# CHAPTER 7

# VERIFICATION

## 7.1 GENERAL

The Verification process confirms that Design Synthesis has resulted in a physical architecture that satisfies the system requirements. Verification represents the intersection of systems engineering and test and evaluation.

### Verification Objectives

The objectives of the Verification process include using established criteria to conduct verification of the physical architecture (including software and interfaces) from the lowest level up to the total system to ensure that cost, schedule, and performance requirements are satisfied with acceptable levels of risk. Further objectives include generating data (to confirm that system, subsystem, and lower level items meet their specification requirements) and validating technologies that will be used in system design solutions. A method to verify each requirement must be established and recorded during requirements analysis and functional allocation activities. (If it can not be verified it can not be a legitimate requirement.) The verification list should have a direct relationship to the requirements allocation sheet and be continually updated to correspond to it.

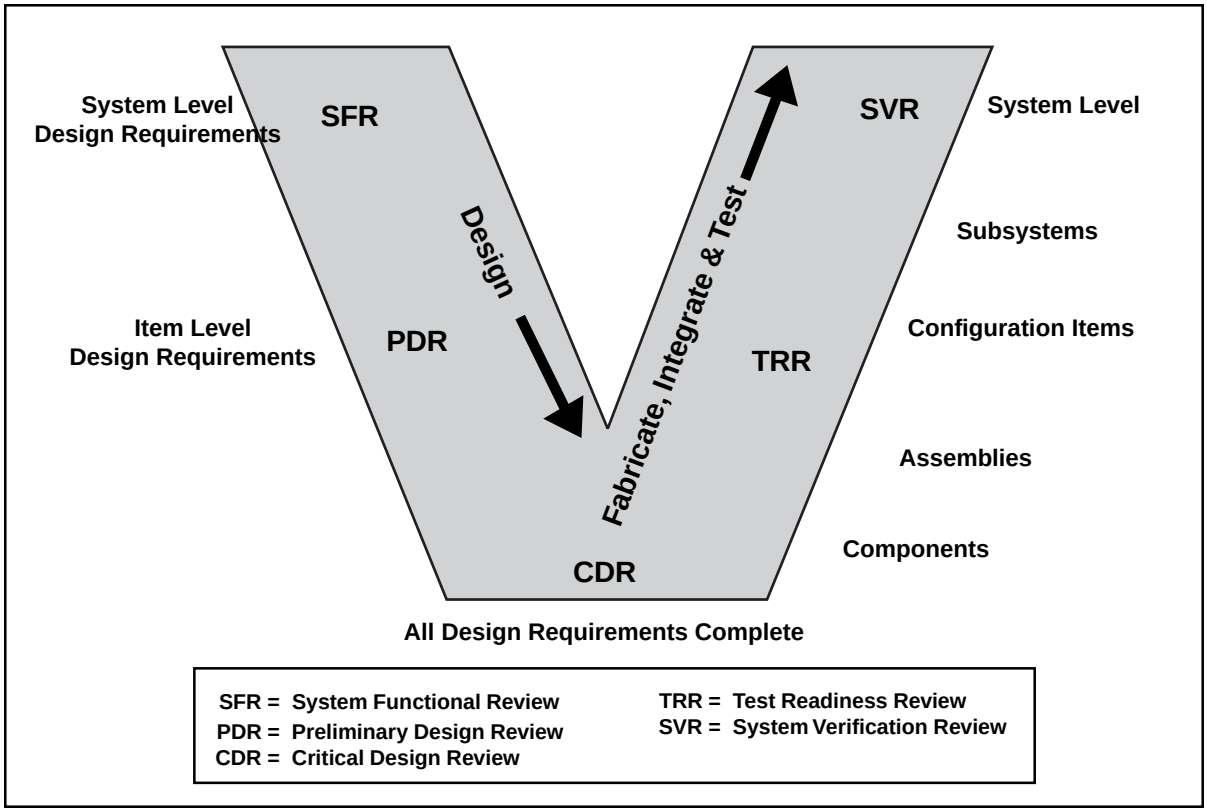


**Figure 7-1. Systems Engineering and Verification**

**Verification Activities**

System design solutions are verified by the following types of activities:

1. Analysis – the use of mathematical modeling and analytical techniques to predict the compliance of a design to its requirements based on calculated data or data derived from lower level component or subsystem testing. It is generally used when a physical prototype or product is not available or not cost effective. Analysis includes the use of both modeling and simulation which is covered in some detail in chapter 13,

2. Inspection – the visual examination of the system, component, or subsystem. It is generally used to verify physical design features or specific manufacturer identification,

3. Demonstration – the use of system, subsystem, or component operation to show that a requirement can be achieved by the system. It is generally used for a basic confirmation of performance capability and is differentiated from testing by the lack of detailed data gathering, or

4. Test – the use of system, subsystem, or component operation to obtain detailed data to verify performance or to provide sufficient information to verify performance through further analysis. Testing is the detailed quantifying method of verification, and as described later in this chapter, it is ultimately required in order to verify the system design.

Choice of verification methods must be considered an area of potential risk. Use of inappropriate methods can lead to inaccurate verification. Required defining characteristics, such as key performance parameters (KPPs) are verified by demonstration and/or test. Where total verification by test is not feasible, testing is used to verify key characteristics and assumptions used in design analysis or simulation. Validated models and simulation tools are included as analytical verification methods that complement other methods. The focus and nature of verification activities change as designs progress from concept to detailed designs to physical products.

During earlier design stages, verification focuses on proof of concept for system, subsystem and component levels. During later stages, as the product definition effort proceeds, the focus turns to verifying that the system meets the customer requirements. As shown by Figure 7-1, design is a top-down process while the Verification activity is a bottom-up process. Components will be fabricated and tested prior to the subsystems. Subsystems will be fabricated and tested prior to the completed system.

**Performance Verification**

Performance requirements must be objectively verifiable, i.e., the requirement must be measurable. Where appropriate, Technical Performance Measurements (TPM) and other management metrics are used to provide insight on progress toward meeting performance goals and requirements. IEEE Standard P1220 provides a structure for Verification activity. As shown in Figure 7-2 the structure is comprehensive and provides a good starting point for Verification planning.

## 7.2 DOD TEST AND EVALUATION

DoD Test and Evaluation (T&E) policies and procedures directly support the system engineering process of Verification. Testing is the means by which objective judgments are made regarding the extent to which the system meets, exceeds, or fails to meet stated objectives. The purpose of evaluation is to review, analyze, and assess data obtained from testing and other means to aid in making systematic decisions. The purpose of DoD T&E is to verify technical performance, operational effectiveness, operational suitability; and it provides essential information in support of decision making.

**Common Types of T&E in DoD**

T&E policy requires developmental tests. They confirm that technical requirements have been

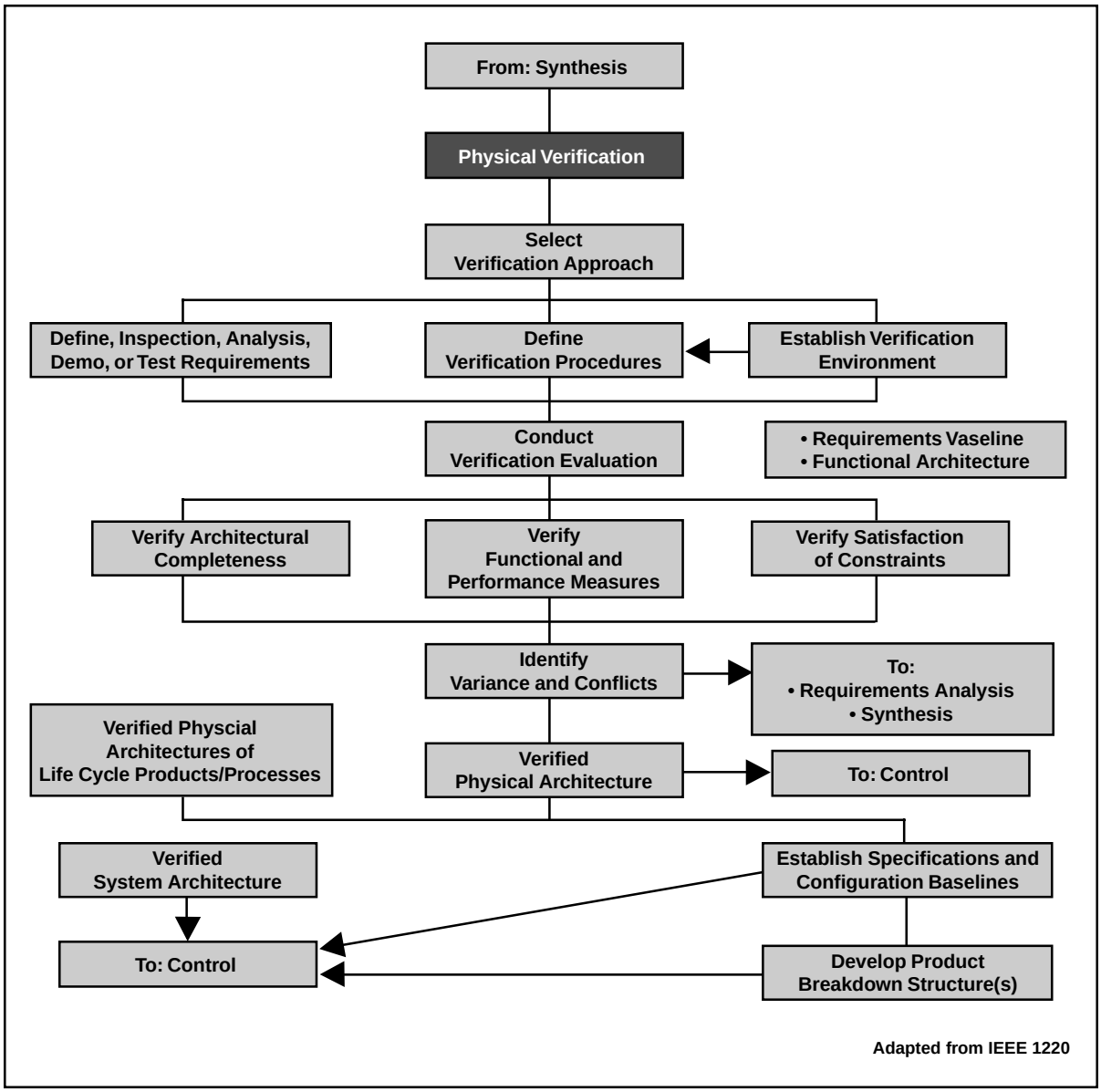


**Figure 7-2. Verification Tasks**

satisfied, and independent analysis and tests verify the system's operational effectiveness and suitability. DoD T&E traditionally and by directive is categorized as:

- Developmental T&E which focuses primarily on technical achievement,

- Operational T&E which focuses on operational effectiveness and suitability and includes Early Operational Assessments (EOA), Operational Assessment (OA), Initial Operational Test and Evaluation (IOT&E), and Follow-On Operational Test and Evaluation (FOT&E), and

- Live Fire T&E which provides assessment of the vulnerability and lethality of a system by subjecting it to real conditions comparable to the required mission.

**T&E**

The program office plans and manages the test effort to ensure testing is timely, efficient,

comprehensive and complete—and that test results are converted into system improvements. Test planning will determine the effectiveness of the verification process. Like all systems engineering planning activities, careful attention to test planning can reduce program risk. The key test planning document is the Test and Evaluation Master Plan (TEMP). This document lays out the objectives, schedule, and resources reflecting program office and operational test organization planning decisions. To ensure integration of this effort, the program office organizes a Test Planning Work Group (TPWG) or Test Working Level IPT (WIPT) to coordinate the test planning effort.

**Test Planning Work Group/Test WIPT**

The TPWG/Test WIPT is intended to facilitate the integration of test requirements and activities through close coordination between the members who represent the material developer, designer community, logistic community, user, operational tester, and other stakeholders in the system development. The team outlines test needs based on system requirements, directs test design, determines needed analyses for each test, identifies potential users of test results, and provides rapid dissemination of test and evaluation results.

**Test and Evaluation Master Plan (TEMP)**

The Test and Evaluation Master Plan is a mandatory document prepared by the program office. The operational test organization reviews it and provides the operational test planning for inclusion. The TEMP is then negotiated between the program office and operational test organization. After differences are resolved, it is approved at appropriate high levels in the stakeholder organizations. After approval it becomes binding on managers and designers (similar to the binding nature of the Operational Requirements Document (ORD)).

The TEMP is a valuable Verification tool that provides an excellent template for technology, system, and major subsystem-level Verification planning. The TEMP includes a reaffirmation of the user requirements, and to an extent, an interpretation of what those requirements mean in various operational scenarios. Part I of the required TEMP format is *System Introduction*, which provides the mission description, threat assessment, MOEs/MOSs, a system description, and an identification of critical technical parameters. Part II, *Integrated Test Program Summary*, provides an integrated test program schedule and a description of the overall test management process. Part III, *Developmental Test & Evaluation (DT&E) Outline*, lays out an overview of DT&E efforts and a description of future DT&E. Part IV, *Operational Test & Evaluation (OT&E) Outline*, is provided by the operational test organization and includes an OT&E overview, critical operational issues, future OT&E description, and LFT&E description. Part V, *Test & Evaluation Resource Summary*, identifies the necessary physical resources and activity responsibilities. This last part includes such items as test articles, test sites, test instrumentation, test support equipment, threat representation, test targets and other expendables, operational force test support, simulations, models, test-beds, special requirements, funding, and training.

**Key Performance Parameters**

Every system will have a set of KPPs that are the performance characteristics that *must* be achieved by the design solution. They flow from the operational requirements and the resulting derived MOEs. They can be identified by the user, the decision authority, or the operational tester. They are documented in the TEMP.

**Developmental Test and Evaluation**

The DT&E verifies that the design solution meets the system technical requirements and the system is prepared for successful OT&E. DT&E activities assess progress toward resolving critical operational issues, the validity of cost-performance tradeoff decisions, the mitigation of acquisition technical risk, and the achievement of system maturity.

DT&E efforts:

- Identify potential operational and technological capabilities and limitations of the alternative concepts and design options being pursued;

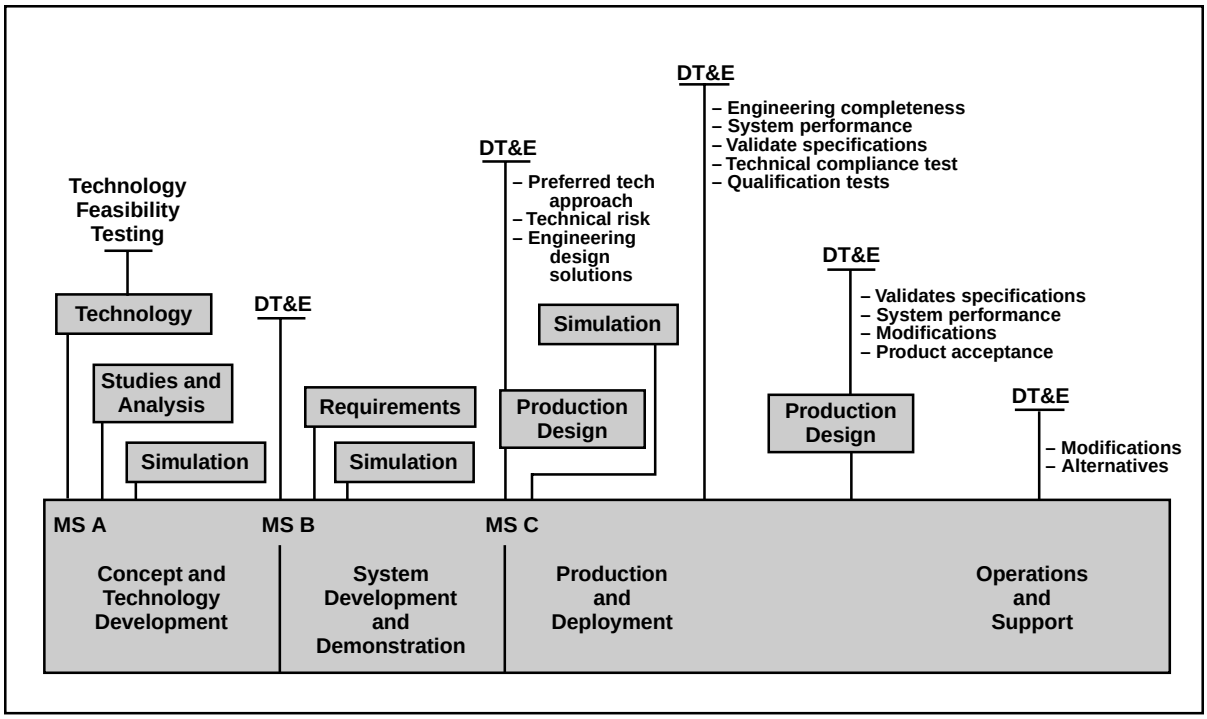


**Figure 7-3. DT&E During System Acquisition**

- Support the identification of cost-performance tradeoffs by providing analyses of the capabilities and limitations of alternatives;
- Support the identification and description of design technical risks;
- Assess progress toward resolving Critical Operational Issues, mitigating acquisition technical risk, achieving manufacturing process requirements and system maturity;
- Assess validity of assumptions and analysis conclusions; and
- Provide data and analysis to certify the system ready for OT&E, live-fire testing and other required certifications.

Figure 7-3 highlights some of the more significant DT&E focus areas and where they fit in the acquisition life cycle.

**Live Fire Test and Evaluation**

LFT&E is performed on any Acquisition Category (ACAT) I or II level weapon system that includes features designed to provide protection to the system or its users in combat. It is conducted on a production configured article to provide information concerning potential user casualties, vulnerabilities, and lethality. It provides data that can establish the system's susceptibility to attack and performance under realistic combat conditions.

**Operational Test and Evaluation**

OT&E programs are structured to determine the operational effectiveness and suitability of a system under realistic conditions, and to determine if the minimum acceptable operational performance requirements as specified in the ORD and reflected by the KPPs have been satisfied. OT&E uses threat-representative forces whenever possible, and employs typical users to operate and maintain the system or item under conditions simulating both combat stress and peacetime conditions. Operational tests will use production or production-

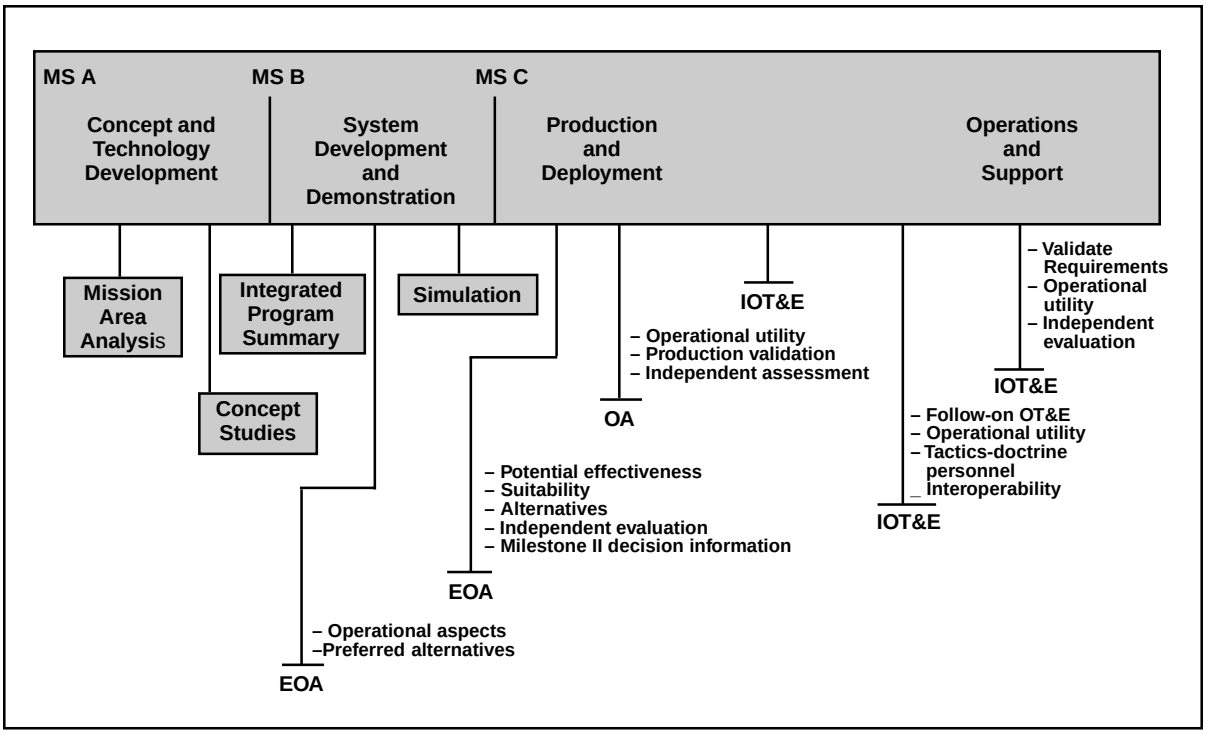


**Figure 7-4. OT&E During System Acquisition**

representative articles for the operational tests that support the full-rate production decision. Live Fire Tests are usually performed during the operational testing period. Figure 7-4 shows the major activities associated with operational testing and where they fit in the DoD acquisition life cycle.

### OT&E Differences

Though the overall objective of both DT&E and OT&E is to verify the effectiveness and suitability of the system, there are distinct differences in their specific objects and focus. DT&E primarily focuses on verifying system technical requirements, while OT&E focuses on verifying operational requirements. DT&E is a program office responsibility that is used to develop the design. OT&E is an independent evaluation of design maturity that is used to determine if the program should proceed to full-rate production. Figure 7-5 lists the major differences between the two.

## 7.3 SUMMARY POINTS

The Verification activities of the Systems Engineering Process are performed to verify that physical design meets the system requirements.

- DoD T&E policy supports the verification process through a sequence of Developmental, Operational, and Live-Fire tests, analyses, and assessments. The primary management tools for planning and implementing the T&E effort are the TEMP and the integrated planning team.

| Development Tests | Operational Tests |
|---|---|
| • Controlled by program manager<br>• One-on-one tests<br>• Controlled environment<br>• Contractor environment<br>• Trained, experienced operators<br>• Precise performance objectives and threshold measurements<br>• Test to specification<br>• Developmental, engineering, or production representative test article | • Controlled by independent agency<br>• Many-on-many tests<br>• Realistic/tactical environment with operational scenario<br>• No system contractor involvement<br>• User troops recently trained<br>• Performance measures of operational effectiveness and suitability<br>• Test to operational requirements<br>• Production representative test article |

**Figure 7-5. DT/OT Comparison**