition process. Linkage must exist among the various MOEs and MOPs used in the AoA or ORD and T&E. In particular, the MOEs, MOPs, and criteria in the ORD, the AoA, the TEMP, and the Acquisition Program Baseline (APB) must be consistent with one another. The APB, approved by the Milestone Decision Authority (MDA), contains the most important cost, schedule, and performance parameters (both objectives and thresholds) for the program.

- Planning must provide for completion of Initial Operational Test and Evaluation (IOT&E) and LFT&E, as required before full-rate production can be entered.

- Sufficient testing must be conducted on commercial and nondevelopmental items to ensure performance, operational effectiveness, and operational suitability for the military application. Test planning for these items must include consideration of operational testing and LFT&E needed to ensure effective performance in the intended operational environment.

However, the test program should be tailored to recognize commercial testing and experience.

- Testing must be planned and conducted to take full advantage of existing investment in DoD ranges, facilities, and other resources wherever practical, unless otherwise justified in the TEMP. Department of Defense Directive 3200.11, "Major Range and Test Facility Base," Changes 1-3, 29 September 1980, identifies the major ranges and test facilities. In addition, the potential environmental impacts associated with testing must be considered.

- Early testing of prototypes in the System Development and Demonstration Phase and early operational assessments should be emphasized to assist in identifying risks.

- M&S should be an integral part of T&E planning. Accredited M&S are applied, as appropriate, throughout the system life cycle in support of the various acquisition activities, including requirements definition and logistics support. PMs integrate the use of M&S within program planning activities; plan for life-cycle application, support, and reuse of models and simulations; and integrate M&S across the functional disciplines.

A combined DT/OT approach is encouraged to save time and cost. The combined approach must not compromise either developmental or operational test objectives. A final independent phase of OT&E is required for beyond-LRIP decisions.

## Test Resources

Each service conducts test resource planning, which consists of three elements:

1. The T&E master plan (TEMP), which addresses all test resources needed to support weapons systems acquisition
2. The Central Test and Evaluation Investment Program (CTEIP)
3. The resources planning process

The manager for an acquisition program must recognize that requirements for T&E exist throughout a system's life cycle and plan and conduct tradeoff analyses to identify and schedule test resources required to support life-cycle T&E.

The term "test resources" encompasses all resources needed to conduct a test, including, but not limited to, the following:

- Test articles
- Test ranges
- Manpower, training, and base operations support (BOS)
- Research, development, test, and evaluation (RDT&E) support

- Military construction (MILCON)
- Flying hours
- Support equipment
- Threat systems (red, blue, and gray)
- Models and simulations
- Instrumentation
- Communications
- Range equipment, facilities, and safety
- Data production
- Data protection and security systems
- Weather support, mapping, charting, and geodesy products
- Munitions and targets

The services must plan, program, and budget in accordance with the Planning, Programming, and Budgeting System (PPBS) for these DT&E test resources:

- Facilities
- Manpower
- Instrumented threat simulators
- Replacement costs for T&E capital investments
- Real property maintenance
- Base operations support
- T&E support (infrastructure)

## Integrated Test Program

The PM should begin an integrated test planning effort to plan for system T&E as early as feasible in the acquisition process. The PM will form IPTs involving all acquisition players (contractors, subcontractors, developmental and operational testers, maintainers, logisticians, and users).

The PM should then maintain a continuous integrated planning effort using IPTs to implement the test program and adjust planned activities when unexpected circumstances arise. This integrated test planning must consider combined testing whenever practicable. The PM will develop and follow an Integrated Test Program (ITP) approach that integrates all testing in order to:

- Ensure that the required resources are available.
- Prevent test duplication through use of a combined DT&E/OT&E approach.
- Properly integrate the DT&E program with the overall acquisition strategy.

The IPT capitalizes on the strengths of all participants working as a team for the overall benefit of the program. A number of IPTs may work simultaneously on various aspects of the acquisition program. For example, the Test Planning Working Group (TPWG) is a specialized IPT addressing test matters and charged with developing the TEMP. The IPTs report their results to an Overarching IPT (OIPT), which consists of senior decision-makers.

## Combined Testing

A combined DT/OT approach should be used to the maximum extent possible. The combined approach must not compromise either developmental or operational test objectives. A final independent phase of OT&E will be required for beyond-LRIP decisions. The combined DT&E/OT&E strategy will be directed in the PMD and described in the TEMP.

**Combined DT&E and OT&E.** A combined DT&E/OT&E approach and combined test force (CTF) organizational structure will be used to the maximum extent possible. Because the resources, test events, and data for DT&E and OT&E are often similar, developmental and operational testers are able to integrate their efforts to improve overall test efficiency. However, the combined test approach must not compromise either developmental or operational test objectives. A final phase of dedicated I/QOT&E will be required for beyond-LRIP decisions. The combined DT&E/OT&E strategy will be described in the TEMP.

**Combined Test Force.** Formation of a CTF will be directed in program documentation or in detailed memorandums of agreement. The CTF will be chartered to build early and complete integration of operational users, system and support contractors, developmental testers, and operational testers into a smooth continuum of test efforts. All test organizations participating in the CTF will make resources available under a unified command structure at a single location or involving locations determined to be the most efficient organization. The CTF structure will be described in the TEMP.

**Order of Combined Testing.** The PM will generally conduct DT&E first to answer critical technical or engineering questions, as well as to determine or verify the system's performance envelope. DT&E information may come from contractor-conducted and/or government-conducted tests. OT&E personnel will participate in DT&E as early as possible to familiarize themselves with the system, and to review test data as early as possible. As DT&E progresses, more DT&E and OT&E events and data requirements will be combined where possible. Operational testers may also use OA and operational utility evaluations (OUE) as necessary.

**Responsibility for Combined Test Results.** The responsible test organization (RTO) is ultimately responsible for achieving DT&E objectives. The designated OT&E agent is responsible for achieving OT&E objectives and for evaluating and reporting results independently. The PM, RTO, and OTA must play active roles in test planning, contract reviews, test execution, and test oversight to ensure the validity of contractor DT&E data.

## Automated Tools and Formats for Test Planning

The Automated Test Planning System (ATPS) provides structured and systematic methods for TEMP preparation, review, and program risk assessment. It improves TEMP consistency, quality, and efficiency, and helps reduce the learning curve for less experienced testers. Copies of this personal computer-based expert system can be obtained from DOT&E. Additional ATPS background is provided in Appendix G.

# 4.0 S&T PLANNING AND EXECUTION DURING PRE-MILESTONE-A T&E

T&E can be both a recipient of and a participant in S&T funding, which can be applied to support technological developments for T&E facilities, associated M&S, etc., or used to perform technology demonstrations in support of horizontal integration and synchronization of advanced technologies and advanced distributed simulation products for experimentation in joint warfighting exercises.

## Development and Transition of Superior Technology

The DoD S&T program has the objective of developing options for future decisive military capabilities based on the superior technology that is a principal characteristic of our military advantage. It is imperative that DoD's S&T program invent, develop, and harness technology to realize the new warfighting capabilities required by our military leadership.

The defense S&T program is guided by the President's National Security Strategy and the military needs stated by the military departments, the Joint Chiefs of Staff, and the unified commanders. The S&T program reduces performance risks and enables more rapid development and deployment of affordable advanced technologies. A major emphasis is on maintaining military advantage through S&T investment, and a major conclusion is that investments in science and technology are critical to military preparedness. The traditional concepts of maneuver, strike, protection, and logistics are leveraged with technological advances and information superiority to produce improvements that are potentially so powerful that they become, in effect, new operational concepts

These new operational concepts interact to create the powerful, synergistic effect of full-spectrum dominance, the capability to dominate an adversary across the full range of military operations. Full spectrum dominance, depicted in Figure 4, is emerging as a key characteristic of the U.S. Armed Forces for the 21st century.

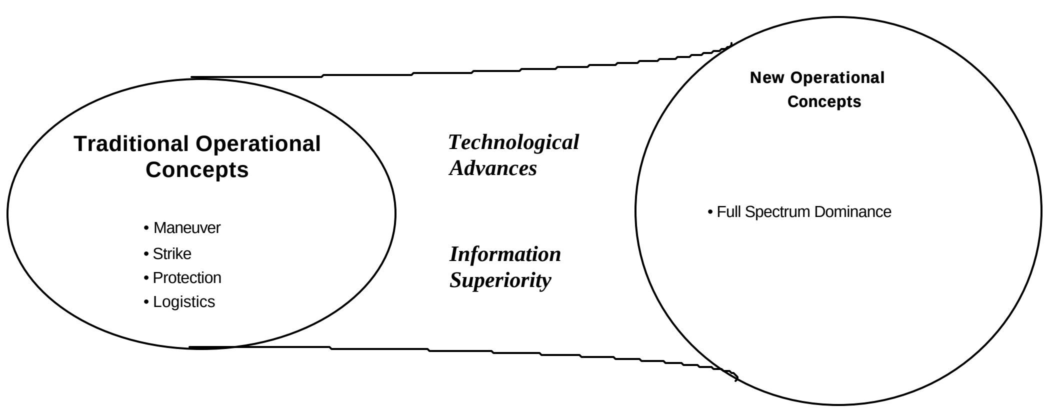


*Figure 4. Relationship of Operational Concepts to Full-Spectrum Dominance*

## Modeling and Simulation Technology for Warfighter Needs

M&S technology complements and augments warfighter needs and capabilities through technology demonstrations and developments. These technology developments support all Joint Warfighting Capability Objectives in areas of training, mission planning/rehearsal, battlefield visualization, assessment of tactics/doctrine, and acquisition support.

M&S core technologies must provide a cost-effective and timely capability to authoritatively represent systems, processes, and operational environments. M&S must provide readily available and operationally valid environments for DoD components to train jointly; develop doctrine and tactics; formulate operational plans; assess warfighting situations; support technology assessments, system upgrades, and system developments; and conduct force structure analyses and assessments. Research is needed to more broadly and authoritatively apply M&S across all of DoD.

Major M&S efforts are in the areas of (1) simulation interconnection, (2) simulation information technologies, (3) simulation representation, and (4) simulation interfaces. The efforts of interest concentrate on the technologies that bring about distributed, seamless, interactive, and adaptable models and simulations.

## The Virtual Test and Training Range and the Concept of the Logical Range

The process whereby DoD acquires new weapons systems is being challenged in an unprecedented manner to become more effective and efficient. The changing world scene coupled with advances in and availability of sophisticated technologies has resulted in a reappraisal of existing mechanisms designed to ensure defense preparedness.

DoD's traditional build-test-fix process does not satisfy these goals. It is inherently costly and seems unable to maximize quickly the advantage of innovative technology applications. Within DoD the recognition of this potential is also complicated by the overarching requirement to ensure interoperability of all new weapon systems in the Joint Task Force operational environment.

The DoD acquisition community recognizes these challenges and is in the process of reengineering the acquisition process for major DoD weapons systems. To test the potential of technology applications, respond rapidly, and avoid extensive infrastructure costs, a model-test-model . . . build process, in which computer-based virtual prototypes are used to test the concept and design of the system, is supplanting the traditional build-test-fix process, which depends on physical prototypes. The model-test-model . . . build process promises time and cost savings. Potential efficiency improvements include the following:

- Faster and more efficient prototyping resulting from the relative ease with which changes to computer-based models can be implemented.
- Maximum application of the developed model by the acquisition program for a wide range of purposes from design through test and evaluation to training and doctrine development.
- Use of the authenticated model by other programs as a validated representation of the developed system.

The traditional build-test-fix process used a physical range as the environment within which to test prototype hardware and its software components. Existing physical ranges can be expanded both by connecting the ranges to form a larger physical range complex and by incorporating synthetic components. Synthetic "ranges" can also be created by linking together synthetic components. Each of these configurations, using physical components, synthetic components, or combinations thereof, is a Logical Range. In the Logical Range a site can be a physical range, a hardware-in-the-loop facility, an RDT&E lab, a developer with a Smart Product Model, or any other modeled, prototype, or production copy of an entity. Each site is private and is managed and supported in accordance with the principles of the sponsoring organization. Each site also has tools that allow independent sites to be configured into a combat and engineering environment.

Usually only a subset of available sites is configured for a specific test or exercise. The tools allow the available sites to be reconfigured into a different Logical Range when a different set of participants is needed. New sites are added by integrating tools at the site.

The basic construct for the Logical Range can be described as a layered profile of functionality. The layers include the system under test and/or its operators, a test environment, data acquisition, data transmission, data processing, information presentation, and operational control. A common architecture enables seamless interoperability of the Logical Range.

## Test Resource Requirements and Acquisition

The individual services are responsible for planning and maintaining test resource requirements, as well as for developing and advocating solutions to address critical OT&E resource requirements at T&E investment forums. Test resource requirements are the test capabilities and assets needed for OT&E, but currently not available. The services define and assess the availability of the test assets required for their tests. Solutions and operational needs are marketed to the CTEIP and other investment avenues.

As early as possible, operational testers must begin planning for OT&E resources and identify both funded and unfunded requirements in test resource planning and the TEMP. All unfunded requirements must be shown as either disconnects or initiatives for the Program Objectives Memorandum (POM) cycle. The program executive officers (PEOs) and the services' lead organizations provide guidance and management of test resource acquisition. Accurate and early resource identification, programming, budgeting, and appropriation are critical. Highly specialized resources (e.g., threat simulators, M&S tools, or advanced instrumentation) and test articles may require many years of lead time.

# 5.0 POST-MILESTONE-A T&E

Post-Milestone-A T&E is the process by which systems or components are compared against requirements and specifications through testing. The results are evaluated to assess the progress of design, performance, supportability, etc. Prototype, production, or specifically fabricated hardware and software are used to obtain or validate engineering data on the performance of the system during the program's development phase (normally funded from RDT&E). This phase includes the following:

- Detailed planning, conduct, support, data reduction and reports (excluding Contract Data Requirements List data, as well as all hardware/software items that are consumed or planned for consumption in the conduct of such testing).
- All effort associated with the design and production of models, specimens, fixtures, and instrumentation in support of the system-level test program.

Both developmental and operational T&E are used during the post-Milestone-A phase, DT&E as an engineering tool to reduce risk throughout the defense acquisition cycle and OT&E as a means of assessing the success of a system's actual or simulated employment by typical users under realistic operational conditions. As a system undergoes design and development, the emphasis in testing moves gradually from DT&E, which is concerned chiefly with attainment of engineering design goals, to OT&E, which focuses on questions of operational effectiveness, suitability, and supportability. Although development and operational test events are usually separate, DT&E and OT&E are not necessarily serial phases in the evolution of a system.

## Requirements and Responsibilities

Because T&E conducted after Milestone A is mandated to adhere to the DoD acquisition process, it is paramount that we develop a basic understanding of how DoD affects T&E accomplishment. Information on required post-Milestone-A T&E can be found in DoDD 5000.1 and DoD 5000.2-R, which rank first and second in order of precedence for providing mandatory policies and procedures for the management of acquisition programs.

OSD is responsible for assessing whether the systems engineering practices and DT&E policies and procedures required by regulation are being met, as well as for ensuring that threat target and simulator acquisitions meet DT&E and OT&E requirements, and for performing independent oversight of component validation processes.

The Director, Defense Information Systems Agency (DISA), through the use of the Joint Interoperability Test Command (JITC), must certify to the developmental and operational testing organizations and to the Chairman of the Joint Chiefs of Staff that command, control, communication, computers, and intelligence (C4I) systems and equipment meet the applicable requirements for compatibility, interoperability, and integration based on JITC certification testing, and other pertinent T&E results.

## Developmental T&E

DT&E is part of the engineering design and development process and is conducted throughout the acquisition process to assist in engineering design and development and to verify whether technical performance specification thresholds and objectives have been met.

**Responsibilities.** DT&E is planned and monitored by the developing agency and is normally conducted by the prime contractor under conditions that are not fully representative of field operation. However, the developing agency may perform technical compliance tests before OT&E.

DT&E supports the system design process through a test-analyze-fix-retest approach that involves both contractor and government personnel. Because contractor testing plays a pivotal role in the total test program, it is important the contractor establish an integrated test plan early to ensure that the scope of the contractor's test program satisfies government and contractor test objectives.

The PM remains responsible for the ultimate success of the program. The PM and the program office test specialist must foster an environment that provides the contractor with sufficient latitude to pursue innovative solutions to technical problems, at the same time providing the data needed to make rational trade-off decisions between cost, schedule, and performance as the program progresses.

The PM, with advice from the RTO, determines the most effective test concept for reducing risk during DT&E, then implements it using an integrated test program (ITP) approach.

**Tasks Required.** DT&E includes T&E of components, subsystems, preplanned product improvement (P3I) changes, hardware and software integration, and production qualification testing. DT&E encompasses the use of models, simulations, and test beds, as well as of prototypes or full-scale engineering development models of the system. This part of the process may involve a wide degree of test complexity, depending on the type of system or test article (electronic breadboards or brassboards, components, subsystems, or experimental prototypes) under development.

DT&E programs must accomplish the following:

1. Identify potential operational and technological capabilities and limitations of the alternative concepts and design options being pursued.
2. Support the identification of cost-performance trade-offs by providing analyses of the capabilities and limitations of alternatives.

3. Support the identification and description of design technical risks.
4. Assess progress toward meeting Critical Operational Issues, mitigation of acquisition technical risk, achievement of manufacturing process requirements, and system maturity.
5. Assess validity of assumptions and conclusions from an analysis of alternatives.
6. Provide data and analysis in support of the decision to certify the system ready for OT&E.
7. In the case of automated information systems, support an information systems security certification prior to processing classified or sensitive data and ensure standards conformance certification.

**Early DT&E Strategy Planning.** The PM must start early to develop a DT&E strategy using the systems engineering process to support the selected acquisition strategy. But first the user's mission, priorities, and operational requirements must be defined. Modified acquisition strategies that are evolutionary or incremental or involve commercial off-the-shelf (COTS) and non-developmental items (NDI) are increasingly used to exploit rapidly advancing technologies and to meet demands for reduced time and cost. The PM should consider DT&E strategies that emphasize combined DT&E/OT&E, earlier tester involvement, and more system contractor testing.

**DT&E Planning and Integrated Product and Process Development.** The IPPD process integrates all acquisition activities from definition of requirements to production, fielding, deployment, and operational support. The purpose is to optimize design, manufacturing, business, and supportability processes. PMs and developmental testers should apply the concept of IPPD throughout the acquisition process to the maximum extent practicable. PMs will maximize the overall performance of the entire acquisition system, not just the performance of individual functional areas, by identifying problems early and maintaining a cooperative spirit of problem resolution. (See DoDD 5000.1 and DoD 5000.2-R.)

**DT&E Planning and the Systems Engineering Process.** Systems engineering transforms an operational need into a description of system parameters and integrates those parameters to optimize effectiveness of the whole system. Test planning is an integral part of the systems engineering process, with the DT&E process verifying that the designs meet the performance requirements.

The PM, who manages these efforts, must understand how the requirements are being verified and must involve testers in the preparation of the Request for Proposal (RFP), Statement of Objectives (SOO), performance Statement of Work (SOW), and other early documentation. As the systems engineering process continues to translate operational requirements into technical requirements and confirm those translations, testers must ensure that the technical requirements are quantifiable and testable within the time and funding allowed. As the acquisition community defines the technical requirements, testers must identify, define, and set priorities for the test requirements.

Systems engineering is both a technical process and a management process. The PM will use the systems engineering process to control the entire system-development effort, and to achieve an optimum balance of all system elements. Systems engineering is an iterative process that translates operational needs into descriptions of system parameters in the form of specialized program plans and documentation. Typical outputs are the Systems Engineering Management Plan (SEMP), TEMP, Integrated Logistics Support Plan (ILSP), interface control documents, risk analyses and assessments, DT&E test plans, trade studies, design documentation, software development plans, and producibility plans. The PM integrates these documents to optimize overall system effectiveness.

The PM will ensure that system definition and design reflect the technical requirements for all system elements such as equipment, software, personnel, facilities, and data. Testers will ensure that these technical requirements are quantifiable and testable within the time and funding allowed. Testers will identify, define, and set priorities for all required DT&E; identify required test resources; and then design, plan for, and conduct experiments to influence system design and verify performance predictions.

**Risk Reduction and Management.** A major objective of DT&E is the reduction of acquisition risk. To assess and manage risk, PMs, RTOs, and other acquisition managers should use a variety of techniques, including technology demonstrations, prototyping, and T&E. Risks must be well understood and risk management approaches developed before decision authorities authorize a program to move to the next phase of the acquisition process.

The PM will establish a risk management program to be applied throughout the design process. A structured process will be established for reviewing and approving all test plans before any DT&E occurs. The test-plan review process will include thorough technical and safety reviews.

**Use of M&S During DT&E.** In DT&E, testers use modeling and/or simulation as tools to evaluate the system's performance in areas that cannot adequately be tested by other means. M&S are used to supplement and complement DT&E. Testers may use M&S for early program assessments but not as the sole basis on which to provide system evaluations. M&S have the potential to shorten the test process and hold down costs. Credible M&S can assist decision-makers when actual testing is either not possible or impractical because of the scope, cost, or complexity of the test scenario.

PMs for programs using M&S must ensure that the office of prime responsibility (OPR) for M&S coordinates the TEMP and test plan. The model user must identify to the lead test agency the analyst resources needed to collect appropriate accreditation data during any planned testing. New M&S must comply with guidelines of the Defense Modeling and Simulation Office (DMSO) and of the individual services. The PM must ensure that any M&S test report data come from an accredited model or simulation and that any modifications to significant portions of the model or simulator, including control of M&S code configuration, are accredited.

M&S are integral parts of the test process used to supplement and complement open-air testing, HITL testing, installed-system facility testing, measurement facility testing, and integration laboratory testing. The PM is responsible for planning and executing all required M&S support during DT&E. The RTO will support the PM's development and application of standard digital system models (DSM) for the system under test. The RTO will assist in model verification, validation, and accreditation according to DoD guidance.

## Operational T&E

OT&E is conducted to determine the operational effectiveness and suitability of a system under realistic operational conditions, including combat; determine if the thresholds and objectives in the approved ORD and the critical operational issues (COI) have been satisfied; and assess impacts to combat operations.

The tests or assessments are normally conducted and data are normally evaluated by an independent field agency that is separate from both developer and user. IOT&E is performed in an environment that is as operationally realistic as possible. A complete evaluation of the system's supportability design parameters (e.g., operational repair and maintenance) and logistics elements should be conducted during the System Development and Demonstration Phase and should employ production-representative systems.

This evaluation may continue into the next phase with pilot or full-rate production items. Each logistics element should be provided in a condition or configuration that is close to or identical to the one provided after deployment. As a minimum, the operational test environment should include the following:

- Representative military operation and maintenance personnel
- Personnel trained with a prototype of the planned formal training program
- Draft technical manuals
- Production-representative systems
- Support equipment selected for operational use
- Realistic tactical environment

The intent of OT&E is to ensure that new systems meet users' requirements, operate satisfactorily, and are supportable under actual field conditions. By the end of System Development & Demonstration, OT&E must have been adequate to determine whether the system will be operationally effective and operationally suitable in combat use by typical users.

**Management Responsibilities.** OSD/DOT&E is responsible for the following:

- Exercise oversight responsibility for major defense acquisition programs, or any program in which the Secretary of Defense or Congress has special interest or oversight.

- Prescribe overarching DTE, OT&E, and LFT&E policies and procedures for DoD.
- Monitor and review all LFT&E and OT&E in DoD.
- Prepare an annual report for the Secretary of Defense and Congress summarizing the OT&E activities of DoD during the fiscal year.
- Publish once a year, in conjunction with the DD, DT&E, a combined list of OSD T&E oversight programs.
- In conjunction with DD, DT&E, approve the TEMP for OSD oversight programs.
- Approve OT&E plans for oversight programs.
- Participate in integrated product teams (IPT) as required for program planning and test execution.

**Prerequisites to OT&E.** The developing agencies (i.e., materiel and combat developers) must complete the following tasks before they start OT&E:

- Define risk management measures and indicators, with associated thresholds, to address performance and technical adequacy of both hardware and software.
- Establish the maturity criteria and performance exit criteria necessary for certification for OT&E. The PM documents these maturity and performance exit criteria in the TEMP.
- Support the conduct Operational Test Readiness Reviews conducted by the OTA.
- Review all available interoperability assessments (e.g., OAs, JITC interoperability assessments, and standards conformance reports) during Operational Test Readiness Reviews (OTRRs) to highlight potentially critical interoperability problems for assessment during OT&E.
- Complete a mission impact analysis of unmet criteria and thresholds, including critical interoperability problems to be assessed during OT&E.
- Prepare and distribute to TEMP signatories a DT&E report as prescribed below.
- Formally certify the system ready for OT&E.
- Certify and accredit communications systems (see DoD Instruction 5200.40[i]);
- Conduct Environment, Safety, and Occupational Health review for each test (see ??).

DoD components are required to brief DOT&E on concepts for an OT&E or OA 120 days prior to start. They must submit the T&E plan 60 days prior to start and report major revisions as they occur. Test plans are to include test objectives, MOEs, MOPs, measures of operational suitability (MOSs), planned operational scenarios, threat representations, targets, resources, test limitations, and methods of data gathering and certification, reduction, and analysis. These details of the planned test events allow DOT&E to assess operational realism.

DOT&E approves, in writing, the adequacy of the OT&E plans (including project funding) for all ACAT I programs, selected ACAT IAM programs, and other programs under DOT&E

oversight (identified on the "Designation of Programs for OSD Test and Evaluation (T&E)-Oversight" memorandum), prior to starting OT&E. DOT&E approves plans for all OAs in DOT&E-oversight programs, prior to execution. This approval requirement applies to major revisions, as well.

**Program Acquisition Categories.** An acquisition program is a directed and funded effort that is designed to provide a new or improved materiel capability in response to a validated need. PMs must know the ACAT for their program (refer to DoD 5000.2-R, Section 1.3, for definitions) because ACAT will affect many OT&E processes:

- Approval authority
- Level of test
- Briefing trail

A list of oversight programs is published annually by DOT&E and USD(AT&L). This list contains all ACAT I and IA programs and may include programs with smaller dollar values. PMs should be aware if their programs are on this oversight list.

**Types of OT&E.** Test managers must understand the different types of test events in which OT&E is involved, and under what circumstances these events are required. Public Law (U.S. Code, Title 10), top-down direction, and mutual support agreements are among the factors that determine whether the services' operational agencies participate in the program, as well as which type of test activity can be applied. The services' operational agencies are often the decision authorities on which type of test activity will be applied.

Table 1 shows the different types of test activities a test manager may employ during OT&E. The T&E activities in this matrixed list are initial OT&E (IOT&E), qualification OT&E (QOT&E), follow-on OT&E (FOT&E), OA, and OUE. An OA is designated as an early operational assessment (EOA) if it is performed prior to Milestone B. The services' operational agencies also participate in multiservice OT&E (MOT&E) testing, which is an IOT&E, QOT&E, or FOT&E that the services' operational agencies accomplish with one or more services.

**Service Operational Agencies' Customers.** The main external customers of the services' operational agencies are the operational users, decisionmakers, and developers. Viewing individual customers as members of these groups can help the T&E planner determine needs and expectations, and prioritize and focus products. Typical customers are as follows:

- *Operational users:* commanders in chief, major commands, and operators/maintainers.
- *Decisionmakers:* Secretary of Defense (SECDEF); DOT&E; secretary of the lead service; Undersecretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)); chief of staff of the lead service; Designated Acquisition Commander (DAC); and the services' operational agencies.
- *Developers:* Program offices (POs), PEOs, lead service.

*Table 1. Test-Type Application Matrix*

| Type | When To Use | Used For | What Customer Wants |
|---|---|---|---|
| OA | When directed by higher authority<br>When programs are complex and involve high risk<br>Before MS III | Early look at standard acquisition programs<br>Nonrepresentative test articles (prototype, pre-production, etc.)<br>Not used in lieu of or substitute for OT&E | To assess readiness for LRIP and OT&E (potential impacts to effectiveness, suitability)<br>To assess testability of requirements<br>To identify deficiencies, risks, omissions in program |
| EOA | Same as OA<br>Before MS II | Same as OA<br>Assessing the most promising design approach during concept development | To get assurance that selected design concept has potential to fulfill the user's requirements |
| IOT&E | For support beyond LRIP(MS III)<br>When 3600 (R&D) money is used | Determining operational effectiveness and suitability<br>Supporting fielding/IOC decision<br>Assisting in tactics development | To get a risk assessment for the acquisition<br>To support production decision<br>To identify deficiencies |
| QOT&E | When items are commercial off-the-shelf, nondevelopmental, or modifications to existing systems<br>When 3400 (O&M) money is used | Same as IOT&E | Same as IOT&E |
| FOT&E | Service Commands responsible for FOT&E unless directed otherwise | Refining estimates obtained from IOT&E or QOT&E<br>Completing deferred IOT&E or QOT&E testing<br>Evaluating changes/ verifying correction of deficiencies<br>Developing tactics<br>Reevaluating system to ensure that it continues to meet operational needs | To ensure that system continues to meet user's needs<br>To assess deficiency corrections |
| OUE | For nontraditional programs(including ACTDs)<br>For expanded or modified role in existing system normally not used for ACAT I or DoD oversight programs<br>*Cannot* support production decisions | Determining operational utility of system<br>Evaluating expanded or modified role in existing system<br>*Cannot* be used to replace OT&E or OA | To obtain short-term, credible test that adds value<br>To obtain flexibility in documentation estimate of concept, utility, technology, or system<br>For identification of deficiencies and capabilities<br>To obtain information supporting AoA and source selections |

**OT&E Requirements.** The DoD Component OTA is responsible for OT&E, within which the following procedures must be used:

- OT&E must use threat or threat representative forces, targets, and threat countermeasures, validated by the Defense Intelligence Agency or DoD Component intelligence agency, as appropriate. DOT&E, which approves the measures to be used, also oversees threat target, threat simulator, and threat simulation acquisitions and validation to meet developmental, operational, and live fire T&E needs.
- Information assurance testing must be conducted on information systems to ensure that planned and implemented security measures satisfy ORD and System Security Authorization Agreement requirements when the system is installed and operated in its intended environment. The PM, OT&E test authority, and designated approving authority must coordinate and determine the level of risk associated with operating the system and the extent of security testing required. Any requirements to reconstitute or recover information-system capabilities damaged by information assurance threat agents should also be tested during OT&E.
- Typical users must operate and maintain the system or item under conditions simulating combat stress and peacetime conditions.
- The independent OTAs must use production or production-representative articles for the dedicated phase of OT&E that supports the full-rate production decision (or for ACAT IA or other acquisition programs, the deployment decision).
- Test planners must consider M&S. OT&E should leverage M&S used during DT&E to improve its credibility and reduce M&S development time and costs. Whenever possible, the OA should draw on test results with the actual system, or subsystem, or key components thereof, or with operationally meaningful surrogates. When actual testing is not possible to support an OA, such assessments may use computer modeling, HITL simulations (preferably with real operators in the loop), or an analysis of information contained in key program documents. The TEMP explains the extent of M&S that may support OT&E.
- The OTA must adequately test and evaluate all hardware and software alterations that materially change system performance (operational effectiveness and suitability). Such alterations include system upgrades and changes to correct deficiencies identified during T&E.
- Naval vessels, the major systems integral to ship construction, and military satellite programs typically have development and construction phases that extend over long periods of time and involve small procurement quantities. To facilitate evaluations and assessments of system performance (operational effectiveness and suitability), the PM must ensure that the independent OTA is involved in monitoring or participating in all relevant testing. Such participation ensures that the OTA will use all relevant results to complete OAs. The OTA determines which test data will be included or excluded during OAs and determines the requirement for any additional operational testing needed for effectiveness and suitability.

- OTAs must conduct an independent, dedicated phase of OT&E before full-rate production to evaluate operational effectiveness and suitability as required by *10 USC 2399* for ACAT I and II programs.
- OTAs must participate in early DT&E and phases involving M&S to provide operational insights to the PM, requirements developers, and acquisition decision-makers.
- For systems with joint interoperability requirements, all available interoperability assessments (e.g., OAs, JITC interoperability assessments, and standards conformance reports) should be reviewed during the OTRR before IOT&E is conducted. Potentially critical interoperability problems must be highlighted for assessment during OT&E.
- OT&E must identify potentially adverse electromagnetic environmental effects (E3) and spectrum availability situations. Operational testers must use all available data and review DD Form 1494 or JF-12 to determine which systems need field assessments.
- All weapon, command, control, communication, computer, intelligence, surveillance, reconnaissance, and information programs dependent on external information sources or providing information to other DoD systems must be assessed for information assurance. The level of information assurance testing depends on the system risk and importance. Systems with the highest importance and risk must be subjected to penetration-type testing prior to the beyond-LRIP decision. Systems with minimal risk and importance are subject to normal National Security Agency security and developmental testing, but are not subject to field penetration testing during OT&E.
- OT&E must take maximum advantage of training and exercise activities to increase the realism and scope of OT and reduce testing costs.
- DOT&E must determine the quantity of articles procured for OT&E for Major Defense Acquisition Programs (MDAPs); the cognizant OTA must make this decision for non-MDAPs (according to *10 USC 2399*).
- The operational effectiveness of MDAPs for large-scale training systems must be determined based on their demonstrated training effectiveness.
- Each DoD Component must provide weapons effectiveness data for weapons in the acquisition process to DOT&E for use in the Joint Munitions Effectiveness Manuals. The Component must provide that data before the weapon achieves initial operational capability and prepare the data in coordination with the Joint Technical Coordinating Group for Munitions Effectiveness.
- DOT&E must assess the adequacy of OT&E and LFT&E. DOT&E must also evaluate the operational effectiveness, suitability, and survivability, as applicable, of systems under its oversight.

DOT&E oversight programs beyond LRIP, require continued DOT&E test-plan approval and monitoring, as well as follow-on OT&E (FOT&E) reporting to complete the IOT&E activity, to refine IOT&E estimates, to verify correction of deficiencies, to evaluate significant changes to system design or employment, and to evaluate whether the system continues to meet operational needs and retain operational effectiveness in a substantially new environment, as appropriate.

## Full-System Test Planning

Testing of full systems is often accomplished to examine the vulnerability of a fully combat-loaded aircraft to current threats. Although full-system testing is usually very expensive and may lead to the loss of a complete aircraft, that type of test is often the only way to determine the synergistic effects caused by a threat impact on the system. Full-system testing often causes loss or degradation to more than one critical component and/or subsystem. Also frequently occurring are unexpected results that may not have been observed with only component or subsystem testing.

## Survivability and Lethality Testing

Survivability and lethality testing is mandated by LFT&E legislation. Guidelines are provided in Appendix B of Volume 2, *Survivability and Acquisition*, which describes a disciplined management approach for the conduct of LFT&E within DoD. If this approach is followed, compliance with LFT&E legislation will be ensured. The guidelines describe the objective and scope of LFT&E; provide guidance for LFT&E planning, testing, evaluation, and documentation; and discuss the responsibilities of LFT&E principals.

**LFT&E Objective**. The objective of LFT&E is to provide a timely and reasonable assessment of the vulnerability and lethality of a system as it progresses through its development and prior to full-rate production. In particular, LFT&E accomplishes the following:

- Provides information to decision-makers on potential user casualties, vulnerabilities, and lethality, taking into equal consideration susceptibility to attack and combat performance of the system.
- Ensures that knowledge of user casualties and system vulnerabilities or lethality is based on testing of the system under realistic combat conditions.
- Allows any design deficiency identified by the testing and evaluation to be corrected in design before proceeding beyond low-rate initial production.
- Assesses battle damage repair capabilities and issues. Although assessment of battle damage repair capability is not a statutory requirement of LFT&E, test officials should exploit opportunities presented by LFT&E to assess such capabilities whenever prudent and affordable.

**Requirements and Waivers**. Title 10, United States Code, Section 2366, says that survivability and lethality testing must be conducted on a covered system, major munition program, missile program, or product improvement to a covered system, major munition program, or missile program before the system or program can proceed beyond LRIP. A covered system is any vehicle, weapon platform, or conventional weapon system that includes features designed to provide some degree of protection to users in combat and that is an ACAT I or II program.

Depending upon its intended use, a commercial or nondevelopmental item may be a covered system or part of a covered system.

Survivability testing begins at the component, subsystem, and subassembly level, culminating with tests of the complete covered system or program, or covered product improvement, configured for combat. Such testing must be conducted sufficiently early in the development phase of the system or program (including a covered product improvement program) to allow any design deficiency demonstrated by the testing to be corrected in the design of the system, program, or product improvement before proceeding beyond low-rate initial production. For commercial and nondevelopmental items that are covered systems, the Under Secretary of Defense (Acquisition & Technology) identifies equivalent events for the items that will allow the requirements of statute and this Regulation to be met.

As delegated by the Secretary of Defense, USD(AT&L) for ACAT ID programs, or the Component Acquisition Executive (CAE) for programs in categories lower than ACAT ID, may waive the requirement for realistic survivability (i.e., full-up, system-level tests) and lethality tests if, before the system or program enters engineering and manufacturing development, the USD(AT&L) or the CAE certifies to Congress that live fire testing of such a system or program would be unreasonably expensive and impractical.

In the case of a covered system (or covered product improvement program for a covered system), USD(AT&L) or the CAE may waive the application of the required survivability and lethality tests and instead allow testing of a system or program by firing munitions likely to be encountered in combat at components, subsystems, and subassemblies. Such testing would also include design analyses, M&S, and analysis of combat data in lieu of testing the complete system configured for combat. The strategy for such alternative testing must be included within the waiver request, which is jointly reviewed by DOT&E and D, S&TS, and approved by DOT&E. Such alternative testing may not be carried out unless the USD(AT&L) or the CAE certifies to Congress, before the system or program enters engineering and manufacturing development, that the survivability and lethality testing that would be required without the waiver would be unreasonably expensive and impracticable.

In either case, any such certification from USD(AT&L) or the CAE must include a description of the DOT&E-approved alternative strategy, along with an explanation of plans to evaluate the survivability or lethality of the system or program and assessments of possible alternatives to realistic survivability and lethality testing of the system or program. Any waiver of the requirement for realistic survivability testing does not remove the requirement for survivability testing of components, subsystems, and subassemblies.

Waivers and the use of alternative survivability and lethality testing must be addressed in the TEMP for the covered system, program, or covered product improvement program. Requirements for CAE certifications and reports are spelled out in Title 10, United States Code, Section 2366(c), “Major systems and munitions programs: survivability and lethality testing required before full-scale production," with any waiver authority to be submitted to Congress through DOT&E and USD(AT&L).

## Other Testing

Appendix H discusses other types of acquisition testing.

# Appendix A.

# Test and Evaluation Master Plan

The OTA and TPWG will document the overarching test strategy in the Test and Evaluation Master Plan (TEMP). The TEMP requires Service Commands and OSD review and approval if the program is ACAT I or on the OSD oversight list. OT&E must not start until the TEMP is approved. Multi-service and joint programs require multiple service approval of a single, integrated TEMP.

**Coordination With Test Community**

Concurrent with the market investigation process, the program office prepares the TEMP in cooperation with the test community. It is important to ensure all critical survivability support related requirements are identified so they can be included in subsequent testing. Potential sources of existing data relative to critical survivability support related requirements should be identified. Then, these requirements must be coordinated between survivability personnel representing the user and program office and the testing community for inclusion in the TEMP.

(Note: A contractor that has participated (or is participating) in the development, production, or testing of a system for a DoD Component (or for another contractor of DoD) may not be involved in any way in the establishment of criteria for data collection, performance assessment, or evaluation activities for the operational test and evaluation. These limitations do not apply to a contractor that has participated in such development production or testing solely in testing for the federal government.)

**TEMP Contents.** The TEMP must fully integrate the OT&E strategy, test and evaluation concept, schedule, funding, and associated documentation with the overall acquisition strategy. The TEMP provides linkage between operational requirements, system characteristics, key parameters (performance, cost, and schedule), MOEs used in OT&E, and how these elements support the mission or task the system is to perform. In addition, the TEMP must document the following specific areas: how MOEs and MOPs will be addressed during OT&E; OTA responsibilities and key organizational relationships; how and when a combined DT&E/OT&E approach will be used if time and cost savings warrant; all test resources (funding, M&S, facilities, personnel, test articles, etc.); and the impacts of test and resource limitations. See DoD 5000.2-R, Appendix 3, for details about content and format.

**TEMP Preparation.** Operational testers will assist the PM in developing and updating the TEMP, as required. The initial TEMP must be as specific as possible in addressing the T&E

strategies, with follow-on TEMPs providing more details on the T&E strategies as the system matures. The PM will use an IPT approach (e.g., a TPWG) which includes DTSE&E and DOT&E representatives, if appropriate. The OTA is responsible for writing Part IV (the OT&E section) and developing the OT&E resources portion in Part V of the TEMP. No areas will remain “to be determined” (TBD) past MS II. The completed TEMP represents agreement among all TPWG participants.

A TEMP describes the program’s overall test and evaluation strategy. The TEMP is prepared as early as possible in the acquisition process (normally prior to Milestone B), and is designed to identify and integrate objectives, responsibilities, resources, and schedule for all test and evaluation to be accomplished prior to key decision milestones.

**Relationship of AOA, Operational Requirements Document (ORD), Acquisition Program Baseline (APB), and TEMP.** Inconsistencies may develop among the description of system capabilities used in the AOA, those required in the ORD, and those proposed for the TEMP. In that case, it is wise to resolve the system performance inconsistencies before committing them to the TEMP, since the TEMP MOEs and thresholds will form the basis for evaluation by the testers. The Test and Evaluation Master Plan should document how the AOA measures of effectiveness and related measures of performance will be addressed in test and evaluation. Requirements stated in the analysis of alternatives, ORD and APB must be in harmony and should be reflected consistently in the TEMP. In particular, the MOEs, MOPs, and criteria should be consistent.

**Operational Requirement Document (ORD) and Testing.**

Test and evaluation strategy is to reference the ORD as follows:

- Test planning, at a minimum, addresses all system components (hardware, software, and human interfaces) that are critical to the achievement and demonstration of contract technical performance specifications and operational effectiveness and suitability requirements from the ORD.

- Quantitative criteria are phrased so they provide substantive evidence for analysis of hardware, software, and system maturity and readiness to proceed through the acquisition process. Linkage is to exist among the various Measures of Effectiveness (MOEs); Measures of Performance (MOPs), which are used in the analysis of alternatives or the ORD; and test and evaluation. In particular, the MOEs, MOPs, the ORD criteria, the analysis of alternatives, the TEMP, and the APB are to be consistent.

- OT&E programs are to be structured to determine the operational effectiveness and suitability of a system under realistic conditions (e.g., combat) and to determine if the minimally acceptable, ORD-specified operational performance requirements have been satisfied.

**Protection of Data:** Appropriate measures should be taken to protect sensitive design information, proprietary information, and test data throughout the test planning, execution and reporting process.

**TEMP Development Through Integrated Product Teams (IPTs).** The TEMP should be developed by an IPT with OSD and OTA participation as needed. Early OTA involvement is critical to ensure that requirements can be tested, test resources are sufficient, and early assessments are planned. Copies of the approved (or draft if not yet approved) MNS, STAR, and ORD should be available to the T&E IPT and the TEMP approval chain. Other documents referenced in TEMP may be needed as well.

Survivability must be a participant in the Test and Evaluation Integrated Product Team (T&E IPT) planning of DT&E and OT&E and is directly responsible for the planning of postdeployment survivability assessments. An integrated database of all data from DT/OT survivability evaluations provides larger sample sizes that are needed for confidence in the validity of test results and as an aid to minimize redundant testing.

The Test and Evaluation Master Plan (TEMP) focuses on the overall structure, major elements, and objectives of the test and evaluation program that is consistent with the acquisition strategy. It is to include sufficient detail to ensure the timely availability of both existing and planned test resources required to support the test and evaluation program.

**A TEMP is to:**

1. be prepared for all ACAT I and ACAT IA programs and other acquisition programs designated for DOT&E or Office of the Secretary of Defense test and evaluation oversight (10 USC2399 ) Title 10, United States Code, Section 2399, Operational test and evaluation of defense acquisition programs;

2. be approved by the DOT&E and the DS&TS for all ACAT I and ACAT IAM programs and other designated programs; and,

3. provide a road map for integrated simulation, test, and evaluation plans, schedules, and resource requirements necessary to accomplish the test and evaluation program.

The TEMP format and procedures may be used at the discretion of the MDA for other ACAT II and III programs and highly sensitive classified programs.

1. Test planning, at a minimum, is to address all system components (hardware, software and human interfaces) that are critical to the achievement and demonstration of contract technical performance specifications and operational effectiveness and suitability requirements from the ORD.

2. Quantitative criteria is to be phased so as to provide substantive evidence for analysis of hardware, software and system maturity and readiness to proceed through the acquisition process. Linkage is to exist among the various MOEs and MOPs used in the analysis of alternatives or ORD, and test and evaluation; in particular, the MOEs, MOPs, and criteria in the ORD, the analysis of alternatives, the TEMP and the APB are to be consistent.

3. Test and evaluation planning must provide for completion of Initial Operational Test and Evaluation (IOT&E) and LFT&E, as required, before entering full-rate production.

4. Sufficient testing must be conducted on commercial and non-developmental items to ensure performance, operational effectiveness, and operational suitability for the military application. Test planning for these items is to include consideration of operational testing and LFT&E needed to assure effective performance in the intended operational environment. However, the test program is to be tailored to recognize commercial testing and experience.

5. Testing is to be planned and conducted to take full advantage of existing investment in DoD ranges, facilities, and other resources, wherever practical, unless otherwise justified in the TEMP. 305135618:DoDD 3200.11 Department of Defense Directive 3200.11, Major Range and Test Facility Base, September 29, 1980 (Changes 1-3) identifies the major ranges and test facilities. In addition, the potential environmental impacts associated with testing must be considered (42 USC4321 -- 42 Title 42, United States Code, Section 4321-4347, National Environmental Policy Act and EO 12114 Executive Order 12114, Environmental Effects Abroad of Major Federal Actions).

6. Early testing of prototypes in the System Development & Demonstration Phase and early operational assessments are to be emphasized to assist in identifying risks.

7. Modeling and simulation is to be an integral part of test and evaluation planning.

A combined developmental test and operational test (DT/OT) approach is encouraged to achieve time and cost savings. The combined approach is not to compromise either developmental or operational test objectives. A final independent phase of operational test and evaluation is required for beyond low-rate initial production (LRIP) decisions.

The Director, Operational Test and Evaluation (DOT&E) and the Director, Test, Systems Engineering and Evaluation (DS&TS) are granted full and timely access to all available developmental, operational and live fire test and evaluation information.

**LFT&E and the TEMP:** The TEMP summarizes where, when, and how the LFT&E issues will be tested/evaluated. Specific LFT&E items considered for inclusion in the TEMP are: a description of the overall Live Fire Test and Evaluation strategy for the item; critical Live Fire Test and Evaluation issues; required levels of system vulnerability/lethality; the management of the Live Fire Test and Evaluation program; Live Fire Test and Evaluation schedule, funding plans and requirements; related prior and future Live Fire Test and Evaluation efforts; the evaluation plan and shot selection process; Modeling and Simulation strategy and VV&A; and major test limitations for the conduct of Live Fire Test and Evaluation. Live Fire Test and Evaluation resource requirements (including test articles and instrumentation) are to be appropriately identified early in the development cycle and appear in the Test and Evaluation Resource Summary. The TEMP includes a matrix that covers all tests within the LFT&E strategy, their schedules, the issues they will address and which planning documents the Services propose for submission to DOT&E for approval and which are proposed to be submitted for information and reviews only.

**LFT&E Detailed Test and Evaluation Plan:** The LFT&E Detailed T&E Plan describes the detailed test procedures, test conditions, data collection and analysis processes to be used during the conduct of each Live Fire Test. Annex B of the plan provides additional detail on the content of the Detailed Test and Evaluation Plans required for the Full-up System Level Live Fire Tests. The Detailed Test and Evaluation Plan is to be submitted to DOT&E for comment at least 30 days before test initiation. DOT&E has 15 days for submission of comments subsequent to its receipt of the Detailed Test Plan/Evaluation Plan.

Evaluation Plan. No standard format is prescribed, but the Plan must contain at least the following information:

1. A cover page providing the name of the system, the activity/agency responsible for preparation of the Plan, date, classification, and applicable distribution statement.

2. A coordination sheet containing signatures of Service approval authorities.

3. Administrative information: name, organization, telephone, and E-Mail addresses of key LFT&E personnel.

4. Description of threat weapons or targets that the system is expected to encounter during the operational life of the system, and the key characteristics of these threats/targets that affect system vulnerability/lethality; a reference to the specific threat definition document or authority; a discussion of the rationale and criteria used to select the specific threats/targets and the basis used to determine the number of threats/targets to be tested and evaluated in LFT&E.

5. If actual threats/targets are not available, then the plan must describe the threat/target surrogate to be used in lieu of the actual threat/target, and the rationale for its selection.

6. A statement of the test objectives in sufficient detail to demonstrate that the evaluation procedures are appropriate and adequate.

7. A description of the specific threats/targets to be tested including a detailed configuration and stowage plan (to include payload configuration) for each shot. Describe the rationale or operational scenarios on which the target configuration/stowage was based.

8. A listing of any differences between the system to be tested and the system to be fielded. As specifically as possible, identify the degree to which test results from the tested configuration are expected to be representative of the vulnerability or lethality of the fielded systems.

9. Identification of any test limitations, particularly any potential loss of realism from absence of components, arising from the use of surrogates, from the inserting of fuzes on stowed ammunition, or any other environmental, safety or resource constraints. Identify the impact of these limitations on test results.

10. A description of the shot selection process. Describe the process to be used to establish the test conditions for randomly selected shots, including any rules ("exclusion rules") used to determine whether a randomly generated shot may be excluded from testing. For engineering shots (i.e., shots selected to examine specific vulnerability/lethality issues), describe the issue and the associated rationale for selecting the specific conditions for these shots. List the specific impact conditions and impact points for each shot, and whether it is a random or engineering shot.

11. A detailed description of the test approach, test setup, test conditions, firing procedures, damage assessment and repair process, planned test sequence, instrumentation, data collection and analysis procedures, and responsibilities for collecting and documenting test results. Include any standard forms that will be used to document test results.

12. A prediction of the anticipated results of each shot. These predictions may be based on computer models, engineering principles, or engineering judgment. Detail is to be consistent with the technique used for casualty/damage prediction.

13. A detailed description of the analysis/evaluation plan for the Live Fire Test. The analysis/evaluation plan must be consistent with the test design and the data collected. Indicate any statistical test designs used for direct comparisons or for assessing any pass/fail criteria.

14. A general description, including applicable references, of any vulnerability/lethality models to be used to support shot-line selection, pre-shot predictions, or the analysis/evaluation. This material is to include a discussion of model algorithm or input limitations, as well as references to the sources of key model inputs.

15. A detailed description of the approach to analyzing and mitigating the potential environmental impacts, consequences, or effects of the test activities, unless adequately described elsewhere.

**Service Coordination.** The PM will submit the TEMP “in parallel” to all organizations represented on the TPWG. Organizations are normally allowed 30 days for coordination, and TEMP due dates are firm (see Table 6.1). Organizations will not withhold TEMP coordination or approval in an attempt to resolve issues or force solutions. If issues remain unresolved for more than 30 days, the dissenting organization must provide a position statement or a formal nonconcurrence. When the TEMP cannot be submitted on time, the PM must write to the appropriate approval authority stating the reason for the delay and commit to a new submittal date.

**Service-Level Approval.** Service approval consists of T&E organizations and SAE signatures. For Multi-service programs, signatures from the other participating SAEs are also required. TEMP approval authorities will not approve TEMPs without a current MNS, STAR or STA, and ORD. Some TEMPs require additional OSD approval.

**TEMP Updates and Changes.** After initial submission, the PM revises the TEMP to support milestones, or to reflect significant changes or breaches in the program. OTAs will continue developing Section IV in support of the PM ‘s TEMP review cycle. Updates or changes will be submitted to the PM through the TPWG, as appropriate.

**Test Planning Working Group (TPWG).** The TPWG (also called the T&E IPT) is mandatory for major defense acquisition programs (MDAP or ACAT I) and OSD OT&E oversight programs, and is highly recommended for all others The TPWG will include representatives from each organization involved in the test program. All TPWG members must work together as a cross-functional team. The OTA representative must be empowered to make decisions for the OTA, be highly knowledgeable in the discipline of operational testing, and provide full support in the development and coordination of the TEMP.

# Appendix B.

# Simulation Test and Evaluation Process

**In Conjunction with Testing**

As real hardware and software representations/mock-ups of the system's components or subsystems (brass boards, breadboards) are built, these representations are tested in the laboratory environment (i.e., they replace their digital counterparts). Upon entering this phase, STEP assumes an expanded and more integrated role. It is at this point that data from actual hardware exists to employ the *model-test-model* approach.

M&S is employed in the planning of tests to support a more efficient use of resources. Simulated tests can be run on virtual ranges to predict system performance, assess the system's operational effectiveness, evaluate data collection capabilities and test procedures, conduct rehearsals, and determine if the test limitations (and their effects on the ability to demonstrate whether or not critical system design issues) have been resolved.

M&S is used to provide stimuli with as many operational characteristics as possible or provide a real-time baseline to evaluate the progress of the tests. Test results are evaluated and used for the refinement of the system's requirements and design. Under STEP, they are also used to support the validation of the existing M&S. These models and simulations can then be employed with greater confidence to examine conditions not yet tested.

STEP tools are used to provide data for determining the real component or subsystem's performance and interaction with other components (e.g., Hardware-In-the-Loop (HWIL), Software-In-the-Loop (SWIL), integration testing), including the operator of the system (e.g., Human-In-The-Loop (HITL)).
Live tests (e.g., open air range tests) are conducted for both DT and OT. Developmental test includes range tests to demonstrate system and subsystem performance and to provide data for the total evaluation effort. This data can be utilized to support the Verification, Validation, and Accreditation (VV&A) process. Operational test is used to assess the operational effectiveness and suitability of a system under realistic operational conditions.

M&S is used during both DT and OT to increase the amount of data and supplement the live test events that are needed to meet their respective test objectives. Through the integrated use of these simulations, a more successful transition is made from DT to OT. Consequently, DT and OT merge into an efficient, effective, and continuous process for evaluation of system performance and operational effectiveness and suitability.

**STEP and the TEMP**

STEP will have a significant impact on the methods by which traditional test programs are conducted. The impact will be reflected in test activities such as evaluation planning, test planning, and documenting that planning in the TEMP. The TEMP is a “living” document which must accommodate ongoing changes to the acquisition program. The TEMP documents the integration of M&S with the T&E process through STEP and is iterated in conjunction with the development of the new system.

STEP begins with the examination of mission need and the development of operational requirements. M&S tools are used to examine anticipated mission scenarios, threat environments, analysis of alternatives, and technical requirements to help provide a clear understanding of the system capabilities needed. Focused understanding of the mission need, employment context, and requirements aids in the development of precise, testable, technical parameters, operational issues and criteria, and achievable thresholds and objectives. This solid foundation leads to the development of clearly defined DT and OT programs as well as realistic schedule, data, and resource requirements.

The following sections describe how STEP is integrated into the parts of the TEMP.

**System Introduction**

This part of the TEMP documents the measures of effectiveness and suitability derived from system requirements. The traceability of test results to requirements is key to the successful accomplishment of the goal of verification of system requirements. By utilizing the iterative method of STEP, the traceability of requirements from the MNS, ORD, and performance-based specifications to the MOEs and MOPs is clearly discernible. The comparison of simulation output to the MOOs, MOEs, and MOPs can bring early insight to the program not previously available with “traditional” test methods requiring physical system prototypes. The program can use these comparisons to examine the test methods, expand the envelope of the test environment, and reexamine the ability of the system to meet the requirements. The test planning should give careful consideration to the selection and collection of data for these comparisons

**Integrated Test Program Summary**

The integrated test program schedule is the union of all the individual test program parts. It reflects the synergy of the DT, OT, live-fire tests, requirements, resources, time, and funding that culminate in an achievable test program. In order to do this the Program Manager must have a clear understanding of the method by which the system will be developed, tested, and evaluated. STEP integrates test and simulation, and this must be reflected on the integrated test schedule in order to facilitate a successful evaluation strategy.

STEP impacts the integrated test schedule by applying M&S early and throughout the development and test process. By using simulation to accomplish many of the required tasks (reducing the need for expensive "live" assets), the program may be able to avoid expenditures in resources and time. However, the Program Manager must take into account the spectrum of combinations of M&S and test available to the system under development and assess the applicability of those resources. Development of new M&S resources, modification of existing M&S tools, VV&A of appropriate models and simulations, and the availability of data for these resources will all have a significant impact on the development of a realistic, achievable evaluation strategy and schedule.

Therefore, it is imperative to the success of the program that any development of M&S tools be included on the integrated schedule. Design and coding reviews, planned incremental releases, site installation, and related VV&A activities must also be included. Likewise, modifications and VV&A of existing M&S tools as well as data collection need to be delineated on the schedule to ensure adequate time and resources to accomplish all the tasks required.

**Test and Evaluation Resource Summary**

The following STEP-related resources need to be identified in this part:

* Test ranges/facilities including Major Range and Test Facilities Base (MRTFB), industrial and academic facilities

* Threat representations including simulations

* M&S resources to include VV&A

* Unique instrumentation and targets.

STEP changes the focus of the types of resources required for test programs. The use of up-front and continual simulation may reduce the need for live test assets and focus the need for test assets to the key critical tests. The use of simulation can also increase the efficiency of test programs by allowing for dry runs, which can identify procedural and data collection difficulties in advance. Interactive M&S tools can aid in greater understanding of the interaction of systems with operator capability.

The M&S tools used in each stage of the acquisition life cycle may differ as the program matures. However, the resources should not be abandoned, but archived into a repository to be used at later stages in the life cycle of the program or utilized by other programs. The listing of resources should also reflect the estimated resources required to VV&A models and simulations as well as the resources required to obtain and maintain the M&S tools and associated data.

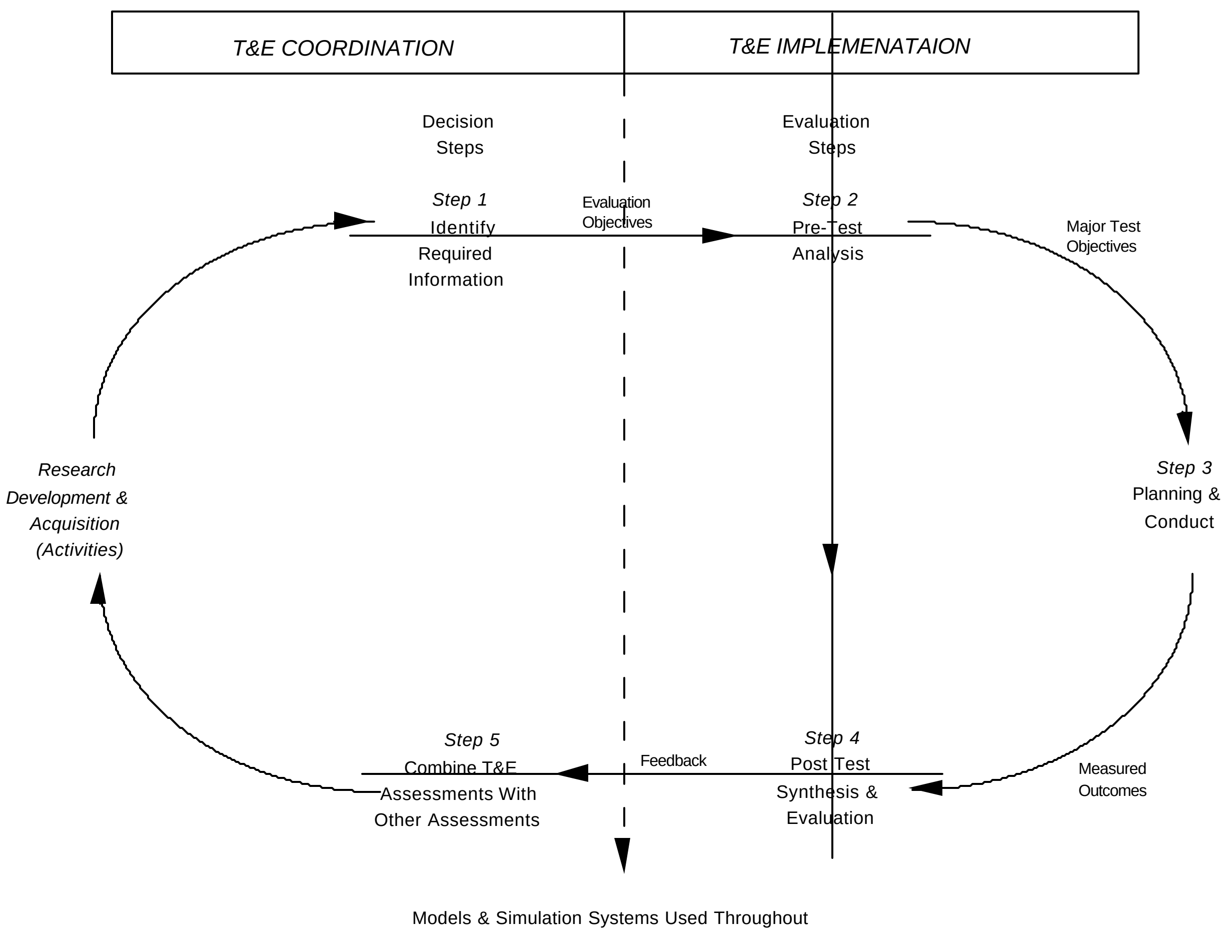
Data collection and validation are critical to the successful ongoing use of models. A genealogy of the M&S development and VV&A depends on the data collected to provide the substantiation for each stage of the VV&A. The data collected must also be archived for future use by the current system or by other systems desiring to utilize existing M&S technology.

While STEP may reduce the number and extent of live resources required for testing, care should be taken to ensure that adequate resources are available for the life of the program. The iterative nature of STEP provides the means of ensuring that the appropriate and testable requirements are developed. It can also aid in the development of a complete resources plan to ensure a complete and accurate test program by allowing for dry runs to determine the overall resources need.

# Appendix C.

# The DoD EW Test and Evaluation Process

The DoD test and evaluation process for electronic warfare systems is depicted as a five step process below.




The DoD Test and Evaluation (T&E) Process for Electronic Warfare (EW) Systems provides a good example of the types and scope of survivability testing required of system acquisition programs. Electronic Warfare is a major component of system susceptibility, which is one of the two main components of survivability (vulnerability, or damage tolerance, being the other). The EW T&E process consists of five steps that are performed within the boundaries of two major functions: the T&E Coordination Function, and the T&E Implementation Function. It is an iterative process that provides answers to critical EW T&E questions for decision-makers in each of the five phases of the DoD acquisition cycle.

**DoD EW T&E Process Coordination Function**

The process begins with the T&E Coordination Function, which has three parts: Research, Development and Acquisition (RDA), Step 1 (Identify Required Information); and Step 5 (Combine T&E Assessments With Other Assessments).

RDA is the basis for all T&E activities in that it generates mission requirements for the system under test (SUT). RDA activities affect T&E from requirements generation through design and development characteristics, specifications, production requirements, and operational concepts. The degree to which each of these has been demonstrated must be considered by decision makers. Answers with regard to the achievement of system performance objectives come from T&E. Answers to other questions, such as costs and schedules, come from other sources such as PA&E, Legal, or Comptroller.

STEP 1(Identify Required Information) is the identification of T&E information required by decision makers. The information required progresses from questions concerning proposed alternative concepts during Acquisition Concept and Technology Development to answers on system technical performance and operational suitability and effectiveness during Acquisition System Development & Demonstration Phase and beyond. The output of Step 1 is the evaluation objectives of the process.

STEP 5 (Combine T&E Assessments With Other Assessments) is where decision makers compare the T&E information with other programmatic information as necessary to decide a proper course of action. This T&E information is normally provided in the form of technical and operational assessments. The T&E process concludes with Step 5.

**DoD EW T&E Process Implementation Function**

The T&E Implementation function encompasses the three steps necessary to develop the information needed to prepare the assessments used by decision makers in Step 5 (Combine T&E Assessments With Other Assessments). This function has three parts:

Step 2 (Pre-Test Analysis), Step 3 (Planning and Conduct) and Step 4 (Post Test Synthesis and Evaluation).

STEP 2 (Pre-Test Analysis), is the evaluation of objectives from Step 1 (Identify Required Information) to determine the types and quantities of data needed, the results expected or anticipated from tests and the analytical and physical tools needed to conduct the tests and evaluations. The output of this step is the expected outcomes of the tests and major test objectives.

STEP 3(Planning and Conduct), is the actual test events combined with data management practices. Given the data requirements from Step 2 (Pre-Test Analysis), T&E managers determine what data already exist in historical files and what data must be developed from new test events. They plan and execute tests necessary to develop the needed data using applicable computer simulation and modeling; system integration laboratories; hardware-in-the-loop test facilities; installed system test facilities; and open air test ranges. Both historical and developed data are reviewed for completeness and accuracy, authenticated, and forwarded in technical and operational test reports for assessment as measured outcomes.

STEP 4 (Post-Test Synthesis and Evaluation), is the comparison of the measured outcomes with the expected outcomes from Step 2 (Pre-Test Analysis), combined with technical operational judgment. The output of Step 4 is the feedback of technical and operational assessments needed by decision makers.

**DoD EW T&E Process's Relationship to Other Technical Functions**
The Test and Evaluation process interfaces with other specialty disciplines as part of the overall systems engineering process during each acquisition phase. Figure X illustrates the two -way flow of information between the T&E function and other program disciplines.

QuickTime™ and a
BMP decompressor
are needed to see this picture.

Figure X. T&E as Part of Systems Engineering

T&E, by the nature of their function must interface with every discipline (including survivability) involved with the design, development, manufacturing, deployment and operation of a system. These interfaces are necessary to obtain data and information to support the test planning as well as provide essential feedback, technical data and test results to the concerned functions so they may validate or change their planning and operations or take corrective actions as appropriate. The IPPD concept serves as an effective two-way conduit for the interchange of this critical information. The PM is to employ the concept of IPPD throughout the program design process to the maximum extent practicable. The use of IPTs is a key tenet of IPPD.

The IPPD management process integrates all activities from product concept through production and field support, using multidisciplinary 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.

# Appendix D.

# EW T&E Test Resources

There are six general categories of T&E resources, see figure X. These are Modeling & Simulation (M&S), Measurement Facilities (MF), System Integration Laboratories (SIL), Hardware-In-The-Loop (HITL) Facilities, Installed System Test Facilities (ISTFs), and Open Air Ranges (OAR). Proper selection and use of these resources (facilities and capabilities) is an important part of T&E. NOTE: Public Law 103-160, 30 November 1993, Section 220(a) applies to ACAT I level electronic warfare systems. That law requires T&E be considered at each of the above types of facilities before proceeding into low-rate initial production. Thus a thorough understanding of these categories and their interrelationships is necessary. Descriptions of each are provided in the following paragraphs and a overview of facilities associated with each resource category is discussed in the Facility and Capability for Test and Training (FACITT) on the TECNET/TECWEB website.

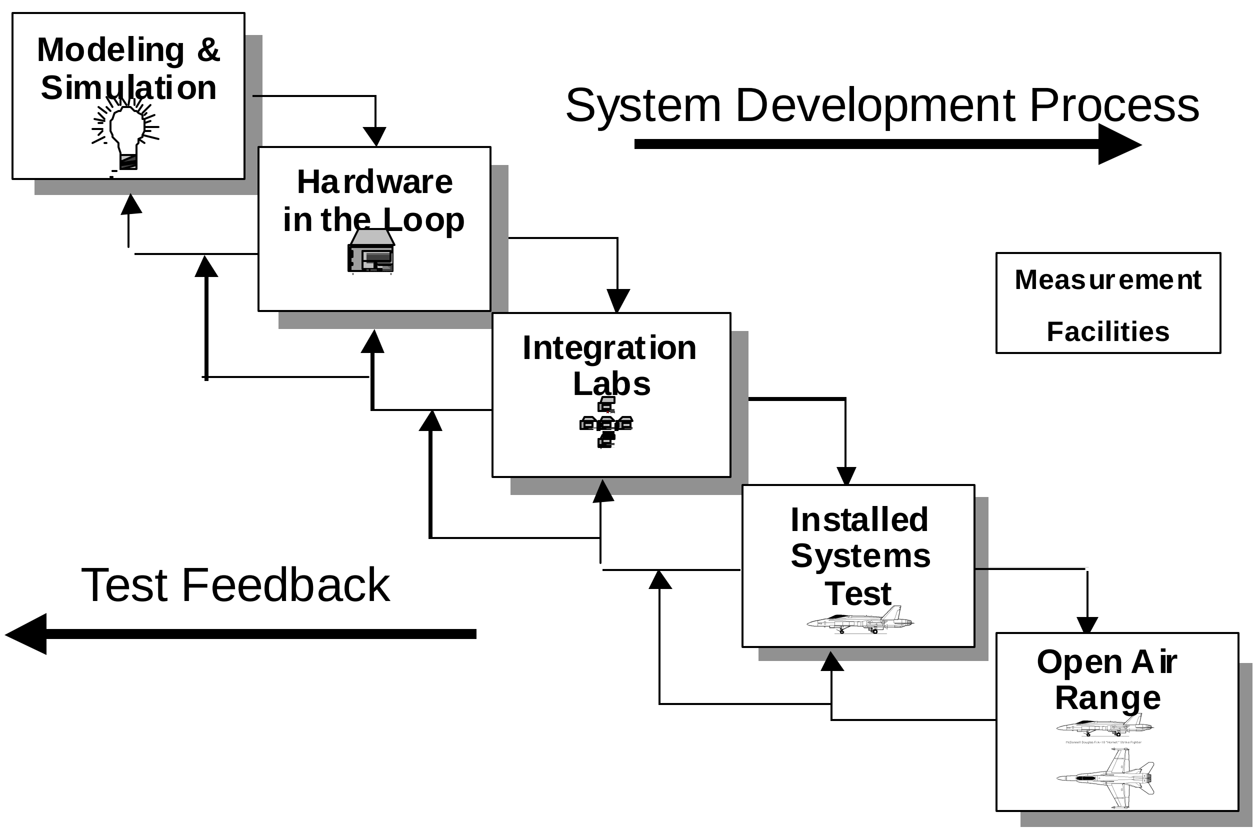


**Figure X** is intended to show how these primarily support the test execution step. Note, however, that M&S also supports the other action steps in the EW T&E process.

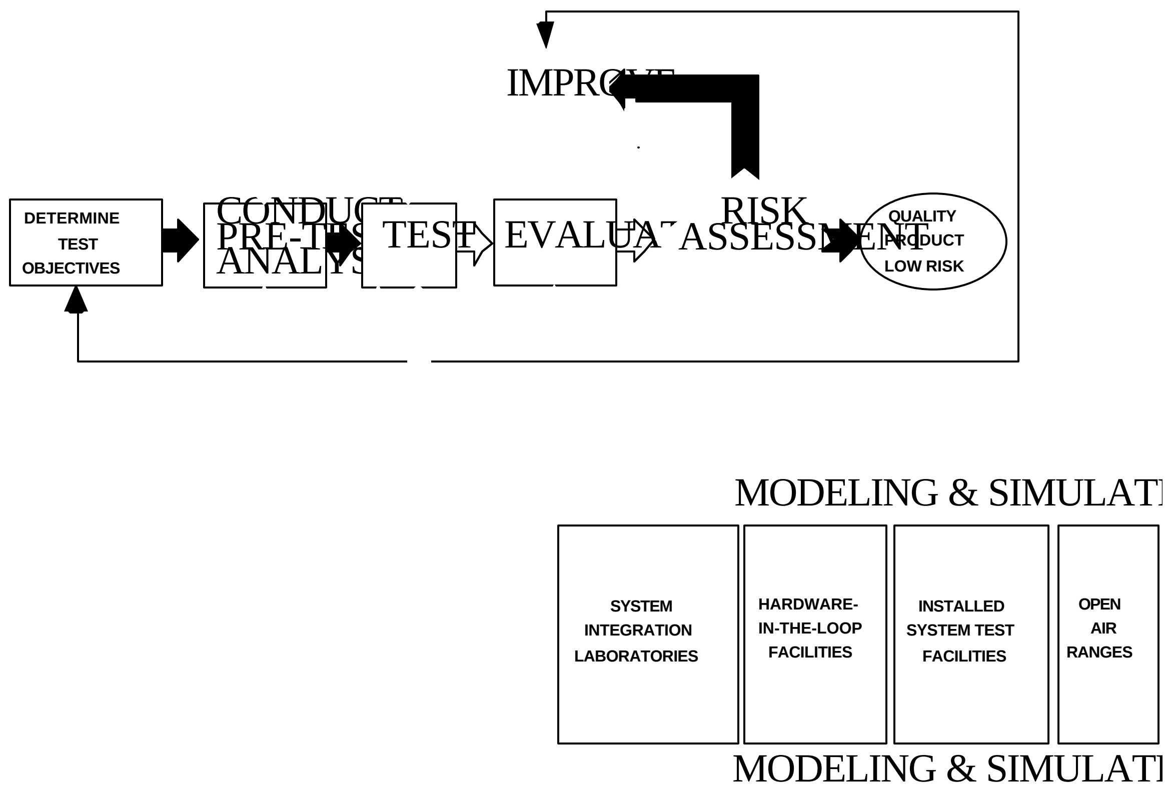



Figure X. Resource Categories Support Test Execution.

**Engineering use of M&S during the System Development & Demonstration Phase**

A major focus of Models and Simulations (M&S) in System Development & Demonstration is at the engineering level models which are used for detailed survivability design, engineering tradeoffs, test planning and support, subsystem and system performance, and verification of compliance with specifications. Models and simulations also support cost/performance analysis and Operational Requirements Document (ORD) updates, Developmental Tests (DT) and OT&E, and prepare for production and deployment of the system.

Several uses of models and simulations used in System Development & Demonstration are defined below:

- Engineering level models and simulations of proposed systems and subsystems will be used for survivability detailed design and assembly of subsystems, components and piece parts. Performance requirements will be verified using a combination of testing and simulation.

- The Hardware/Software In The Loop (HW/SWIL) simulations will be used in a model-test-model process for survivability pre-test planning, test execution, and post-test analysis. Such simulations are able to identify problems in actual test hardware before conducting live tests (i.e. live simulations) on the range. They also provide for parameter variation studies, and augment the matrix of test conditions. The performance estimates from simulations during this phase along with live simulation (test) data provide input for models and simulations at other levels or of other classes.

- Cost models will be able to incorporate cost data from engineering models and actual Low Rate Initial Production (LRIP) hardware for the program cost estimates and cost/performance analysis updates.

- Engagement and mission/battle models and simulations will again be used to evaluate how well the designs allow the proposed system to achieve the necessary Measure of Effectiveness (MOE). The theater/campaign level models and simulations will be used to assess the proposed system and determine its impact on the outcome of conflicts.

- Human interactive simulations will continue to examine tactics within the above framework of constructive models, but will more likely focus on continued refinement of human-machine interfaces.

- Virtual simulations can be used to evaluate systems performance and effectiveness. A virtual prototype can be used to support development efforts including design, support (e.g. maintenance walk-throughs), manufacturing and training. Members from every functional discipline share the same electronic representation of the system facilitating integrated product and process development. Weapon system trainers being developed should take maximum advantage of the models and simulations used in developing the system itself. As these trainers are developed and made available, they may be used for training test crews, and mission rehearsal for live simulations (e.g. OT&E planning).

- Live simulations may take the form of live exercises, or instrumented prototype tests, including Initial Operational Test and Evaluation (IOT&E). Managers should insist that data obtained in these tests are used to further validate the models and simulations.

- A combination of engineering, engagement, mission and campaign simulations, as described in the program TEMP will be required to augment the developmental and operational test program during System Development & Demonstration. Earlier program efforts to define the appropriate models and simulations; Verification, Validation And Accreditation (VV&A) them; and determine the relationships among MOEs and Measures of Performance (MOP) are critical to the successful application of M&S to support or augment the test program.

Models and simulations not only support detailed design during this phase they will continue to be key tools for Integrated Product and Process Development (IPPD), and will reduce design risk by allowing all of the functional disciplines to work from the same design data base. A reduced number of Engineering Change Proposals (ECP) will be an important result of this activity. The HW/SWIL simulations will result in significant risk reduction in test and evaluation through planning, hardware checkout and mission rehearsal. Finally, the transition to production will take place with reduced risk by the electronic transfer of digital design data directly to the manufacturing floor.

At the end of System Development & Demonstration, detailed design of the system including definition of production and support processes is complete. In accordance with M&S planning conducted beginning in the Concept and Technology Development phase, the program office should be prepared to maintain those models and simulations which will be needed for continued support of the weapon system during its life cycle. The Program Manager (PM) also needs to consider how to make representations (models) of the system available to others outside the program office that may have a need to use them.

**M&S.** Digital models and computer simulations are used to represent systems, host platforms, other friendly players, the combat environment, and threat systems. They can be used to help design and define EW systems and testing with threat simulations and missile flyout models. Due to the relatively low cost of exercising these models, this type of activity can be run many times to check what ifs and explore the widest possible range of system parameters without concern for flight safety. These models may run interactively in real or simulated time and space domains, along with other factors of a combat environment, to support the entire T&E process. Computer simulations are constructed to the following levels of technical complexity:

Level I — Engineering. Component level model used to examine technical performance of an individual component or sub-system in the presence of a single threat.

Level II — Platform. Weapon system level models used to evaluate effectiveness, including associated tactics and doctrine, in the context of an integrated weapon system engaged with a single (one-on-one) or a few (one-on-few) threats in a simulated scenario.

Level III — Mission or Engagement. Multiple weapon systems level models (with varying degrees of detail) combined into a simulated mission to analyze mission effectiveness and force survivability of friendly, multi-platform composite forces opposing numerous threats (many-on-many).

Level IV — Theater or Campaign. This level incorporates the C4I contributions of joint-Service (i.e., Army-Air force-Navy) operations against a combined threat force (force-on-force). Level IV integrates the various missions into regional, day and night, and joint operations and assesses the input of electronic warfare on force effectiveness. Inputs into this level consist of the output from Level III analysis and from unique Level IV force-on-force analysis of Level III and force level C4I doctrines.

The objectives of modeling a parameter in the test process are to:

- Define safety footprints or limits.
- Extrapolate test data into untestable regimes.
- Increase sample size once confidence in the model is established.
- Define test facility requirements (e.g., number and types of threats, airspace required, control of background noise and emitters and instrumentation).
- Define and optimize test scenarios.
- Select test points (i.e., successful results would not indicate the need for additional heart-of-the-envelope testing).
- Predict test results for each test objective.

The objective is to determine the capability of M&S, correlated with HITL and OAR tests, can be used to produce credible MOEs in the T&E of threat anti-air missile systems in an ECM/LO environment.

Today, EW T&E uses computer-aided simulations and analysis prior to testing to help design tests and predict test results, and after testing to extrapolate test results to other conditions. In this way M&S is part of all six resource categories. M&S should also be used to provide constant feedback for system development/improvement.
The unique capabilities of today's M&S, what M&S can do, and M&S limitations are summarized in **Table Y**.

Table Y. Modeling & Simulation Capabilities.

| | |
|---|---|
| What Makes M&S Unique | • Only way to do T&E without hardware.<br>• Only way to evaluate operational effectiveness at the campaign level. |
| What M&S Can Do | • Allows a system to be analyzed before any hardware is built.<br>• Provides an audit trail from operational requirements to test criteria.<br>• Allows evaluation in complex scenarios/environments that could not be simulated in a ground test facility or open air range.<br>• Provides high flexibility, repeatability, and insight into results at low cost. |
| M&S Limitations | • Prediction of absolute performance/effectiveness with high confidence.<br>• Achieving the same degree of fidelity as an RF simulator for certain complex functions. |

**Measurement Facilities (MF).** Measurement facilities establish the character of an EW related system/subsystem or technology. They provide capabilities to explore and evaluate advanced technologies such as those involved with various sensors and multi-spectral signature reduction.

Measurement facilities generally fall into the sub-categories of antenna measurement, Radar Cross Section (RCS) measurement, infrared/laser signature measurement, Electromagnetic

Interference and Electromagnetic Compatibility (EMI/EMC) test capabilities. Measurement facilities provide EW and platform antenna pattern descriptions and platform signature data critical for system design and refinement, computer simulation, and HITL testing.

The unique capabilities of Measurement Facilities, what they can do, and their limitations are summarized in **Table Y**.

Table Y. Measurement Facilities Capabilities.

| | |
|---|---|
| What Makes MF Unique | • Provides empirical data that cannot be emulated accurately |
| What MF Can Do | • Measure parameters that contribute to EW performance and effectiveness.<br>• Test certain EW components/techniques to optimize design.<br>• Acquire input data for digital models. |
| MF Limitations | • Simulation of electronic warfare.<br>• Evaluation of EW performance/effectiveness. |

**System Integration Laboratories (SIL).** SILs are facilities designed to test the performance and compatibility of components, subsystems and systems when they are integrated with other systems or functions. They are used to evaluate individual hardware and software interactions and, at times, involve the entire weapon system avionics suite. A variety of computer simulations and test equipment are used to generate scenarios and environments to test for functional performance, reliability, and safety. SILs are generally weapon system specific and are found in both contractor and government facilities.

SILs often employ a variety of real-time/near-real-time digital models and computer simulations to generate scenarios and multi-spectral backgrounds. These models are interfaced with brassboard, prototype, or actual production hardware and software of the systems under test. SILs are used from the beginning of an EW system's development through avionics integration and fielding. Moreover, SILs continue to be used to support the testing of hardware and software modifications or updates occurring throughout an EW system's operational life. The unique capabilities of SILs, what they can do, and their limitations are summarized in **Table Y**.

Table Y. System Integration Laboratory Capabilities.

| | |
|---|---|
| What Makes a SIL Unique | • Tests technical performance down to the component level in the controlled environment of a testbed. |
| What a SIL Can Do | • Facilitates EW/avionic integration using a building block approach.<br>• Permits stimulation of the integrated system with threat signals.<br>• Tests static, open-loop performance at specific points in design envelope.<br>• Provides a Baseline environment in which hardware and software changes can be tested. |
| SIL Limitations | • Evaluation of dynamic performance.<br>• Evaluation of closed-loop EW performance against threat. |

| | |
|---|---|
| | • Evaluation of EW system effectiveness |

**Hardware-in-the-Loop (HITL).** HITL is an important test category because it represents the first opportunity to test uninstalled system components (breadboard, brassboard, preproduction prototypes, etc.) in a realistic RF, Laser, or IR environment. HITL operating environments can provide: terrain effects; high signal/threat density; realistic interactive scenarios; multi-spectral capability; background noise; modern threat representation via closed-loop hybrid threat simulator for EC effectiveness testing; man-in-the-loop interaction; and Integrated Air Defense System (IADS) networking. Capabilities provided by the HITL test environment are: secure (shield/screen room); high data pass rate; test replay/repeatability; and high capacity data collection and recording.

Thus HITL facilities are indoor test facilities that provide a secure environment to test EW techniques and hardware against simulators of threat systems. Primary EW HITL facilities contain simulations of hostile weapon system hardware or the actual hostile weapon system hardware. They are used to determine threat system susceptibility and to evaluate the performance of EW systems and techniques.

Some EW HITL facilities contain US or friendly weapon system hardware. They are used to evaluate and improve the performance of US or friendly weapon systems. These HITL facilities can be used to test US EW systems where the US or friendly weapon system represents threat technology, or where the actual system has become a potential threat to friendly forces.

HITL testing should be done as early in the development process as possible - even if that means using a brassboard configuration. Too often preproduction hardware is developed late in a program, making identification and remedy of problems difficult. EW HITL testing is done to provide repeatable measurements and verification of protection techniques and EW system effectiveness. The unique capabilities of HITL facilities, what they can do, and their limitations are summarized in **Table Y**.

Table Y. Hardware-In-The-Loop Facility Capabilities.

| | |
|---|---|
| What Makes HITL Unique | • Evaluates EW system effectiveness prior to host platform integration in a dynamic environment. |
| What HITL Can Do | • Allows closed-loop effectiveness testing against an IADS.<br>• Allows dynamic testing across the system employment envelope.<br>• Simulates a comprehensive battlefield threat environment.<br>• Tests EW systems in an integrated configuration.<br>• Allows both red and blue man-in-the-loop interfaces.<br>• Provides high flexibility, repeatability, and insight into results at medium cost.<br>• Excellent primer for OAR testing. |
| HITL Limitations | • Testing compatibility and interoperability with the host platform. |

| | |
|---|---|
| | • Simu lation of all flight environment aspects with high confidence. |

**Installed System Test Facilities (ISTF).** ISTFs provide a secure capability to evaluate EW systems that are installed on, or integrated with, host platforms. These test facilities consist of anechoic chambers in which free-space radiation measurements are made during the simultaneous operation of EW systems and host platform avionics and munitions. The EW system under test is stimulated by threat signal generators and its responses evaluated to provide critical, integrated system performance information. Their primary purpose is to evaluate integrated avionics systems (e.g., radar, infrared, communications, navigation, identification, EW systems or subsystems, integrated controls and displays) in installed configurations to test specific functions of complete, full-scale weapon systems. Such testing is done to determine if any EMI/EMC problems exist; to determine system reaction to electromagnetic environments of hostile and/or friendly systems who's signals cannot be radiated in free space on open air test ranges for security reasons; and to support flight testing by providing pre-flight and post-flight checkout capabilities. This ground testing can aid in isolating component, subsystem, or system problems not observable in other ground test facilities but crucial to system checkout prior to open air testing. Failure to evaluate installed EW system performance adequately on the ground typically results in significantly increased flight test cost and lengthened schedules.

- A Category I ISTF performs end-to-end systems effectiveness testing on installed multi-sensor/multi-spectral EW and other avionics/vetronics (vehicle electronics) systems under a wide range of realistic threat and operational conditions. These conditions require the appropriate types and numbers of players. Test events range from DT&E to OT&E. Specific tests include EW effectiveness (especially multi-sensor cued countermeasures), platform susceptibility, human factors, Electronic Protection performance, weapon systems integration performance, Electronic Support systems performance and systems integration testing.
- A Category II ISTF performs end-to-end system integration testing on installed multi-sensor/multi-spectral EW and other avionics/vetronics systems under conditions necessary to prove system performance. Test events are primarily DT&E oriented with some applications to operational testing. Specific tests include: human factors, Electronic Protection, avionics/vetronics systems performance and systems integration testing.
- A Category III ISTF performs specialized testing such as: Electromagnetic environmental effects (E3), limited systems installation and checkout on aircraft, ground vehicles and components.
- A Category IV ISTF performs specialized testing such as: RCS measurements, antenna pattern measurements, and susceptibility to High Powered Microwave.

The unique capabilities of ISTFs, what they can do, and their limitations are summarized in **Table Y**.

Table Y. Installed System Test Facility Capabilities.

| | |
|---|---|
| What Makes an ISTF Unique | • Allows EW system testing on host platform under controlled conditions. |
| What an ISTF Can Do | • Evaluates EW system compatibility and interoperability with the host platform.<br>• Provides pre-flight checkout capability and post-flight diagnostics.<br>• Tests static EW performance of the integrated platform at specific points in the employment envelope. |
| ISTF Limitations | • Dynamic test performance in a free-space environment.<br>• Evaluation of closed-loop performance against a threat in a free-space environment.<br>• Evaluation of EW effectiveness. |

**Open Air Range (OAR).** Open air range test facilities are used to evaluate EW systems in background, clutter, noise and dynamic environments. Typically these resources are divided into sub-categories of test ranges and airborne testbeds.

Open Air Range EW flight test ranges are instrumented and populated with high-fidelity, manned or unmanned threat simulators. Additional emitter-only threat simulators are also used to provide the high signal density characterizing typical operational EW environments. The high cost of outdoor threat simulators limits current range testing to one-on-one, one-on-few, or few-on-few scenarios. Open Air Range testing includes the subcategories of ground test, test track, and flight est. The primary purpose of open air testing is to evaluate the system under real-world representative environment and operating conditions. Open air range testing is used to validate system operational performance/effectiveness at a high level of confidence. If properly structured, flight testing can also be used to validate/calibrate ground test facilities and models. EW components, subsystems, systems, and entire avionic suites can be installed in either a ground or airborne testbed or in the intended operational platform and tested on open air ranges. Real-world phenomena encountered during open air range testing include terrain effects, multi-path propagation, and electromagnetic interference from commercial systems (television and radio broadcasts, micro-wave transmissions, etc.). Flight test ranges also offer the capability to conduct tests using captive carried and live-fired missiles.

Airborne testbeds range from small aircraft with pod-mounted components or systems to large aircraft designed for spread-bench installation and testing of EW and avionic systems. They permit the flight testing of EW components, subsystems, systems, or functions of avionic suites in early development and modification, often before the availability of prototype or production hardware.

The unique capabilities of open air ranges, what they can do, and their limitations are summarized in **Table Y**.

Table Y. Open Air Range Capabilities.

| | |
|---|---|
| What Makes Ranges Unique | • Only facility which provides a realistic flight environment.<br>• Provides high confidence necessary for production certification. |
| What Ranges Can do | • Provide realistic flight environment including atmospheric propagation, terrain effects and ?.<br>• Allow dynamic closed-loop effectiveness testing at specific points in the design envelope.<br>• Calibration and validation of digital models and ground test facilities. |
| OAR Limitations | • Achieving battlefield threat densities and diversities.<br>• Scenario flexibility and statistical repeatability.<br>• Relatively high cost per test. |

# Appendix E.

# The Air Force T&E Process

The Air Force process is applied in all facets of systems as shown in documentation depicted in figure X below.

QuickTime™ and a
BMP decompressor
are needed to see this picture.

Figure X. Air Force Test and Evaluation Process Documentation

The six step process, shown in figure X, is a scientific approach that supports a plan-predict-test-compare philosophy for testing systems. Discipline in the test process is recognized as a contributor to cost effective system acquisitions that satisfy user needs. A disciplined and well structured test program reduces the risk of acquiring an ineffective system and provides a program manager with timely information required to make prudent decisions during system development. Testing encompasses many levels and methodologies, from component tests in laboratories to full mission demonstrations in a real world environment. Regardless of the type of test, there are six guiding principles to help ensure the system under test fulfills its intended purpose.

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BMP decompressor
are needed to see this picture.

Figure X. The Air Force T&E Process

The relationship of the T&E process to T&E resources and system maturity is shown in figure X.

QuickTime™ and a
BMP decompressor
are needed to see this picture.

*Figure X. Test and Evaluation Relationships.*

# Appendix F.

# Major Range and Test Facility Base (MRTFB)

The MRTFB is a national asset that is to be sized, operated, and maintained primarily for DoD T&E support missions, but also be available to all users having a valid requirement for its capabilities. The MRTFB consists of a broad base of T&E activities managed and operated under uniform guidelines to provide T&E support to DoD Components responsible for developing or operating materiel and weapon systems.

In accordance with DoD 5000.2-R , T&E programs are to be structured to integrate all developmental T&E, operational T&E, live-fire T&E, and modeling and simulation activities conducted by different agencies as an efficient continuum. All such activities are to be part of a strategy to provide information on risk and risk mitigation, to provide empirical data for validation of models and simulations, to permit an assessment of the attainment of technical performance specifications and system maturity, and to determine whether systems are operationally effective, suitable, and survivable for the intended use. The MRTFB is part of the National Test Facilities Base and is a national asset that exists primarily to provide T&E information for DoD decision makers and to support T&E needs of DoD research programs and weapon system development programs.

Investments for capabilities in the MRTFB that would only support a single acquisition program are generally funded by that program. Investments by programs for test capabilities at contractor facilities or non-MRTFB installations should be considered only after giving first consideration to improving the MRTFB capabilities, and all programmatic investments are to be reported by means of C-11 Format (c-11form.doc) in the Services' modernization and investment portion of the test and evaluation technical exhibit of their POM submittals.

Other U.S. Government Agencies (Federal, State and local) and allied foreign governments, and defense contractors may be permitted to use the MRTFB. Private organizations and commercial enterprises may use the MRTFBs as authorized by Congress and any subsequent policy from the Under Secretary of Defense for Acquisition and Technology (USD(AT&L)). A commercial enterprise is defined as any U.S. commercial user (a profit-making organization or individual), or a non-Government-sponsored university. MRTFB commanders are to ensure that they are not competing with U.S. private industry in providing services to commercial users or non-DoD Government users. The use of MRTFB facilities by private organizations and commercial enterprises are not to increase the cost to the Department to operate the MRTFBs and are not factored into the decision-making process for sizing and maintaining the T&E infrastructure.

The Department of Defense has designated certain test facilities and ranges that collectively comprise the Major Range and Test Facility Base (MRTFB). The facilities and ranges in the MRTFB are managed by the Services and defense agencies, and are maintained to be available specifically to support acquisition test (developmental and operational) programs under a uniform funding policy. Defense programs pay only the direct costs for use of MRTFB facilities and ranges, the owning Service or defense agency funds the indirect or institutional costs. MRTFB facilities and ranges are available for use by Defense acquisition test programs from any Service or defense agency under this uniform funding policy as prescribed in DoDD3200.11. The available test assets at or capabilities of each facility and range are described in the TECNET/TECWEB website. The Facility and Capability for Test and Training (FACITT), requiring registration, provides detailed information. For additional information, contact the JPO(T&E), Major Mike Scott, FACITT Program Manager, at (240) 857-4766 or <michael.scott@andrews.af.mil>

**The Joint Program Office for T&E (JPO(T&E)).** In support of the T&E Executive Agent Organization Board of Directors (BoD), the JPO(T&E) coordinates the execution of Service and multi-service T&E investment projects. Specific principal responsibilities of the JPO(T&E) include (1) facilitate deconfliction and integration of the various T&E investment products (Services' submissions, Central Test and Evaluation Investment Program (CTEIP) submissions, BoD TRMP and DoD TIS production) and developing development of requirements prioritization; (2) assisting the OSD Test Capability, Budget and Investment Review process by reviewing and deconflicting the T&E investment portions of the draft Service briefings; (3) managing the T&E Corporate Information Management (CIM) initiative; and (4) conducting special studies as directed, to include new projects requirements development, on-going project reviews, and developing opportunities for common maintenance facilities. The JPO(T&E) is composed of a senior-level civilian director, a military deputy director, and supporting staff.

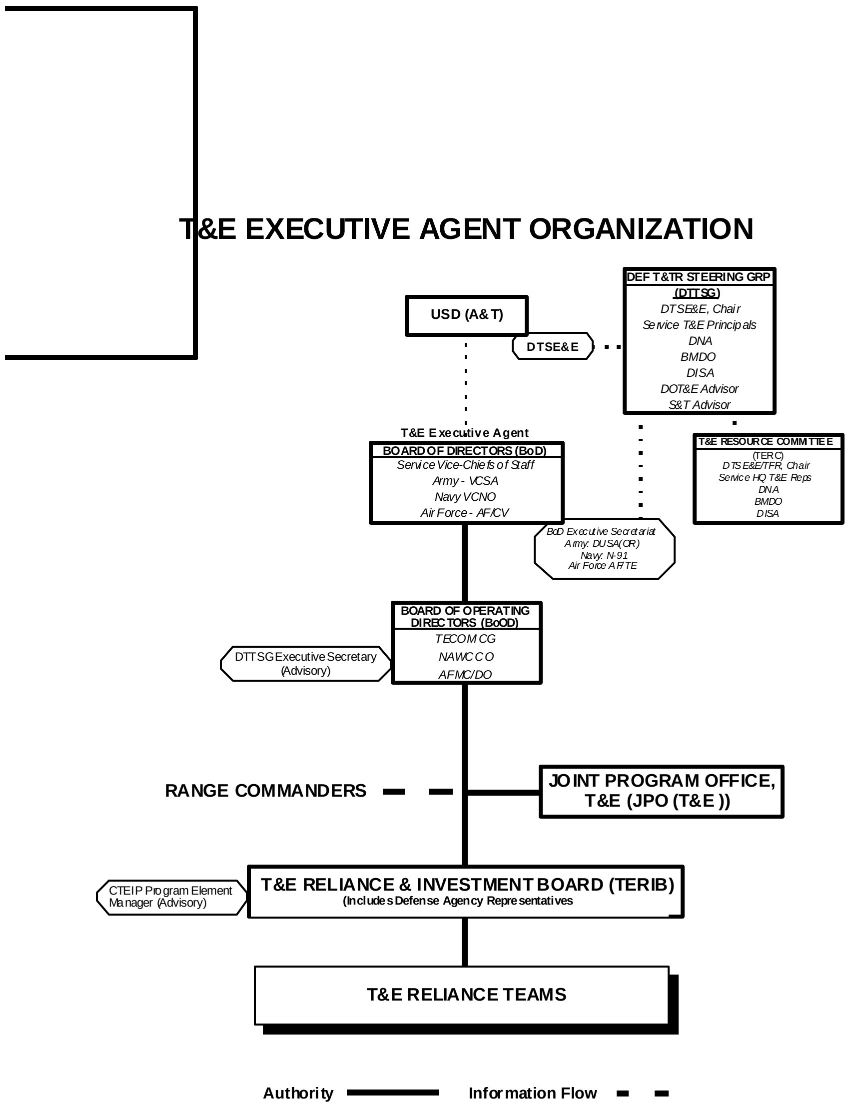


Figure A-1
T&E Organizational Elements

MRTFB test facilities are:

**Army Activities**

White Sands Missile Range, White Sands NM including Electronic Proving Ground at Ft Huachuca, AZ

High Energy Laser Systems Test Facility (HELSTF), White Sands, NM

Kwajalein Missile Range, Kwajalein Atoll

Yuma Proving Ground, Yuma AZ

Dugway Proving Ground, Dugway, UT

Aberdeen Test Center, Aberdeen, MD

**Navy Activities**

Naval Air Warfare Center-Weapons Division, Point Mugu, CA

Naval Air Warfare Center-Weapons Division, China Lake, CA

Naval Air Warfare Center-Aircraft Division, Patuxent River, MD

Naval Air Warfare Center-Aircraft Division, Trenton N.J. (scheduled for closure)

Atlantic Undersea Test and Evaluation Center, Andros Island, Bahamas

Atlantic Fleet Weapons Training Facility, Roosevelt Roads, Puerto Rico

**Air Force Activities**

45th Space Wing, Patrick AFB, FL

30th Space Wing, Vandenberg AFB, CA

Arnold Engineering Development Center, Tullahoma, TN

Air Force Air Warfare Center, Nellis AFB, NV

Air Force Flight Test Center, Edwards, AFB, CA

Utah Test and Training Range, Hill AFB, UT

Air Force Development Test Center, including the 46th Test Group at Holloman AFB, NM

Air Force Development Test Center, Eglin AFB, FL

**Defense Information Systems Agency Activity**

Joint Interoperability Test Command

# Appendix G.

# What is the Automated Test Planning System (ATPS)?

The ATPS is a set of rule-based expert system software tools designed to help improve the overall quality of T&E planning and reporting for DoD acquisition programs. The ATPS provides an intuitive, computer-aided, and structured environment to assist in designing a comprehensive T&E program, in drafting or reviewing a TEMP, and in assessing T&E program risk. The ATPS software is distributed free of charge and is available for both PC and Macintosh workstations.

**Background and Content**

The Deputy Director Test, Systems Engineering and Evaluation (Test and Evaluation) in the Office of the Under Secretary of Defense for Acquisition and Technology (OUSD(AT&L)/DS&TS) conceived of and instituted the development of ATPS as a dedicated, long term effort to counter the effects of the routine turnover of key personnel in the DoD T&E community. This turnover fosters loss of continuity, loss of corporate knowledge, and incomplete knowledge transfer from experienced testers to junior personnel. This loss of knowledge and experience results in lower quality, needless duplication, lack of policy standardization, and overall inefficiency. The development of the ATPS expert system knowledge base capitalizes on the experience and the expertise of seasoned T&E planners and supplements their knowledge with historical data. Each ATPS module guides experienced and inexperienced test planners through a structured and comprehensive process integral to overall T&E planning.

* The TEMP Build Module helps prepare a TEMP that will satisfy the DoD 5000 series requirements, and accommodates all acquisition categories for all Services. This module uses three expert system rulesets to guide users through a structured Service-specific process and generates a file containing the information necessary to prepare a draft TEMP. Word processor editing will produce the final formal TEMP document.

* The TEMP Review Module facilitates a DoD 5000 series-based review of a TEMP. Though designed for major acquisition programs, this module accommodates all acquisition categories for all Services. This module guides users through a structured TEMP review process and generates a file of user comments that can be used to prepare formal correspondence.

* The Test and Evaluation Program Risk Assessment Module uses a milestone-based method to assess T&E program risk. This module guides users through a structured risk assessment procedure and generates a file of comments that can be used to prepare formal

correspondence. The user assigns the risk levels to specific areas and uses the software to sort by risk categories. The ATPS uses a combination of the risk indicators and procedures provided by seasoned testers and evaluators.

* The Test and Evaluation Program Design Module is designed to guide users through an iterative process to develop a comprehensive T&E program. This module uses a requirements-driven work breakdown structure to develop an evaluation strategy and a test strategy**. It encourages using modeling and simulation and integrating test events and training exercises**. Example management tools are included to help in preparing appropriate management documents. This module, as with all modules, will be refined with user feedback.

**Technology and Features**

The ATPS uses a common graphical user interface across all modules and integrates expert system and hypertext technologies to improve consistency, quality and efficiency, and to reduce the learning curve for less experienced test planners. The ATPS provides structured and systematic methods for designing a comprehensive T&E program, for TEMP preparation and review, and for T&E program risk assessment. The ATPS also serves as a corporate repository of T&E planning knowledge. Modules generate output files ready to edit into smooth correspondence or a final document.

On-line help is an integral part of the ATPS software. The ATPS software contains the DoD 5000 series documents, the user manual, and a 8,500-term glossary of T&E and acquisition-related terms. All these help files are hypertext documents with full text search and bookmark capabilities to facilitate point and click maneuvering to all topics particularly related and frequently used topics. The ATPS software also contains technical support information.
ATPS is developed for client workstations utilizing either the Windows or Macintosh platform; however, it has been successfully run on Local Area Networks (LANs) by several organizations. There are over 600 registered T&E users either working in or supporting Army, Navy, Air Force, and OSD offices.

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Obtaining ATPS

The ATPS software is available free of charge to United States Government personnel and civilian contractors supporting the official business of the United States Government. Software registration is required. Additional information may be obtained from the points of contact listed below.

| Points of Contact | Government | Developing Contractor |
|---|---|---|
| Name | Robert Butterworth | Mr. John Allen |
| Phone | 703-578-6595 | 703-413-3152 |
| Fax | 703-578-0527 | 703-413-8059 |
| E-mail | butterrm@acq.osd.mil | allenjb@mail.etas.com |

Organization OSD/DOT&E/R&R
Address Test & Evaluation Center
2001 N. Beaureguard St.
Suite 800
Alexandria, VA 22311-1772

Organization SAIC
Address Crystal Square 5
Suite 202
1755 Jefferson Davis Hwy
Arlington, VA 22202

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It should be noted that each test facility/range will require the translation of top level test plans into a facility/range unique test plan.

# Appendix H.

# Other Testing

**Joint Live Fire / Live Fire Test**

The Joint Live Fire (JLF) program was initiated by the Office of the Secretary of Defense (OSD) in March of 1984 because there was no formal process to test fielded U.S. systems against realistic threats.

The Joint Live Fire program was chartered to focus, through live firing of real munitions, on the vulnerability of fielded armored vehicles and combat aircraft against actual threat systems, and the lethality of U.S. munitions against those threats.

OSD provides the program funding, buys the test articles, and provides technical oversight. The Joint Technical Coordinating Groups (JTCG) for Aircraft Survivability and Munitions Effectiveness administer the programs. The JTCGs, under guidance from OSD, directly coordinate test planning and program direction while the individual services execute and support the tests.

There are two distinct divisions of the JLF program, Aircraft Survivability and Armor/Anti-armor. The program has four primary objectives:

* Establish actual test data on the vulnerability of <u>fielded</u> U.S. systems to actual threat weapons, and the lethality of <u>fielded</u> U.S. munitions or missiles against threat targets.

* Provide insights into necessary U.S. system design changes, such as moving ammunition storage racks to provide greater protection to the crew members.

* Develop Battle Damage Assessment and Repair (BDAR) information to enhance equipment repair in the field for restoration into the battle.

* Provide insights into lethality and vulnerability modeling and simulations that are used in live-fire testing of new systems. The information also helps train soldiers, for example, by enhancing crew training to better report the results of firing engagements at threat systems.

While the JLF program conceptually may have spawned interest resulting in the Congressionally mandated Live Fire Test (LFT) program, each has its own area of applicability. The LFT program focuses on new systems in development, or systems that have product changes or improvements that involve vulnerability or lethality. The driving interest in LFT is to include live-fire testing early in the system acquisition processes, complete the testing, and identify appropriate design changes prior to a decision to proceed beyond low rate initial production. The JLF program focuses on fielded systems which have raised questions involving live fire exposure, or where threat weapon systems change.

JLF often discovers small changes that have large impacts on survivability. These items have developed as a result of JLF, for example:

* Jam-resistant actuators for aircraft which are both lighter and more survivable
* Shielding of critical components of a system
* Adding extra wire to improve redundancy
* Moving detectors to improve warnings
* Modifying software to enhance operations
* Revising stowage to save lives
* Shock mounting soft components to provide durability
* Changing fasteners to create better access
* Fuel management changes to improve efficiency
* Changing trigger pull thresholds so soldiers can better use their equipment.

These and many other beneficial improvements have been the large payoffs from small changes brought about from the JLF program.

JLF also tests foreign vehicles or munitions, to determine the effectiveness of non-U.S. munitions and systems and to discover the pros and cons of a system's attributes that make it survivable. An example of this concept might be the M1 tank series, which has completed its live fire test, but, if a new threat develops, JLF will test that threat against the M1.

LFT is mandated for those systems which are considered major systems based on the individual unit cost, or the aggregated cost of the production run (as in the case of munitions).

Live Fire Testing (LFT). Live fire test and evaluation, as defined in Title 10, U.S. Code, Section 2366, "Major systems and munitions programs: survivability testing and lethality testing required before full-scale production" must be conducted on:
Acquisition Category I and II programs for:

A covered major system (a vehicle, weapons platform, or conventional weapons system designed to provide some degree of protection to the user in combat),
A major munitions or missile, or
A product improvement program of any acquisition category that will significantly affect the survivability of a covered major system or the lethality of a munitions or missile produced under a major munitions program or missile program.

The objective of LFT is to provide a timely and thorough assessment of the survivability/lethality of a system as it progresses through its development but before full-scale production. That assessment should include LFT complemented by modeling/simulation efforts in the evaluation process. The survivability and lethality characteristics of a system or munitions can be evaluated as a result of LFT. Additionally, LFT provides insights into principal damage mechanisms occurring as a result of the munitions/target interaction and techniques for reducing personnel casualties, increasing system survivability, and/or enhancing system lethality.

In contrast to routine DT, LFT involves four elements: preparation of a LFT strategy as a distinct part of the TEMP (Part III, Live Fire Testing); a DTP; on-site oversight by OSD; and the preparation of an independent OSD LFT report for submission to the Secretary of Defense and Congress.

**Joint T&E Programs**

Deputy Director Developmental Test and Evaluation manages the JT&E program and develops the means to ensure that productive joint testing and evaluation is accomplished. The policies and details for administration of the program are set forth in DoD 5000.3-M-4, the Joint Test and Evaluation Procedures Manual. The JT&E Procedures Manual also provides a description of the program, OSD and Service responsibilities relative to the program, and defines the JT&E nomination and selection process. Key to the program management structure is its reliance on established T&E practices to assess the interaction of Service specific systems operating in a joint environment. Management of the JT&E program minimizes Service biases. While JT&E activities are conducted in accordance with established T&E procedures, consistency is maintained with the assigned mission of each participating Service. JT&E activities are supported by personnel and resources from the designated participating Services.

The JT&E Program is composed of three separate but closely related activities:

1) The nomination, coordination, and consideration of the nomination for inclusion in the JT&E Program.

2) A Joint Feasibility Study (JFS) to determine the need and feasibility of approved nominations.

3) Execution of the approved nominations that show potential for significant improvements in joint capabilities.

JT&E Programs are sequentially accomplished with reviews conducted at designated milestones to assure that OSD and Service resources are available and wisely expended. These activities are designed to be expanded in both scope and detail as information and expertise are developed, thus increasing confidence in program decisions at designated milestones.

Nominations for inclusion in the JT&E Program can be submitted from the Services, Commanders-in-Chief (CINC), the Joint Staff, and OSD agencies. The nominations will be reviewed by a Joint Test and Evaluation Planning Committee (JT&E PC) and the Senior

Advisory Council (SAC). DoD 5000.3-M-4 outlines the duties and responsibilities of the JT&E PC and SAC. SAC, which consists of senior officers from OSD and the Services, develops recommendations on which candidate should be approved for inclusion in the JT&E Program, what the priority of recommended nominations should be, and whether a nomination should proceed to a JFS or directly to a JT&E for planning and execution. Based on the SAC recommendations and the availability of funds, the DS&TS may approve the nomination for execution, direct a JFS, charter a JT&E without the benefit of a JFS, or disapprove the nomination.

Under the oversight of OSD, the lead Service conducts a JFS to expand and refine an approved nomination, assess the need and feasibility of executing a JT&E, develop an Analysis Plan for Assessment (APA) and resource/cost estimates for executing the JT&E, and prepare recommendations relative to a potential course of action. If a JT&E is chartered, a Joint Test Force (JTF) is established and organized to plan and execute the activities identified in the program test document (PTD), analyze the results, and evaluate the nomination concepts or issues. At the conclusion of the JT&E, reports are prepared to document JTF findings, conclusions, and recommendations. The approved reports are briefed and distributed to the Services, CINCs, and OSD agencies for inclusion in their acquisition programs and joint operations policies and procedures as appropriate.

Refer to the JT&E Nomination, Joint Feasibility Study, and JT&E handbooks for a thorough description of all procedures and processes related to the JT&E program

**Foreign Comparative Testing (FCT)**

FCT is a DoD test and evaluation program that is prescribed by Title 10, United States Code, Section 2350a(g), Side-by-Side Testing and that is centrally managed by the DS&TS. FCT provides funding for U.S. test and evaluation of selected equipment items and technologies developed by allied countries when such items and technologies are identified as having good potential to satisfy valid DoD requirements.

[i] DoD Instruction 5200.40, *DoD Information Technology Security Certification and Accreditation Process (DITSCAP)*, December 30, 1997