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THE DOD TEST AND EVALUATION PROCESS

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THE DOD TEST AND EVALUATION PROCESS

1. Introduction.

The *DoD Test and Evaluation (T&E) Process* is a five step iterative process that provides answers to critical T&E questions for decision makers. See Figure 1-1. It establishes a comprehensive approach to T&E that may be applied one or more times within each of the five phases of the DoD Acquisition Process shown in Figure 1-2. The process is structured so that it can be used at any time by any program.

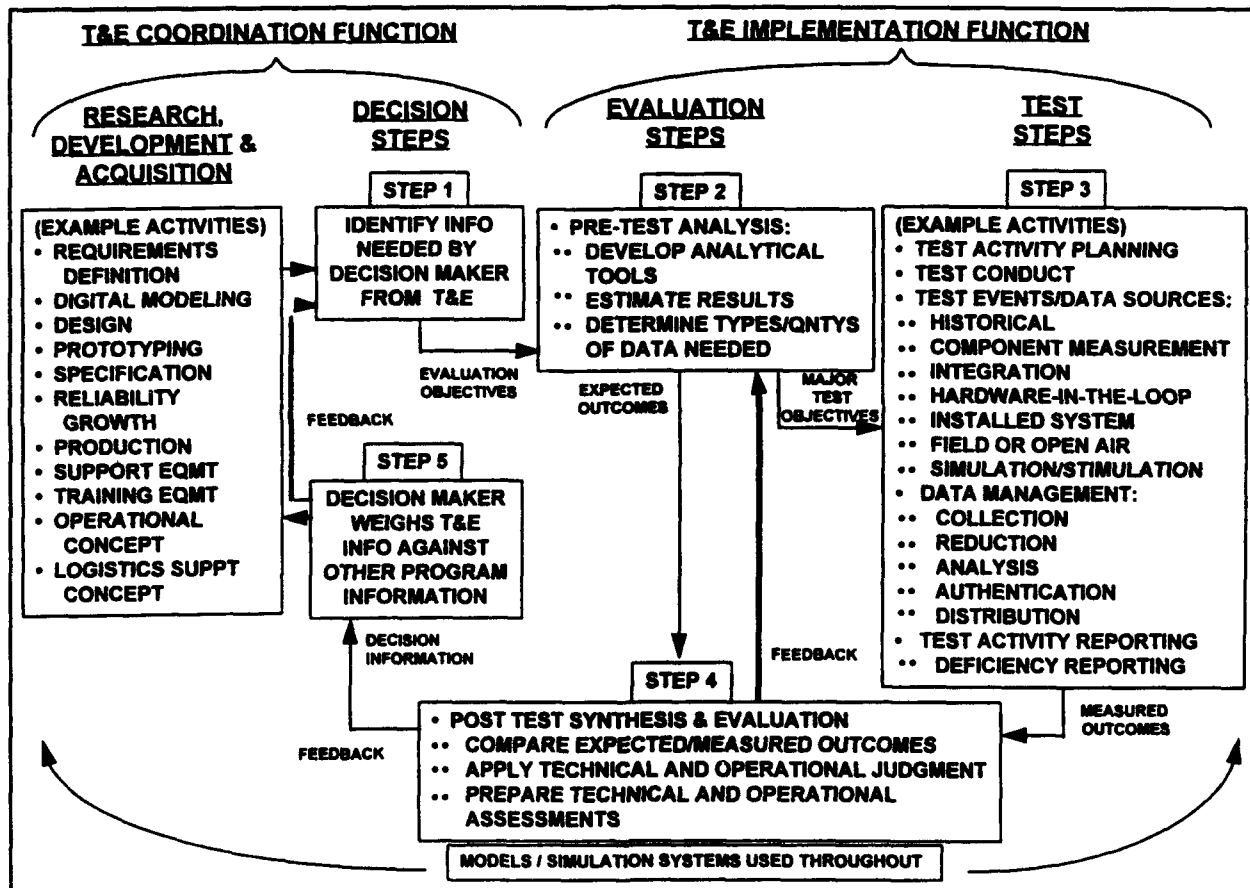


Figure 1-1. The Five Step T&E Process

The Milestone 0 decision marks the beginning of the acquisition process with its approval of the Mission Need Statement (MNS). The MNS defines projected needs in broad operational terms. The Milestone 0 decision also identifies the *alternative concepts* to be studied, approves the start of Phase 0 ³/₄ Concept Exploration and Definition, establishes Phase 0 exit criteria to be evaluated at Milestone 1, and activates the DoD T&E Process. Milestone decisions are

documented in the Acquisition Decision Memorandum (ADM) for acquisition category (ACAT) I programs.

During each phase and at each Milestone, the decision maker needs information from several sources to determine the best course of action. The information needed from T&E can be summarized as a series of

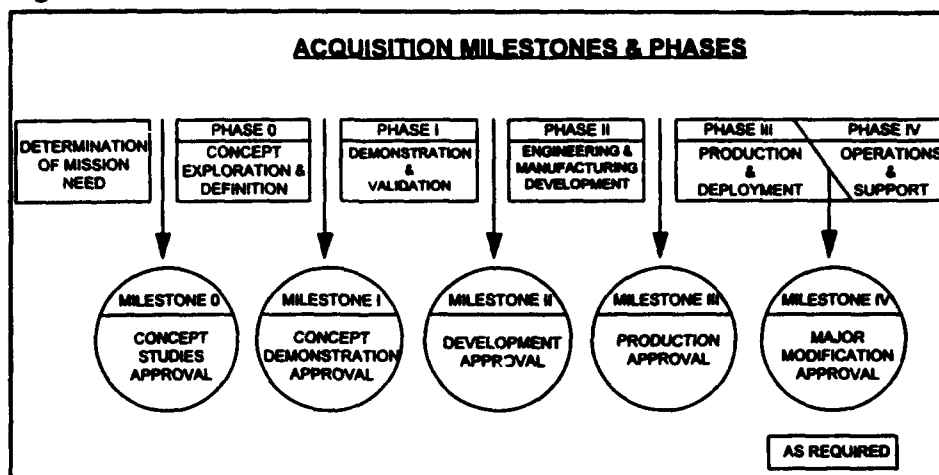


Figure 1-2. The DoD Acquisition Cycle

questions to be answered during each phase. The questions are the basis for the T&E process in that phase. The outcome of the T&E process is technical and operational assessments delivered to the decision maker as answers to those questions. The questions to be asked in each phase are shown below in paragraph 3, Application to the Acquisition Process.

2. DoD T&E Process.

2.1. T&E Coordination Function. The T&E process begins with the T&E Coordination Function, which has three parts: the Research, Development and Acquisition (RDA) Function and Steps One and Five of the Process.

2.1.1. Research, Development, and Acquisition (RDA) Function activities (Figure 2-1) are the basis for T&E activities in that the MNS and Operational Requirements Document (ORD) identify the requirements against which the system must be evaluated. Although requirements generation and maintenance are not part of the T&E process, the T&E community should be involved to ensure that identified requirements are testable, measurable and can be evaluated. Other RDA activities that affect T&E range from specification identification through design, development and production to training and support needs. The degree to which each of these has been demonstrated must be considered by the decision maker. Answers with regard to the achievement of system performance objectives come from T&E. Answers to other questions, such as urgency, military effectiveness, costs and schedules, come from other sources such as Intelligence, Program Analysis and Evaluation (PA&E), Legal, or Comptroller.

At Milestone 0 the user presents the MNS to the Defense Acquisition Board (DAB). If the MNS receives favorable consideration, the DAB authorizes entry into Phase 0, Concept Exploration and Definition, from which are formulated the operational suitability and effectiveness parameters and critical technical parameters (CTPs) against which the system will be tested and evaluated. The objectives of Phase 0 are to explore various materiel alternatives to satisfy the documented mission need, define the most promising system concept, develop risk analyses, and develop a proposed acquisition strategy and initial program objective for cost, schedule and performance for the most promising system concept(s). A Cost and Operational Effectiveness Analysis (COEA) and ORD are prepared.

As the acquisition process proceeds, the concepts to be studied in Phase 0 are defined and the engineering and production prototypes to be evaluated in Phases I and II are built. In Phases III and IV, the system, and its modifications if appropriate, must continue to be evaluated.

RESEARCH, DEVELOPMENT & ACQUISITION

(EXAMPLE ACTIVITIES)

- **REQUIREMENTS
DEFINITION**
- **DIGITAL MODELING**
- **DESIGN**
- **PROTOTYPING**
- **SPECIFICATION**
- **RELIABILITY
GROWTH**
- **PRODUCTION**
- **SUPPORT EQMT**
- **TRAINING EQMT**
- **OPERATIONAL
CONCEPT**
- **LOGISTICS SUPPT
CONCEPT**

**Figure 2-1. Example RDA
Activities**

The RDA activities list in Figure 2-1 includes the following examples:

2.1.1.1. Requirements Definition. System requirements evolve from the Mission Needs Statement (MNS) through the COEA and ORD to the Acquisition Program Baseline (APB) and Test and Evaluation Master Plan (TEMP). Requirements must be clear, complete, consistent, feasible, and evaluateable. They are derived from military needs and stated as technical and/or operational suitability and effectiveness parameters. They must be neither wholly qualitative, which allows uncontrolled personal opinion to enter the process, nor wholly quantitative, forcing "failure" of a system that is "good enough" but not perfect.

Operational requirements are a basis for Critical Technical Parameters (CTPs), used by the developmental T&E (DT&E) program as the basis for its tests. Operational requirements are also a basis for Measures of Effectiveness (MOEs) [e.g., missile miss distances, kill probabilities, detection and tracking ranges] used by the operational T&E (OT&E) agency as the basis for its determination of operational effectiveness and suitability. Measures of Performance (MOPs), derived

from MOEs, may also be used to support the determination of operational effectiveness and suitability. MOEs and MOPs form the basis for the operational evaluation which, in turn, shapes the operational tests.

2.1.1.2. Digital Modeling. Digital models, implemented on computers, are growing in importance, use, and credibility. Digital models used in RDA activities may be similar or identical to those used in the T&E Implementation Function, and in fact may be first created during Concept Exploration and Definition and updated and used as the system proceeds through development and T&E. Models are used during the RDA activity to evaluate concept feasibility and to attempt to define the technical limits of system performance. These models may be simple thought processes or "back of the envelope" estimates, or they may be sophisticated simulations of system performance. But the causal relationship between military effectiveness and system performance must always be developed, validated and documented.

2.1.1.3. Design. System design is the first step in creating the system. It is the process of converting specifications into a visual or mathematical representation of the system. It is perhaps the most critical step in the RDA function because, once built, the system is much more difficult to modify to correct deficiencies built into the original design. Once approved, the design is converted into a prototype. Testing is conducted to assess whether system design meets the requirements.

2.1.1.4. Prototyping. Joint Publication 1-02 states that a prototype is a model suitable for evaluation of design, performance, and production potential. For the purpose of the T&E process, prototypes will be classified as engineering and production.

2.1.1.4.1. Engineering Prototype (EP). A development model of a unit that is close to production. This may apply to circuitry, a device, or a system, and may be in a breadboard (technical) configuration. EPs are normally used in Phase I.

2.1.1.4.2. Production Prototypes (PP). A final model of a design before the pilot unit is approved for production. It should be highly representative of final equipment, except that the exact manufacturing assembly process and production design changes may not yet be used or incorporated. It is suitable for complete evaluation of its electrical and/or mechanical form and may be in a brassboard (technical and operational) configuration. PPs are normally used in Phase II.

2.1.1.5. Specifications are the values that convert requirements into design terms. They must clearly and accurately relate back to the technical

requirements of the system. An audit trail from the requirements documents to the specifications ensures that the system, when built to spec, will perform as intended.

2.1.1.6. Reliability Growth is a process in which the reliability of the operational system improves through identification and correction of systemic reliability failures. During Engineering & Manufacturing Development (EMD), laboratory tests on prototypes are performed to uncover component reliability failures, make design improvements, and project a reliability point estimate. Later, the system is deployed and field data are collected. The validity of the process lies in the activities associated with operational failures. If the user is aggressive in reporting, cataloging and investigating reliability failures, and commits the time and resources to their correction, reliability will, in all likelihood, improve. If these steps are not taken, reliability cannot improve and will probably decrease as the system is subjected to more maintenance than was originally intended.

2.1.1.7. Production is the manufacturing of the system after it has been funded, found to be producible, and deemed operationally suitable and effective. The capability and integrity of the manufacturing process will be evaluated compared to the system design requirements and measured through inspections and testing.

2.1.1.8. Support Equipment is that category of ancillary "things" necessary to sustain the system or, during T&E, to support, monitor and record the test. Support equipment includes common hand and power tools, cameras, vehicles, and a myriad of other items without which the system could not operate properly. Support equipment requirements for T&E must be identified early in the T&E process to ensure availability when needed and must be identified in Part V of the TEMP.

2.1.1.9. Training Equipment. Since most new or highly modified systems are somewhat unique, the personnel who will use and maintain the system must be retrained to use it properly and safely. Training equipment includes those items that either permit that training or are used during training to instruct the operators and maintainers in the correct way to operate and maintain the system.

2.1.1.10. Operational Concept. The operational concept, as defined in the ORD, is the planned methodology by which the system will be used and supported. The ORD provides performance parameters in terms of operational suitability and effectiveness criteria thresholds and objectives. Understanding the operational concept is critical for both DT&E and OT&E personnel.

2.1.1.11. Logistics Support Concept is the plan by which the system will be maintained. It includes spares, transportation, maintenance and

support personnel requirements. Developing integrated logistics support requirements consistent with readiness objectives, design and resources should be considered early in the acquisition process.

2.1.2. STEP ONE is the *identification of T&E information required by the Milestone decision maker*. See Figure 2-2. The required information consists of performance and effectiveness evaluations of how well the system meets the user's needs. This information progresses from answers concerning proposed alternative concepts

in Phase 0 to answers on system technical performance and operational suitability and effectiveness during Phase II and beyond. The required information usually centers on the current system under test (SUT) which will be in the form of concepts, prototypes, both engineering and production, and/or the system itself, depending on the acquisition phase.

Step One of the process is initiated by the preceding

Milestone decision of the Acquisition Process. Areas in which questions can be expected from the Milestone decision maker in each phase are: the relevance of historical data, accuracy of stated requirements, adequacy of T&E infrastructure and technology base, testing alternatives, system performance versus validated threats, projected impact of the system on battle outcomes, capabilities, limitations, feasibility, preferred system, and T&E exit criteria. Association of each question with an acquisition Phase is discussed later in the application of the Process to the acquisition Process. The principal outcome of this Step is the determination of evaluation objectives.

2.1.3. STEP FIVE is where the *decision maker weighs the T&E information against other programmatic information* to decide a proper course of action. See Figure 2-3. The decision will be based on criteria of military worth, as well as

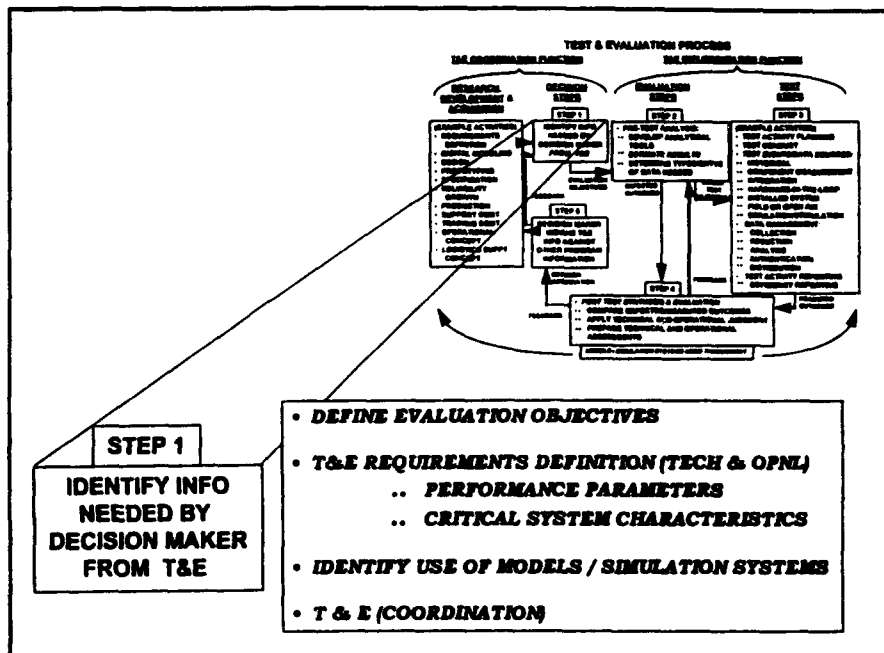


Figure 2-2. Step One: Identification of Information Needed by the Decision Maker

consideration of cost, funding, urgency, etc. When associated with an acquisition milestone, this decision is announced in an ADM which outlines the future course of action for the program and the SUT. Additionally, each milestone decision will contain the "exit criteria" for the next Phase/Milestone.

2.1.4. Feedback. It is possible that the decision maker asked the wrong questions or that the questions were misunderstood by the T&E community. The decision maker should compare the information contained in the assessments with the questions previously asked to ensure that the responses are adequate. Problems should be highlighted and resolved. The decision maker can then rephrase succeeding questions to ensure better understanding of the information needed.

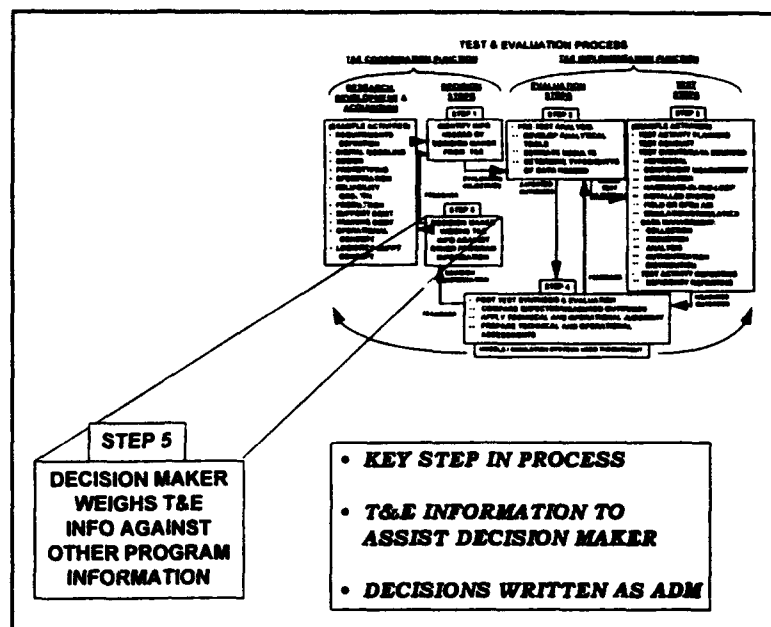


Figure 2-3. Step Five: The Decision Maker Weighs T&E Information Against Other Program Information

2.2. T&E Implementation Function. The test and evaluation implementation function encompasses the three steps necessary to develop the information needed to prepare the assessments used by the decision maker in Step Five.

2.2.1. STEP TWO is the **pre-test analysis** of the evaluation objectives from Step One to determine the types and quantities of data needed, the results expected or anticipated from the tests, and the analytical tools needed to conduct the tests and evaluations. See Figure 2-4.

2.2.1.1. Pre-test analysis develops the analytical tools, allocates test parameters to requirements, estimates test results, determines the types and quantities of data needed, and identifies the major test objectives.

2.2.1.2. The use of validated models and simulation systems during pre-test analysis can aid in determining: how to design test scenario(s), how to set-up the test environment, how to properly instrument the test, how to man and control the test resources, how best to sequence the test trials, and how to estimate outcomes. In this step, models and simulations are used to estimate test results.

2.2.1.3.

The outcome of this step is the *expected outcome* of the system under test. When a determination is made that additional data are necessary and major test objectives are identified, the process moves to Step Three.

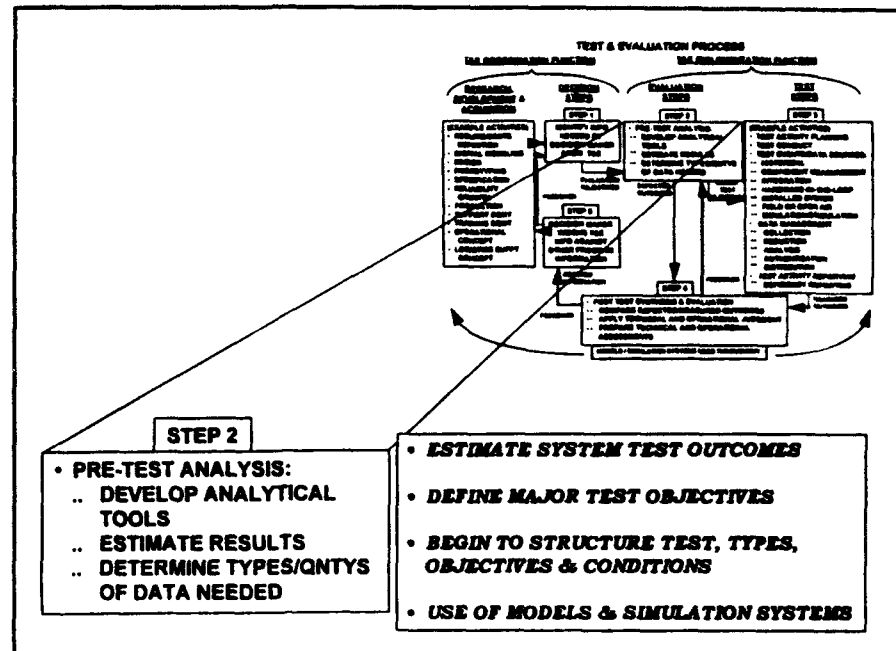


Figure 2-4. Step Two: Pre-Test Analysis

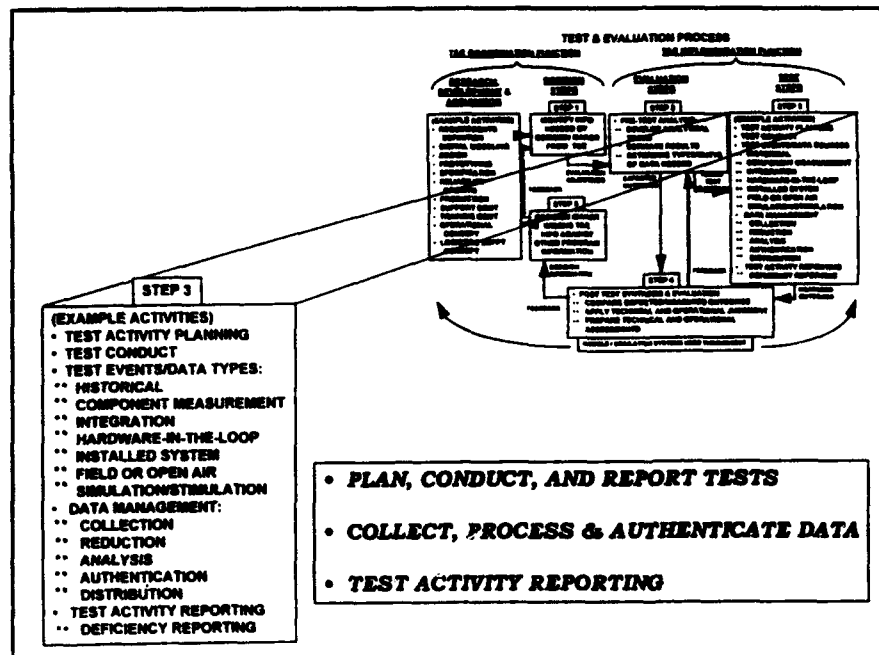


Figure 2-5. Step Three: Test Activity and Data Management

necessary to develop the data. The historical and developed data are reviewed for completeness and accuracy, authenticated, and forwarded to Step Four for assessment as measured outcomes.

2.2.2. STEP THREE, test activity and data management, shown in Figure 2-5, is the actual test activity planning, test conduct and data management. Given the data requirements from Step Two, T&E managers determine what valid data exist in historical files that can be applied to the SUT and what new data must be developed from test events. They plan and execute the tests

2.2.2.1. Test activity planning includes gathering the required test articles and test support equipment, scheduling facilities and identifying the climatic, mission and threat environments.

2.2.2.2. Test conduct is the culmination of test activity planning and with the exception of historical data, is the execution of the actual test events. As shown in Figure 2-5., test activities range from historical searches of the performance of like or similar components, subsystems and systems to actual hardware tests of component incoming parts through multi-system, open-air, operationally realistic "free-play" scenarios. Data gathered during the test, or from historical searches, are input to the data management activity for processing.

2.2.2.2.1. Historical Test Data. The initial step in any test activity should be the examination of previous test data stored in historical archives. Component, subsystem and system data from like or similar components, subsystems or systems must be examined first for applicability, and, if applicable, to reduce the amount and/or type of hardware/software testing necessary for evaluation. Further, modeling and simulation of historical test data, in lieu of actual testing of the current SUT, should be performed to fill historical information voids. This is a highly cost effective procedure that leads to the determination of what data are lacking and therefore needed from new test and evaluation events.

2.2.2.2.2. Component Measurement Test Events often involve the use of specialized capabilities to explore and evaluate advanced technologies and are usually the first test events performed during the development and/or buildup of the system. Examples include incoming parts inspection, thermal, acoustic and vibration cycling, power requirement and heat generation tests.

2.2.2.2.3. Integration Test Events test components, subsystems and systems combined with other elements. The other elements may be other parts of the same system or other systems with which the SUT must operate. These tests are frequently conducted in integration laboratories specifically designed to test the SUT integrated with other systems or functions. Integration laboratories are generally weapon system specific and are used from the beginning of a system's development through integration and fielding. These tests employ a variety of models, simulations, and stimulations to generate scenarios and background at or near real time.

2.2.2.2.4. Hardware-in-the-loop (HITL) Events use elements of the SUT in combination with software to examine the performance of those elements before the entire system is available or when a specific capability cannot be tested. HITL events, such as breadboard, brassboard, or prototype tests permit system/subsystem evaluation during various stages of development.

2.2.2.2.5. Installed Systems Events provide capabilities to evaluate SUTs that are installed on and integrated with their host platforms. These tests can occur in indoor facilities such as electronic warfare (EW) or climatic chambers or as outdoor DT and OT tests. Chambers provide a secure site to evaluate the capabilities and limitations of the system against simulated and stimulated inputs. Climatic chambers examine SUT capabilities in varied temperature and humidity conditions without having to transport the SUT to those naturally occurring climates.

2.2.2.2.6. Field or Open-air Test Events refers to any test conducted in an open environment. It includes surface (land and sea), undersea, airborne and spaceborne testing. Field tests are conducted where it is feasible, safe and secure to test all or part of the SUT in an environment that is normally more realistic than any attainable indoors. Field tests may allow the SUT to be operated more closely to its operational conditions. However, particularly with EW systems, field tests may provide less insight into the performance of a system because indoor facilities are the only place high density, high fidelity threat signals can be generated in a secure environment.

2.2.2.2.7. Simulation/Stimulation Events are used extensively in the DoD test process. They can be applied to computer or physical working models or the SUT. They may be real time or non-real time models. Effective use of credible models and their simulation/stimulation events will provide cost effective T&E.

2.2.2.3. Data management. Data recorded during test events are often not in a form best suited for analysis. Several steps are taken to make the data more usable:

2.2.2.3.1. Data Collection and Reduction. Most data are recorded "raw", scaled to match the recording capabilities of the analog or digital recording system without regard to the actual magnitude of the data. This first step in the data management process is bringing data from all sources together and reducing them to engineering values.

2.2.2.3.2. Analysis and authentication ensures that all data accurately reflect the operation of the SUT. Data from multiple sources are compared for agreement, data dropouts are filled in where possible and questionable data are compared with other sources for reasonableness.

2.2.2.3.3. The data are then *distributed* for further use in the synthesis and evaluation step.

2.2.2.4. Deficiency Reporting is the process of formally documenting failures to meet required performance thresholds or objectives, human factors

2.2.2.5. The end product of this step is *measured outcomes in the form of test and evaluation activity reports which are provided to the analysts for Step Four.*

TEST & EVALUATION PROCESS

THE INFORMATION FUNCTION **THE REPRESENTATION FUNCTION**

TECHNICAL REQUIREMENTS & ACQUISITION

EVALUATION STEPS

TEST STEPS

STEP 1

STEP 2

STEP 3

STEP 4

STEP 5

STEP 6

STEP 7

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Figure 2-6. Step Four: Post-Test Synthesis and Evaluation

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effect of the limitations must be evaluated, if possible, and judgement used to estimate true system performance. However, since this may involve extrapolation of test data, it is inherently risky. Despite the additional cost and time, retesting is usually prudent.

In this step, models and simulations are normally used to process test data and to evaluate system performance and effectiveness using data obtained from the tests. The assumptions of tactics, environment, system performance and support must be carefully chosen and fully described and documented.

2.2.4 Feed- back. As with the decision maker, feedback is necessary within the T&E process to ensure the quality of the output. But unlike the decision maker, who needs to know whether the questions have been answered satisfactorily, here the evaluators must ensure that the data are sufficient to answer the questions posed by (or as understood from) the decision maker. Their satisfaction with the test report data must be transmitted as feedback to the persons responsible for the pre-test analysis to ensure that both the current test and the process itself continue to be as complete, effective and efficient as possible.

This step concludes with the preparation of technical and operational assessments that answer the decision maker's questions at Step One.

2.2.5. The T&E process concludes at Step Five, as noted above, where the decision maker weighs the T&E information against other program information and assesses the progress of the SUT.

3. Application to the Acquisition Process.

The DoD T&E Process can be applied to the five phases of the Acquisition Process shown in Figure 1-2. Its application and execution are based on addressing specific questions in each phase.

3.1. Milestone 0-Concept Studies Approval. The Milestone (MS) 0 decision designates *alternative concepts* for study. T&E concerns at MS 0 are data that can be developed during Phase 0 that support a MS 1 decision with respect to the concepts and the development of recommended T&E "exit criteria" for the Milestone 1 ADM.

3.2. Phase 0-Concept Exploration and Definition. This phase will explore and define each concept. Both technical and operational assessments will be prepared. As a minimum, T&E will address the questions in Figure 3-1 for each concept or concept comparison.

Phase 0-Concept Exploration & Definition

For each concept,

- (1) What T&E data exist? Does analysis conclude that the concept(s) will work? What is the confidence level in this assessment?
- (2) Can requirements, as stated, be evaluated?
- (3) Does the existing T&E infrastructure/technology base permit evaluation? Approximately what is the cost and time frame? If not, approximately what is the cost and time frame to create the infrastructure/technology base?
- (4) What are concept(s) capabilities/limitations versus threats?
- (5) How can T&E favorably impact risk management or risk reduction?
- (6) What alternatives exist to testing/test assets? What are the risks?
- (7) Has the preliminary TEMP been approved? Are the critical technical parameters, the minimum acceptable operational requirements, and the critical system characteristics included?
- (8) Is each proposed concept feasible? Is one concept preferred?
- (9) What are the recommended Phase I T&E "exit criteria"?
- (10) Does the Early Operational Assessment (EOA) address the availability of and planning for resources projected for OT&E test events.

Figure 3-1. Phase 0 T&E Questions

3.3. Milestone I-Concept Demonstration Approval. The MS I decision, rendered in an ADM, selects the preferred concept(s) to continue development. This concept(s) will evolve into EPs for continued T&E. The T&E outcome will be the assessment of each EP.

3.4. Phase I-Demonstration and Validation. This phase will examine each EP. It will result in both technical and early operational assessments. As a minimum, T&E will address the questions in Figure 3-2 for each EP. These questions are basically identical to the Phase 0 questions. However, because the program is more advanced, more data at higher confidence will exist

Phase I-Demonstration & Validation

For each engineering prototype (EP),

- (1) Existing data analysis - will the EP(s) work? What is the confidence level in this assessment?
- (2) Can the requirements, as stated, be evaluated?
- (3) Does the existing T&E infrastructure/technology base permit evaluation? Approximately what is the cost and time frame? If not, approximately what is the cost and time frame to create the infrastructure/technology base?
- (4) What are the capabilities/limitations of each EP versus threats?
- (5) How can T&E favorably impact risk management or risk reduction?
- (6) What alternatives exist to testing/test assets? What are the risks?
- (7) Has TEMP been approved? The TEMP must contain the performance parameters reflected in the ORD, COEA, and APB. They must be consistent.
- (8) Is each proposed EP feasible? Is one preferred?
- (9) What are the recommended Phase II T&E "exit criteria"?
- (10) What are the recommended criteria for certification of readiness for final OT&E?
- (11) Does the EOA address the early projection of potential operational effectiveness and suitability criteria?

Figure 3-2. Phase I T&E Questions

3.5. Milestone II-Developmental Approval. The MS II decision will determine the continued progress of the selected prototype(s) for continued development as *production prototypes (PPs)*. The T&E outcome will be the assessment of each selected prototype.

3.6. Phase II-Engineering and Manufacturing Development. This phase will examine each PP, executing Steps Two, Three, and Four of the T&E process. It will result in both technical and operational assessments. As a minimum, T&E will address the issues in Figure 3-3 for each PP or for comparison.

Phase II-Engineering & Manufacturing Development

For each production prototype (PP),

- (1) For DT&E, what are the capabilities and limitations of each PP being developed? What is the confidence level in this data/assessment?
- (2) For OT&E, are the PPs suitable and effective in satisfying the mission need? What is the confidence level of this assessment?
- (3) Have key performance objectives/thresholds been validated versus advanced threats?
- (4) Are the PPs feasible? Do they satisfy the need? Is one preferred?
- (5) Have requirements changes been incorporated into the APB, ORD and contract specifications?
- (6) Have specification changes been reflected back to requirements and incorporated into the APB and ORD?
- (7) Does the TEMP reflect the changes in (5) and (6)? Has it been approved?
- (8) Should there be a Milestone IV, what are the recommended Phase III T&E "exit criteria"?

Figure 3-3. Phase II T&E Questions

3.7. Milestone III-Production Approval. The MS III decision will determine whether to enter production and deploy one or more of the systems under development.

3.8. Phase III-Production and Deployment. This phase will examine each selected system executing Steps Two, Three, and Four of the T&E process. It will result in Phase III technical and operational assessments. As a minimum, T&E will address the issues in Figure 3-4.

**Phase III-Production & Deployment
and
Phase IV-Operations & Support**

For the selected system.

- (1) For DT&E, what are the deployed system's demonstrated capabilities and limitations? What are the capabilities and limitations of modifications and upgrades?
- (2) For OT&E, does the system continue to be operationally suitable and effective in operational use? Do proposed modifications and upgrades increase the suitability and effectiveness of the system?
- (3) Have performance objectives/thresholds versus advanced threats been validated? Does the system meet these performance objectives/thresholds?
- (4) Is the TEMP current?
- (5) Should a Milestone IV be directed after Milestone III, what are the Phase III T&E "exit criteria?"

Figure 3-4. Phase III and Phase IV T&E Questions

3.9. Milestone IV-Major Modification Approval. The MS IV decision will determine if the major modification of the system is warranted. If so, the DoD Acquisition Phase to reenter will be designated in the ADM.

3.10. Phase IV-Operations and Support. This phase will identify if the fielded system is meeting the users needs and if any shortcomings and deficiencies need to be corrected to improve performance. As a minimum T&E will address the questions in Figure 3-4.

4. Program Documentation.

Documentation requirements outlined in the DoD 5000 publications will remain unchanged except for the TEMP. The TEMP format will be updated to include the application of the Process.

5. Summary.

The DoD T&E process is applicable to any system acquired by the Department under the provisions of the DoD 5000 series documents. This process is defined in more detail for EW systems in - *A Description of the DoD Test and Evaluation Process for Electronic Warfare Systems*, June 13, 1994.

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13 ABSTRACT (Maximum 200 words)

In July 1993, the House Armed Services Committee (HASC) expressed concern over the development process for airborne electronic combat systems. The committee stated one reason for this concern was the "lack of a comprehensive, integrated, and clearly defined electronic combat test process" that all services would follow and thereby improve the acquisition system. In response, the DoD Director, Test and Evaluation (T&E) convened a task force that included representatives from OSD, JCS, and the Services. This T&E Process is an unofficial byproduct of that Task Force.

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