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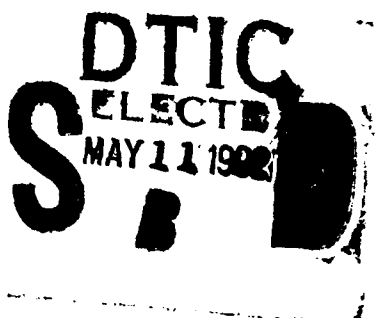


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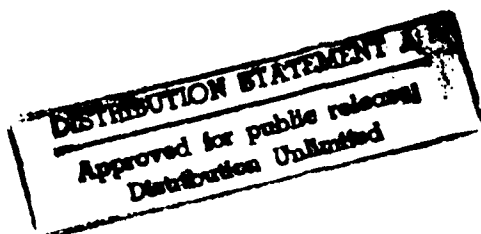
Better Assessment of Operational Suitability

Volume I: Final Report

TE101R1



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BETTER ASSESSMENT OF OPERATIONAL SUITABILITY

EXECUTIVE SUMMARY

Fielding operationally suitable weapon systems is a prime objective of Defense acquisition. An operationally suitable weapon system is one that is available for combat when needed, is reliable enough to accomplish the mission, operates satisfactorily with Service personnel and other systems, and does not impose an undue logistics burden in peacetime or wartime. Operational test and evaluation (OT&E) is required to evaluate the effectiveness and suitability of major systems before the full-rate production decision.

Our review of seven systems fielded over the past 6 years compared OT&E results with field experience. This review showed both strengths and weaknesses in the treatment of suitability. On balance, OT&E has been a reasonable predictor of suitability. However, several systems have not achieved their availability goals, and they consume significantly more logistics resources than anticipated. We believe that many of the major suitability problems could have been avoided through better suitability assessment. We present findings from the case studies, conclusions about the causes of the problems, and recommendations for improving suitability assessment.

SUITABILITY ASSESSMENT FINDINGS

To interpret the case studies, we investigated the three elements of a weapon system: the end item (or primary mission equipment), peculiar support (e.g., test program sets and training), and general logistics support (e.g., supply support).

OT&E found most major problems that relate to end-item suitability. For example, reliability problems were detected in environmental control equipment, propulsion equipment, avionics, and software. However, OT&E failed to identify

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some suitability problems associated with cumulative effects, such as corrosion and fatigue.

Peculiar support was only partially tested during OT&E. As a result, OT&E did not find problems that existed in a major fault diagnosis system and in some avionics support. When peculiar support was thoroughly tested, problems were found and corrected before fielding.

General logistics support was not tested and was seldom evaluated during OT&E. General logistics support elements were not included in operational tests of the case studies. In two cases, field suitability has been notably degraded by supply problems.

Three additional general findings are noteworthy. First, OT&E did not raise any false alarms. The problems cited by OT&E suitability evaluations were real problems. Second, OT&E reports focused on the items tested and the data from the tests. Little use was made of data from other sources, such as development testing or logistics support analysis, or modeling and analysis to augment the suitability test data. Third, corrective action programs can be used prior to fielding to correct suitability problems found in OT&E. Significant problems found in OT&E were corrected through dedicated programs that specified actions and those responsible for the actions.

CONCLUSIONS

Acquisition policy to ensure the suitability of fielded systems is in place. The shortcomings in OT&E could not be attributed to inadequate policy. The 5000 series of DoD instructions provides the direction and defines the products needed at each milestone. This policy recognizes the iterative nature of suitability testing, and that suitability assessment is the responsibility of the entire test and evaluation (T&E) community. Because suitability problems are reaching the field without being identified (even though the policy is adequate), it follows that policy implementation needs to be improved.

The crucial suitability issues are not adequately identified early in the T&E process. For the case studies, this was the primary reason why the suitability assessments of the fielded systems revealed problems not identified in OT&E. An issue may be crucial because of risks associated with

new technologies, operational concepts, or support concepts, or because it represents a major consumer of logistics resources. If the crucial suitability issues are not identified early and addressed in test plans, then operational tests will not reveal problems associated with them.

Inadequate treatment of peculiar support equipment is a serious shortcoming. Support equipment is frequently omitted from test plans and not adequately considered in operational suitability assessments. Both wartime performance and peacetime cost of a system can depend heavily on peculiar support equipment. Increasing use of electronics and two-level maintenance will exacerbate the issue.

RECOMMENDATIONS

To better put current suitability assessment policy into practice at the Office of the Secretary of Defense (OSD) level we recommend that:

- Increased attention and technical support be devoted to suitability assessment and testing at each phase of development to help find deficiencies as early as possible
- Increased use of corrective action programs be made in the most appropriate phase to correct deficiencies
- Results and data from all phases and technical disciplines be made available and used to better coordinate and integrate suitability test and evaluation throughout development
- Critical items of peculiar support equipment be identified, included in the test plans, and made available for testing.

We make specific suggestions on how these recommendations can be applied by OT&E action officers. These suggestions should be extended across the board to all OSD offices concerned with suitability assessment. Doing so will help ensure that suitability issues are considered and that proper actions are taken to get more suitable systems into the field. Judging from past experience, such an effort

is needed and will pay for itself many times over in improved availability and avoided logistics costs.

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CHAPTER 1. NATURE OF THE PROBLEM

Fielding operationally suitable systems is a prime objective of Defense acquisition. A suitable weapon system is one that is available for combat when needed, is reliable enough to accomplish the mission, operates satisfactorily with Service personnel and other systems, and does not impose an undue logistics burden in peacetime or wartime.¹ Concern about the Department's success in fielding suitable systems was expressed in an October 1990 memorandum from the DUSD(A).

The Director, Operational Test and Evaluation (DOT&E), is required by Title 10, Sec. 2399, United States Code (U.S.C.)² to report on the operational effectiveness and suitability of major systems before the full-rate production decision. His report is to be based on an evaluation of whether the test and evaluation (T&E) performed were adequate and whether the results confirm that the items or components actually tested are effective and suitable for combat. As a "final" check on suitability before production, DOT&E helps assure that systems will be suitable when fielded.

RESULTS OF CASE STUDIES

To determine whether systems were suitable when fielded and what differences exist between suitability as observed in operational test and evaluation (OT&E) and suitability as observed in the field, we examined seven cases. The case studies are listed in Table 1-1. They were chosen to represent each Service and each major conventional warfare area. In addition, each system had to have gone through OT&E relatively recently and yet have accumulated sufficient field experience for suitability judgments to be made. Since the cases were not intended to be a statistically significant or representative sample, no extrapolations should be made from them to determine the percentage of

¹The official definition of operational suitability is the degree to which a system can be placed satisfactorily in field use with consideration given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, documentation, and training requirements.

²The complete text of U.S. Code, Title 10, Section 2399 is in the Appendix.

unsuitable systems or the total cost of correcting unsuitable systems, or to derive any other statistic of that nature. The cases did, however, exhibit a range of outcomes, and they do illustrate certain problems and opportunities for improvements in the suitability assessment process.

TABLE 1-1
CASE STUDIES

| System | Service | Date of OT&E |
|-----------------------------------|-------------------|-----------------------|
| Mobile subscriber equipment (MSE) | Army | Aug. – Oct. 1988 |
| M939-A2 5-ton truck | Army | Aug. – Oct. 1988 |
| AH-64 Apache helicopter | Army | Jul. – Sep. 1986 |
| Landing craft air cushion (LCAC) | Navy | Feb. 1985 – Apr. 1987 |
| AV-8B Harrier | Navy/Marine Corps | Aug. 1984 – Mar. 1985 |
| LANTIRN NAV Pod | Air Force | Apr. – Nov. 1989 |
| F-16 C/D Block 40 | Air Force | May – Oct. 1989 |

Specific System Findings

The suitability of the systems when tested and when fielded varied widely across the seven case studies.

The mobile subscriber equipment (MSE) and the 5-ton truck both exhibited problems in OT&E that were corrected by aggressive corrective action programs, and both have since proven to be suitable in the field.

The AH-64, although rated as potentially suitable at the end of OT&E, has failed to meet its suitability goals. Its availability, as measured by fully mission capable rate, has been 50 to 65 percent as opposed to the goal of 70 percent. That means the downtime has been 17 to 67 percent more than anticipated. This is true even though more money than anticipated was spent for spare parts to compensate for reliability problems in major components such as the rotor blades and the shaft-driven compressor. The cost of these extra parts is conservatively estimated at \$200 million. In our judgment, these and other suitability problems could

have been detected and flagged in operational testing (OT) and/or development testing (DT).

The fielding of the Landing Craft Air Cushion (LCAC) was delayed as a result of reliability problems found during OT&E. Eventually, these problems were corrected and the system was judged potentially suitable. However, after fielding, it still experienced suitability problems in the areas of corrosion, training, and supply support that could and should have been identified. To illustrate the financial cost of not identifying such problems early, the life-cycle cost to correct LCAC corrosion problems that could have been avoided totals over \$170 million.

The AV-8B was judged potentially suitable. In peacetime, the AV-8B has not reached its mission-capable targets because of lower-than-planned levels of maintenance manning and spares support. When these resources were raised to the planned levels during Desert Storm, the aircraft was suitable.

The LANTIRN NAV Pod progressed from "not operationally suitable" in its first OT&E to "operationally suitable" in follow-on OT&E (FOT&E). Observed reliability growth has been slower than predicted, but the NAV pod reliability eventually exceeded its reliability goal. The engineering change process behind the improvement was an informal corrective action program. Field experience shows that the NAV pod is indeed suitable.

The F-16 C/D Block 40 met almost all of its suitability goals at OT&E, although it had several avionics reliability problems that have not yet been fully solved. The aircraft is suitable in the field, consistently exceeding its availability goal.

Volume II of this report contains the detailed case studies covering each of the seven systems just described.

General OT&E Findings

Three general findings are noteworthy. First, **OT&E did not raise any false alarms**. In the case studies, all of the problems noted in OT&E were real problems. If they were not resolved prior to fielding, they showed up after fielding

The second general finding from the cases studied is that **OT&E reports focused on what was tested and on data**

flowing from that test. The reports did not use data from other sources or (with rare exceptions) use modeling and analysis to assist in evaluation. (We speculate that this situation resulted in part from the congressional language and concerns reflected in Title 10, Sec. 2399, U.S.C. This language [see the Appendix] discourages the use of modeling in lieu of test and speaks of the suitability of the item tested, not the suitability of the complete system to be fielded. Its intent is to prevent suitability judgments from being made on promised rather than actual performance. However, it should not be extended, in our judgment, to preclude the use of all other sources of data or of modeling to augment test data and help evaluate the results. OT&E is specifically authorized by law to have access to such information.)

The third general finding is that **corrective action programs (CAPs) can be used successfully prior to fielding to correct suitability problems found in OT&E.** The MSE and the 5-ton truck are good examples. In the case of the MSE, significant problems were found in OT and were corrected in a short time through a dedicated program that laid out specific actions and those responsible for taking those actions. The improvements resulting from the program were tested in turn in subsequent FOT&E. In the case of the 5-ton truck, the corrective action program was undertaken while the test was in progress and succeeded by the end of the test in correcting the relatively minor problems found in the test.

Analysis of Findings – Elements of a Suitable System

To interpret the case study findings, we first briefly review the three elements³ of a suitable system. We then discuss the findings for each element.

The first element is the "**end item**" itself. At the time when OT&E takes place, just before the full-rate production decision, the end item under test should be a "production representative" article. It is usually a low-rate initial

³These three elements are equivalent to those defined in DoD Instruction 5000.2 as "the prime mission equipment," "the logistics support structure for the system," and "the other elements of the operational support infrastructure within which the system must operate "

production (or pilot production) item. Thus the end-item configuration at this point should be relatively stable.

The second element of the system is its **"peculiar support."** At OT&E, this element – which includes built-in test (BIT) and external test equipment, technical data, training curricula and materials, facilities, and unique depot repair capabilities – is often less mature than the end item. In fact, some parts of the peculiar support may not be available for testing at this stage.

The third and final element of system suitability is the total Service logistic system within which the weapon system operates – called here **"general logistics support."** At OT&E, this infrastructure is usually not represented at all. In some cases it is simulated (for example, during the test the resupply of spare parts may be delayed for a time that is thought to be representative of the delays within the Service logistics system). After fielding, however, it is this support infrastructure that will provide the supplies and repairs that the system will need in order to operate. Thus, the support infrastructure often has a critical influence on the observed suitability of the system in the field.

Table 1-2 summarizes the most significant findings from the case studies.

TABLE 1-2

RESULTS OF OT&E VERSUS FIELD SUITABILITY

| Suitability element | Finding |
|---------------------------|---|
| End item | OT&E found most major problems; missed cumulative effects problems. |
| Peculiar support | Problems missed; often not tested. |
| General logistics support | Generally not tested or evaluated. |

End Items

OT&E found most major problems relating to end-item suitability. For example, reliability problems such as the air conditioner on the AV-8B, software in the MSE, and avionics in the F-16 were detected. The one class of end-

item problems not found were those relating to cumulative effects. Some examples are delamination of AH-64 main rotor blades, heat-shield wearout on the AV-8B, corrosion problems on the LCAC, and generator aging problems on the MSE. The OT did not last long enough for these problems to show up during the test, and no attempt was made in the evaluation of test results to use DT results or other information to predict what suitability problems might appear after extended use in the field.

Cumulative effects example: Heat shield wearout on the AV-8B

The AV-8B uses two titanium heat shields to deflect hot exhaust from the aircraft structure. The heat shields are cited by maintenance personnel in the Harrier squadrons as one of the chief maintenance burdens. The heat shields were designed to be removed and refurbished when worn. However, removal requires drilling out the rivets holding the shield to the structure and then using larger rivets to reattach the shield. After this procedure has been done several times, the holes in the heat shield that have been drilled out have to be built back up to the original specification. This process requires a higher level of maintenance and is time consuming. The problem was not recognized in OT because the procedure did not have to be carried out repetitively in the limited time OT took place.

Peculiar Support

Peculiar support was only partially tested. But even in some cases (such as LANTIRN) in which peculiar support was only partially tested, the system proved to be suitable; others, such as the Fault Detection/Location System (FD/LS) on the AH-64, and, to a lesser extent, F-16 Block 40 avionics, had unanticipated problems later in fielding. Where peculiar support was thoroughly tested (for example, new equipment training in the MSE), problems were found and subsequently corrected before fielding.

This inconsistent treatment of peculiar support is in our opinion a serious shortcoming. Both the wartime performance and peacetime cost of weapon systems depend on the success of peculiar support. The ability to accurately and quickly diagnose faults, verify equipment status, and perform calibrations affects availability, mission reliability, and maintenance and training requirements. Critical items

of peculiar support should be identified early on, made available for test, and thoroughly tested.

Test designers frequently assume that support equipment will not be sufficiently mature for testing at OT&E and, therefore, do not include provisions for the support equipment in the test plans. Thus, support equipment performance is often not considered in the OT&E operational suitability assessments.

It has been suggested that, in some cases, peculiar support equipment could have been made available for testing but was not. One suggested "rationale" for this phenomenon was that if the peculiar support equipment were to fail testing, the entire system acquisition might be delayed.

This unavailability of critical support equipment is a widespread problem. It highlights the need for discipline in the system and for up-front identification of peculiar support that is crucial to suitability.

Peculiar support example: AH-64 Fault Detection/Location System (FD/LS)

The FD/LS provides the means to test AH-64 subsystems and isolate faults to the line replaceable unit (LRU) level. It is designed to work with the electronic equipment test facility (EETF). During OT, the EETF was incomplete and could not be assessed. Hence, the maintenance concept for the AH-64 could not be tested. Even the FD/LS itself was not tested thoroughly. No faults were inserted to test its diagnostic powers during the logistics demonstration, and although inaccurate fault detection was noted during operational test, it was not judged to be a serious problem. Today, FD/LS still has a 40 percent error rate in fault detection.

General Logistics Support

General logistics support was not tested and was seldom evaluated during OT&E. In the case of the LCAC, wholesale supply support later proved to be a major field suitability problem. The AV-8B's availability has also suffered from supply system problems.

CONTEXT OF SUITABILITY ASSESSMENT

To draw conclusions from these findings, we must first look beyond OT&E to the larger context of suitability assessment. Figure 1-1 pictures the various phases of suitability testing. Suitability should be assessed from early development through fielding. However, not all elements of suitability will be demonstrable at all times. On one hand, for instance, the reliability of the prime mission equipment – and in particular the reliability of critical components – may be demonstrated relatively early in the system's development. On the other hand, the interaction of the prime mission equipment and its peculiar support with the larger logistics system may be demonstrated *in toto* only after the system is fielded, perhaps only after it is fielded in quantity. Thus, what is available to be tested during each phase differs.

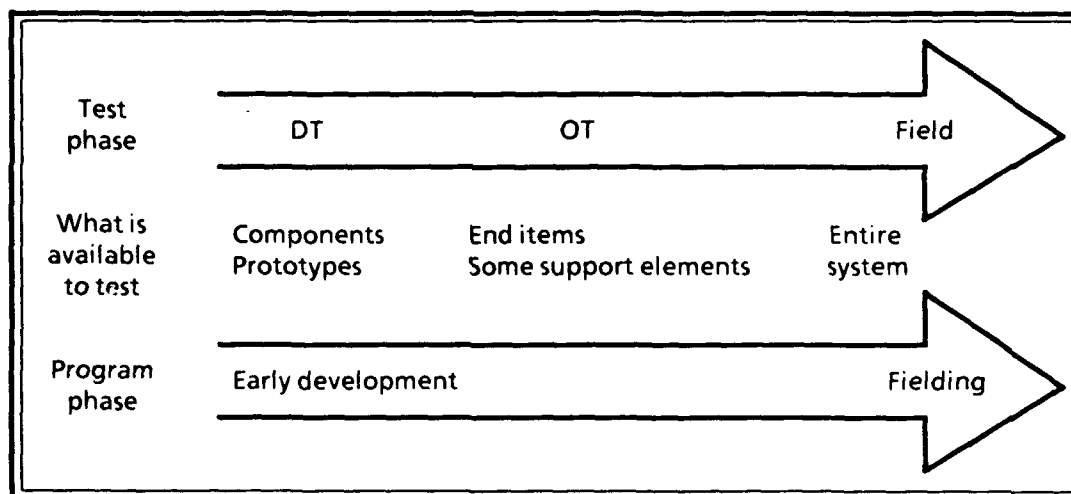


FIG. 1-1. PHASES OF SUITABILITY TESTING

The information available at each phase, however, does not depend solely on what hardware items are available for test. Results of previous tests, and models and analyses, can be used to augment test data and help project future performance. At OT, for example, the results of DT are known and can often be used to inform and benefit the test and evaluation process. Because DT is continuous, it can use results of earlier tests as well. Deciding what is essential to test requires using models and analysis to determine what will be crucial suitability determinants after fielding. Thus, at each stage of testing, looking both

forward to fielding and backward to already available information is essential to efficient suitability assessment.

Findings in Context

Looking at the findings from the OT&E case studies in this context, the greatest difficulty appears to result from the isolation of OT&E. The case studies show that OT was successful at finding the end-item suitability problems that were present in the specific end items tested. Otherwise, suitability problems were often not found. Problems that could have been apparent from DT results (such as corrosion on the LCAC) were not investigated in DT or OT. Elements that would become crucial to meet suitability targets when the system was fielded (such as the fault diagnostics on the AH-64) were not rigorously tested. If there had been more interchange with the DT community and better understanding of the crucial suitability issues, more of these problems might have been identified in testing. If such issues are to be (a) identified as critical before testing and (b) acted on as a result of the tests, then the Deputy Director of Defense Research and Engineering (Test and Evaluation) DDDRE(T&E) and DOT&E will have to devote more attention to suitability assessment. Because their training and experience are primarily in operational and technical issues, the DOT&E staff's focus needs to be expanded to more adequately cover suitability.

The inadequate definition of key suitability issues is a major shortcoming. An issue may be critical because of risks associated with new technology applications, operational concepts, or support concepts, or because it represents a major consumer of logistics resources. If these risks are not identified early and addressed in test plans, then subsequent testing will not reveal them.

At the same time, it is not clear from the case studies that development test data are communicated and utilized to the extent possible. Nor have the results of logistic support analysis (LSA) and the integrated logistics support (ILS) process, where critical suitability issues are identified, been widely or actively disseminated. A disciplined acquisition process should strive to take maximum advantage of the already available information to help make suitability judgments.

Principles of Suitability Assessment

Placing the case-study results and the objective of the acquisition process in this context, we derive four principles for assessing the suitability of major systems:

- (1) Assess suitability in each phase of development.
- (2) Find deficiencies as early as possible.
- (3) Correct deficiencies in the most appropriate phase.
- (4) Coordinate and integrate suitability testing and evaluation across all phases.

The first principle follows from the fact that opportunities to assess suitability differ at each phase but exist in all phases. The second principle is simply common sense: knowledge gained early can inform the rest of the process. The third principle recognizes that although a problem may be known, its solution may best be pursued at a later date. There is no need to stop a program every time a problem is identified until it is fixed – particularly because suitability problems can often be surmounted in numerous ways, and which way is best may not be immediately evident. This principle should not be taken as an excuse for inaction – if a problem can be economically solved early, and most suitability problems cost less to fix early than late, it should be. Finally, it is clear that we cannot afford to perform separate suitability assessments that do not take advantage of information already gained. It is not businesslike to fail to build on earlier results and to fail to think ahead to the cost and suitability drivers for fielded systems.

These principles do not require new policy directives. In fact, adequate policy to ensure the suitability of fielded systems is already in place. The current 5000 series of DoD instructions and its predecessors provide the direction and define the appropriate products needed. For example, the DOT&E is called upon to assess the operational suitability of systems before they enter full-rate production. The DDDRE(T&E) is tasked with oversight of testing for reliability, and the Services' development testing agencies are tasked with certifying that a system is ready for operational testing.

THE NEED TO IMPROVE IMPLEMENTATION

If, although policy is adequate, systems are being fielded with suitability problems, either it is simply impossible to field suitable systems or else policy *implementation* needs to be improved.

The case studies show that it is possible to field suitable systems. A good example of this is the fielding of the Army's MSE. The system (a large and complex communications system supplying the telephone network - including switches, radio linkages, and mobile instruments - for an Army Corps) was suitable when fielded and performed beyond expectation in Desert Storm. This happened in part because suitability testing discovered problems in reliability and training that were overcome by a CAP prior to fielding. It is instructive to note the major increases in reliability - from 76 to 191 hours between operational mission failures for the node-center switch, for example - resulting from the CAP were achieved at a cost of less than \$10 million. For a system with acquisition cost in excess of \$4 billion, this was a small sum. It is clear, then, that suitable systems can be fielded, that an active suitability assessment program coupled with an effective CAP can contribute to fielding success, and that the cost of doing it right need not be excessive.

We believe that policy implementation needs to be improved for more suitable systems to be fielded. In the remainder of this volume, we discuss several ways in which this might be done.

CHAPTER 2. RECOMMENDATIONS

The case studies show that critical suitability test issues are not adequately defined and followed up – especially issues primarily associated with logistics support. Critical suitability issues drive wartime availability and peacetime costs. To use scarce test and evaluation (T&E) resources most effectively, the T&E community needs to identify the critical suitability issues early and then ensure that the T&E plans and execution are consistent with the key issues.

Current policy, as embodied in the 5000 series of instructions, provides for thorough treatment of suitability. In this chapter, we make three recommendations for implementing this policy better and one recommendation to strengthen one aspect of current policy – testing peculiar support equipment.

IMPROVED IMPLEMENTATION

Improved implementation of policy is necessary to better ensure that major systems are suitable when fielded. To accomplish this, suitability assessments should be undertaken according to the four principles set out in the preceding chapter:

- (1) Assess suitability in each phase of development.
- (2) Find deficiencies as early as possible.
- (3) Correct deficiencies in the most appropriate phase.
- (4) Coordinate and integrate suitability testing and evaluation across all phases.

Our three recommendations to put these principles into practice are:

Recommendation 1. Devote increased attention and technical support to suitability assessment and testing at all phases to put into practice the first two principles.

Chapter 3 suggests how suitability assessments could be improved.

This first recommendation follows from our observations from the case studies that crucial elements of suitability were not always identified as such. Increased technical support is indicated because of the limited size and scope of expertise of DOT&E staff and because suitability is difficult to assess. Simply stated, there is no "cookbook" for evaluating suitability. For example, identifying the critical issues for evaluation requires knowledge of the system itself, its expected employment, previous systems, the larger logistics system, and achievable system parameters. Because of the complex interactions among the elements of suitability - and among the mission equipment, its operators and maintainers, its peculiar support, and the larger logistics system - simple rules for evaluating suitability do not exist.

The complex nature of suitability assessment means that increased levels of qualified technical support will be required by the OSD offices to identify suitability problems early and to make suitability assessments at all phases.

Recommendation 2. Place increased emphasis on the use of corrective action programs as follow-ups to suitability assessments to improve suitability. This will put into practice the third principle, correcting problems in the most appropriate phase.

The case studies showed the successful use of CAPs for two systems. In the case of the MSE, for example, large improvements to system suitability were achieved at low cost, and the results of the CAP were verified by follow-on operational testing. It should be noted that the MSE contract included performance requirements and incremental purchases that motivated improvement by the contractor. The planned use of CAPs recognizes that every system is likely to have some suitability problems during testing. Being prepared to correct those problems through a CAP will ensure that those that can be corrected rapidly will be, and that those whose solution may need to be delayed will not be forgotten. The CAP has to specify clearly when the problems will be corrected, who is responsible for making the correction, and where the resources to make the correction will come from. The

informed use of CAPs will help overcome suitability problems in the appropriate phase.

Recommendation 3. Make results and data from all phases and disciplines more available and encourage their use. This will partially accomplish the fourth principle, more coordination among phases.

The case study results showed that simply taking advantage of existing information would have improved the suitability assessments that were made. As a first step, this information should be made readily accessible (in fact, it should be sent to the offices that are responsible for suitability assessment as a matter of routine). These offices should also encourage the use of this information in assessments they perform and also in assessments analogous Service offices perform. Coordination among the OSD offices dealing with suitability is now beginning to be pursued. For this effort to succeed, a clear picture of what information needs to be shared should be developed.

A disciplined process for testing and assessing suitability, and increased resources for technical support, will help ensure that suitability issues are considered and proper actions are taken to get more suitable systems into the field. Judging from past experience, such an effort is needed and will pay for itself many times over in improved availability and avoided logistics costs.

PECULIAR SUPPORT

Peculiar support equipment plays a crucial role in suitability that will increase as systems move to two-level maintenance. Performance of the critical peculiar support equipment will have a direct and significant impact on the operational suitability of a weapon system in both peacetime and wartime. Therefore, it is essential that the critical support equipment be part of the total operational suitability assessment.

If, as some contend, development of peculiar support equipment must follow that of the end item, then it will not be possible to fully assess suitability of systems at OT&E. However, if, as we contend, it is possible to develop the peculiar support concurrently, then crucial items can and

should be made available for test. We make the following recommendation to improve peculiar support:

Recommendation 4. Require critical peculiar support equipment to be made available for initial OT&E.

The remainder of this volume illustrates how these recommendations might be applied and how they could be put into practice by DOT&E. A similar analysis should be performed for the other offices involved in suitability assessments [such as, at the OSD level, DDDRE(T&E)].

CHAPTER 3. IMPROVING SUITABILITY ASSESSMENTS

DOT&E is positioned to motivate improved treatment of suitability in OT&E. For the Milestone III decision, DOT&E reports to the Secretary of Defense and Congress on the adequacy of the operational test and on whether or not the system is suitable. In addition, DOT&E has signature approval of the Test and Evaluation Master Plan (TEMP) and operational test plans.

These opportunities to influence the treatment of operational suitability for major acquisition programs are highlighted in Figure 3-1, extracted from DoDI 5000.2. Each box with a darkened border represents a step in which DOT&E has a review and approval role.

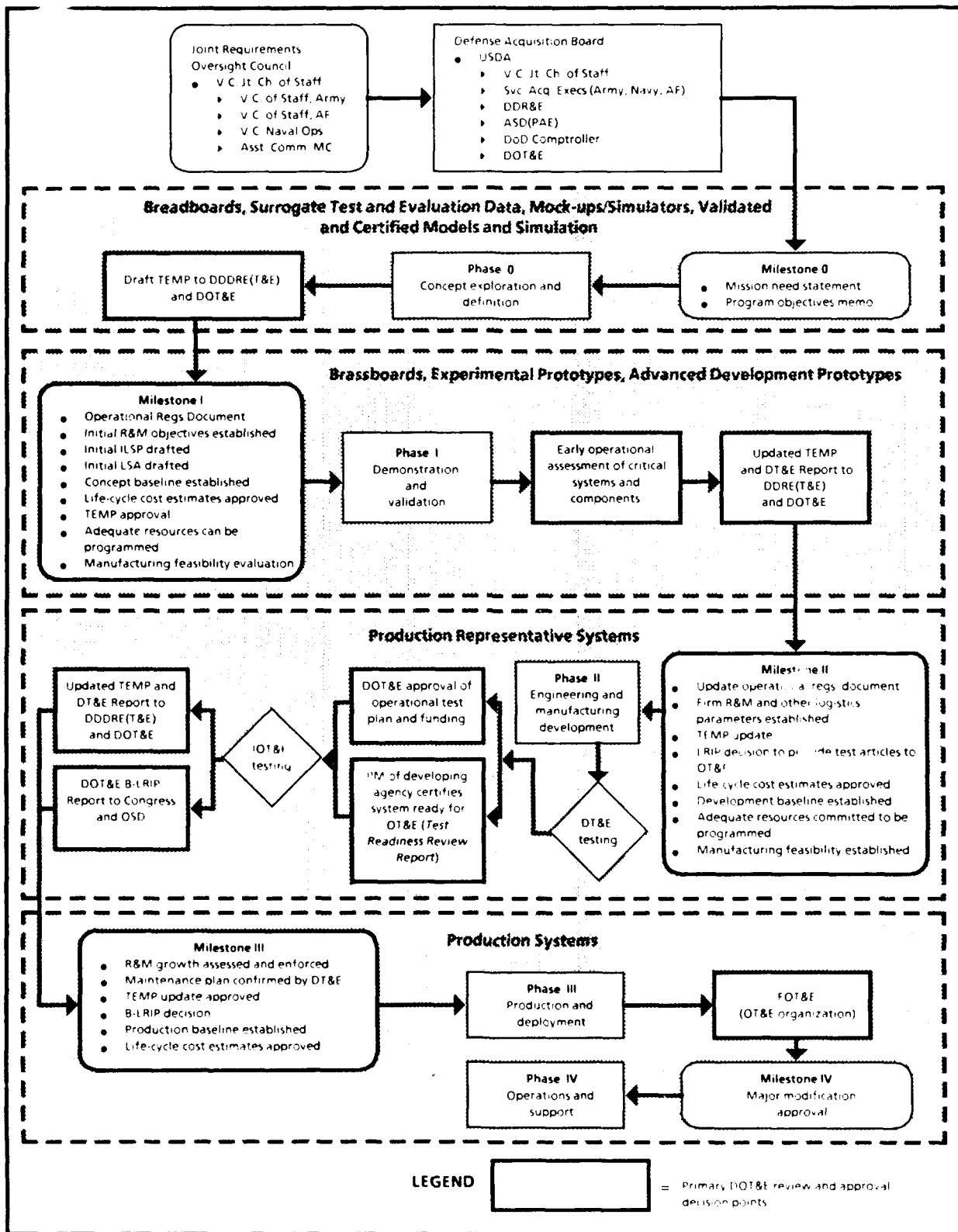
To exercise this authority, DOT&E needs to ensure that the TEMP and test plans provide for adequate treatment of suitability. This chapter describes some candidate tools that can be applied by DOT&E action officers to provide this assurance.

Suitability depends on many players, including the project manager, the intended user, the supporting commands, Service testing agencies, DDDRE(T&E), and DOT&E. The suggestions in this chapter were originally conceived for use by DOT&E, but they could be useful to the other players as well.

METHOD FOR SUITABILITY ASSESSMENT

We have identified four primary actions that DOT&E can apply throughout the development process to implement the recommendations from Chapter 2. They are shown in Figure 3-2.

These four actions are included in DOT&E's current approach. However, as evidenced by the case studies (and a brief review of two systems now in development), these actions are not adequately performed.



Note: B-LRIP = beyond low-rate initial production, PM = program manager

FIG. 3-1. TESTERS' PROCESS FLOW IN WEAPON SYSTEMS DEVELOPMENT UNDER DoD DEFENSE ACQUISITION POLICY

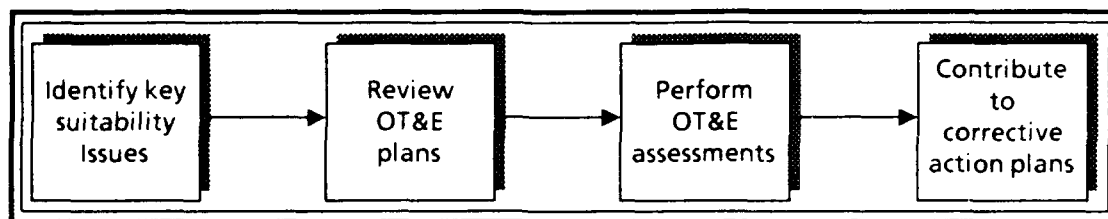


FIG. 3-2. PRIMARY DOT&E ACTIONS FOR IMPROVING THE TREATMENT OF OPERATIONAL SUITABILITY

The first three of these actions should be performed at least once in each major acquisition (and may need to be repeated in response to changes in mission requirements, operations and support concept, or design). If the system fully satisfies all of its effectiveness and suitability requirements at OT&E, then a corrective action plan may not be needed. (As a practical matter, major weapon systems and their acquisitions are sufficiently complex that some corrections will almost certainly be required after initial OT&E.) Specific suggestions for accomplishing the primary actions are presented in the following sections.

Identify Key Suitability Issues

Key suitability issues are those aspects of suitability that could cause system performance or cost to be unacceptable. They are either areas of risk or logistics drivers (i.e., major consumers of logistics resources).

Typically, suitability risks are associated with major changes in one or more of the following areas:

- Technology and its applications
- Operational concept
- Support concept.

For example, the AH-64's composite material main rotor blade represented the first use of that material in such a demanding application. The originally expected replacement interval was 1,500 flight hours. In contrast, field data indicate a replacement interval of only 164 hours. For examples of changes in the support concept, consider the Advanced Tactical Fighter (ATF) and the RAH-66 Comanche helicopter. Both vehicles plan to use two-level maintenance, a major change from the traditional

three-level approach. Because success of the two-level concept is critically dependent on the accuracy of the fault diagnosis system, fault diagnosis is a key suitability issue.

Logistics drivers are the system characteristics that consume the majority of the logistics resources. Examples of logistics drivers are high-failure-rate modules, inaccurate fault diagnostics, and mismatches between maintenance skills and requirements. The logistics drivers may or may not be associated with logistics risks. Even though a logistics driver may be of low risk, it should be examined because of its importance to affordable system performance.

Table 3-1 displays three methods for identifying key suitability issues. They are presented in order of increasing resource requirements.

TABLE 3-1
METHODS FOR IDENTIFYING KEY SUITABILITY ISSUES

| Method 1 Document review | Method 2 Analysis | Method 3 Simulation |
|---|---|--|
| <p>List suitability issues and goals from system requirements documents</p> <p>Check for issues and goals in TEMP</p> | <p>Compare with other systems</p> <p>Review the elements of integrated logistics support</p> <p>Analyze the relationships among the measures and assumptions used</p> | <p>Construct a model of system costs and performance; include operations and support concepts</p> <p>Analyze the impact of changes in operations and support variables</p> |

Document Review

The document review method requires the least time and effort. It is suited to finding large inconsistencies between requirements documents and the TEMP.

Table 3-2 lists relevant requirements documents. They include high-level descriptions of the operations and support concepts. These documents provide explicit and implicit descriptions of suitability issues. The document

review method does not ensure that all the suitability issues are addressed (since the requirements documents may not provide a comprehensive treatment of suitability issues). But since it is fast and easy to apply, it offers significant benefits for the effort required.

TABLE 3-2

SYSTEM DOCUMENTS CONTAINING SUITABILITY REQUIREMENTS

| Document | Program phase |
|-----------------------------------|---------------------------|
| Mission need statement | Milestone 0 |
| Operational requirements document | Milestones I and II |
| Logistic support analysis results | Milestones I, II, and III |
| RAM rationale report | Milestones I and II |

Note: RAM = Reliability, Availability, Maintainability.

Perhaps the best source of suitability issues (at least theoretically) is the documentation of the selected tasks from logistic support analysis (LSA). These tasks are described in MIL-STD-1388-1A. Their purpose is to identify the critical support issues.

Selected Logistic Support Analysis (LSA) Tasks

Task Section 200: Mission and Support Systems Definition

Purpose: To establish supportability objectives and supportability-related design goals, thresholds, and constraints through comparison with existing systems and analysis of supportability, cost, and readiness drivers.

Task 301: Functional Requirements Identification

Purpose: To identify the operations and support functions that must be performed for each system alternative under consideration and then identify the tasks that must be performed in order to operate and maintain the new system in its intended environment.

Task 303: Evaluation of Alternatives and Tradeoff Analysis

Purpose: To determine the preferred support system alternative(s) for each weapon system alternative and to participate in alternative system tradeoffs to determine the best approach for satisfying the need with the best balance among cost, schedule, performance, readiness, and supportability.

Both DoDI 5000.2 and MIL-STD-1388-1A require LSA to be performed at each stage of development, with the level of detail increasing as system development proceeds. "The logistics support analysis process will be used to: (1) develop and define supportability related design factors, and (2) ensure the development of a fully integrated system support structure." (DoDI 5000.2, Part 7, Section A, p. 7-A-3) The program office is responsible for the LSA. For most major systems, the LSA is performed by contractors. The LSA reports can be used by DOT&E to identify the key suitability issues.

Example - Document Review

We applied the "document review" method to a major aeronautical system currently in concept development. A brief review indicated the following key suitability issues: operational availability (A_o), mean time between mission failure (MTBMF), direct maintenance man-hours per flight hour (DMMH/FH), transportability, and two-level maintenance. All but the last issue have quantitative criteria.

There is no guarantee, however, that the suitability issues derived from the system documents will be comprehensive. DOT&E needs a comprehensive list of the key suitability issues.

Analysis

A more involved and more thorough approach for identifying the key suitability issues is analysis. In this context, analysis is the assessment of the suitability characteristics and resources required by the proposed design to operate in the expected scenarios. Analysis may be used to determine when the key suitability issues are comprehensive, consistent, and credible.

Two sources of candidate suitability issues for consideration are the DOT&E *Operational Suitability Guide, Volume I – A Tutorial*, (February 1990), and the elements of integrated logistic support.

Analysis can be performed by comparing the system being assessed with similar systems (or subsystems) already fielded. This approach requires consideration of the

suitability and logistics support elements in the context of the mission and the operations and support concepts for the proposed system. It requires familiarity with the elements of logistics and how they are used in various support concepts. It benefits from the analyst's experience with other weapon systems.

Another analysis approach is to review the logical relationships among the quantitative measures of suitability and to determine the assumptions on which the measures are based. By perturbing the assumed values, the analyst can assess the significance of the effect of assumed values on achieving the stated quantitative goals. If attainment of a goal is sensitive to an assumed value for some parameter, then that parameter may be a candidate for OT&E.

Example - Sensitivity Analysis

For the aforementioned aeronautical system, A_0 was found to be a function of the mean time between mission failure (MTBMF), the mean time to restore (MTTR) the system, and the administrative and logistics down time (ALDT) per maintenance action. Goals were provided for MTBMF and MTTR. The ALDT value was derived from a model of the aircraft maintenance process, but no rationale for the assumed values was provided in the available documents. Based on experience, the assumed ALDT value was judged to be optimistic. Furthermore, a 1-hour increase in ALDT requires an increase of over 1 hour in the MTBMF goal for the system to achieve its A_0 goal. This finding suggests that the ALDT should be assessed in OT&E.

Analysis requires more effort than document review, but it is more likely to result in a list of key suitability issues that will be necessary and sufficient to determine the system's suitability at Milestone III.

Simulation

The third and most involved method is simulation. In this method, models are constructed to represent the cost and performance of the proposed design in the expected scenarios. Cost and performance should be expressed as functions of suitability elements. The models are then exercised with varying sets of input values to estimate the impacts of changes in suitability characteristics. Modeling

and analysis encourage the development of an explicit rationale to explain why certain suitability issues are key. However, the effort required to develop and certify a model may be extensive.

In some cases, it may be possible to use existing models. In others, it may be necessary to construct an appropriate model.

Example - Simulation

For the aeronautical system in the preceding examples, one could build a computer model to simulate one squadron operating according to the operational requirements document under the assumed manning levels, failure rates, maintenance times, fault diagnostics performance, and depot support. The simulation could be used to estimate the major consumers of logistics resources. The assumed inputs could be perturbed to identify the assumptions that could have the most severe impact on the ability of the system to satisfy its top-level performance requirements. The results would indicate key suitability issues.

Review OT&E Plans

Once the key suitability issues have been identified, the next step is to ensure that the OT&E plans address the issues. The fundamental question is whether or not execution of the OT&E plans will provide an adequate basis for assessing the key suitability issues.

Some suitability issues have well-defined measures that depend only on the prime mission equipment. Other issues are less well defined and depend on interactions with other systems or resources. The test planners must decide how each suitability measure will be addressed, whether it be by testing, modeling, expert judgment, or other means. DOT&E must decide whether the treatment given to each suitability issue is appropriate.

Several methods of review are possible. The simplest method is a mechanical check using the following questions:

- Is each issue addressed in the plan?
- Are test resources identified?

- Are test personnel identified?
- Are there provisions for collection of test data?
- Are models to be used? Are they identified and justified?

Example - TEMP Review

The OT&E chapter of the TEMP for the aeronautical system does not address transportability, which was identified as a key suitability issue in the requirements documents. In addition, no attention is given to verifying the ALDT estimate.

Answers to the preceding questions are necessary to determine the adequacy of OT&E plans, but they may not be sufficient. Analysis of the test duration and conditions may be required.

For measures that are to be tested, the nature and length of testing should be sufficient to estimate the parameter with reasonable confidence. Some factors to consider are:

- Treatment of scheduled/phase maintenance
- Treatment of inspection time
- Representative faults for the fault diagnosis system and maintenance actions
- Representative environments and stresses.

Table 3-3 shows one format (with hypothetical entries) that could be used for checking the coverage of suitability issues by the TEMP. Such a table provides a mechanism to ensure that test plans are thoroughly reviewed.

Some measures may be evaluated by using models. Because the complete logistic support structure will rarely be available prior to Milestone III, OT&E cannot provide a thorough test of suitability issues that depend on the complete structure. Availability is one such issue. Depot support may be another one.

DOT&E should consider the credibility of the proposed models. The model may have been certified for application

TABLE 3-3

EXAMPLE FOR TRACKING TREATMENT OF KEY SUITABILITY ISSUES IN THE TEMP
(The entries are hypothetical)

| Issue | Measure | TEMP coverage | | | Comments |
|---------------|-----------------------------------|---------------|-----------|----------|---|
| | | Resources | Scenarios | Data | |
| Availability | A ₀ in combat scenario | Limited | Adequate | Adequate | Use model to combine R&M and support data |
| Reliability | MTBCF | Adequate | Limited | Adequate | Use models to augment scenarios |
| Mobility | Pack/unpack times | Adequate | Adequate | Adequate | Physical fits verified in DT |
| Depot support | TBD | No | No | No | |

Note: MTBCF = mean time between critical failure; TBD = to be determined; R&M = reliability and maintainability

to the current problem. If not, then it should have been subjected to a general verification and validation process. If neither of these reviews have been accomplished, then DOT&E should consider requiring the test plan to include some assessment of the model. DOT&E should consider the assumptions used by the model. (Examples include ALDT, order and shipping times, and availability of spares and consumables.) If the model is sensitive to the assumptions and the assumptions are not well justified, then DOT&E should consider including the assumptions in the test and evaluation plans.

Perform OT&E Assessments

After the operational test is performed, DOT&E reviews the results and develops its own interpretation of the results. The key suitability issues need to be assessed along with the effectiveness issues. The assessment should recognize the suitability issues that could not be fully assessed in OT&E, the attendant risks, and the need for any follow-on tests to verify suitability.

Questions such as the following should be addressed:

- Is the assessment comprehensive with respect to the key suitability issues?
- Are the major assumptions justified?
- Are there suitability problems that should receive corrective action?
- Are there key suitability issues that require further OT&E?

OT&E assessments are limited by the scope of OT&E. Practical constraints on test time, maturity of peculiar support elements, and interfaces with the general logistics support structure restrict the ability to fully demonstrate operational suitability. It may be possible to mitigate these restrictions by augmenting the test results with analysis, data from other sources, and review of the plans for the affected suitability elements.

The results of OT&E may have utility beyond the Milestone III decision. Potential beneficiaries of the OT&E results include the Cost and Operational Effectiveness Analysis (COEA), logistic support analysis and integrated logistic support plans (LSA/ILSP), development testing, and operating doctrine.

Contribute to Corrective Action Plans

Because of the complexity of modern weapon systems, it is likely that not all suitability issues can be fully resolved during OT&E and that some modifications to the system will be made as a result of OT&E. DOT&E could note in their report whether a well-defined CAP is in place to make these modifications, whether it is resourced, and whether responsibilities have been clearly assigned. DOT&E should also review the status of the suitability assessment and the scope of any proposed design changes to determine the need for FOT&E.

SUMMARY

DOT&E has been given a major statutory role in assessing and reporting on operational effectiveness and suitability. The steps outlined above should help DOT&E fulfill that role more efficiently and effectively and thus help ensure

the fielding of suitable systems. Similar steps by the development testing community could further enhance system suitability.

GLOSSARY

| | | |
|----------------|---|---|
| A _o | = | operational availability |
| ALDT | = | administrative and logistics down time |
| ATF | = | Advanced Tactical Fighter |
| BIT | = | built-in test |
| B-LRIP | = | beyond low-rate initial production |
| CAP | = | corrective action program |
| COEA | = | Cost and Operational Effectiveness Analysis |
| DDDRE(T&E) | = | Deputy Director of Defense Research and Engineering (Test and Evaluation) |
| DMMH/FH | = | direct maintenance man-hours per flight hour |
| DOT&E | = | Director, Operational Test and Evaluation |
| DT | = | development testing |
| DT&E | = | development, test, and evaluation |
| DUSD(A) | = | Deputy Under Secretary of Defense (Acquisition) |
| EETF | = | electronic equipment test facility |
| FD/LS | = | Fault Detection/Location System |
| FOT&E | = | follow-on operational test and evaluation |
| ILS | = | integrated logistic support |
| LCAC | = | Landing Craft Air Cushion |
| LRU | = | line replaceable unit |

| | | |
|----------|---|---|
| LSA | = | logistic support analysis |
| LSA/ILSP | = | logistic support analysis and integrated logistic support plans |
| MSE | = | mobile subscriber equipment |
| MTBCF | = | mean time between critical failure |
| MTBMF | = | mean time between mission failure |
| MTTR | = | mean time to restore |
| OSD | = | Office of the Secretary of Defense |
| OT | = | operational testing |
| OT&E | = | operational test and evaluation |
| RAM | = | reliability, availability, maintainability |
| R&M | = | reliability and maintainability |
| PM | = | program manager |
| T&E | = | test and evaluation |
| TBD | = | to be determined |
| TEMP | = | Test and Evaluation Master Plan |

APPENDIX. U.S. CODE, TITLE 10, SECTION 2399

§2399. Operational test and evaluation of defense acquisition programs

(a) Condition for proceeding beyond low-rate initial production.

(1) The Secretary of Defense shall provide that a major defense acquisition program may not proceed beyond low-rate initial production until initial operational test and evaluation of the program is completed. (2) In this subsection, the term "major defense acquisition program" means—

(A) a conventional weapons system that is a major system within the meaning of that term in section 2302(5) of this title; and

(B) is designed for use in combat.

(b) Operational test and evaluation. (1) Operational testing of a major defense acquisition program may not be conducted until the Director of Operational Test and Evaluation of the Department of Defense approves (in writing) the adequacy of the plans (including the projected level of funding) for operational test and evaluation to be conducted in connection with that program.

(2) The Director shall analyze the results of the operational test and evaluation conducted for each major defense acquisition program. At the conclusion of such testing, the Director shall prepare a report stating the opinion of the Director as to—

(A) whether the test and evaluation performed were adequate; and

(B) whether the results of such test and evaluation confirm that the items or components actually tested are effective and suitable for combat.

(3) The Director shall submit each report under paragraph (2) to the Secretary of Defense, the Under Secretary of Defense for Acquisition, and the congressional defense committees. Each such report shall be submitted to those committees in precisely the same form and with precisely the same content as the report originally was submitted to the Secretary and Under Secretary and shall be accompanied by such comments as the Secretary may wish to make on the report.

(4) A final decision within the Department of Defense to proceed with a major defense acquisition program beyond low-rate initial production may not be made until the Director has submitted to the Secretary of Defense the report with respect to that program under paragraph (2) and the congressional defense committees have received that report.

(5) In this subsection, the term "major defense acquisition program" has the meaning given that term in section 138(a)(2)(B) of this title.

(c) Determination of quantity of articles required for operational testing. The quantity of articles of a new system that are to be procured for operational testing shall be determined by—

(1) the Director of Operational Test and Evaluation of the Department of Defense, in the case of a new system that is a major defense acquisition program (as defined in section 138(a)(2)(B) of this title); or

- (2) the operational test and evaluation agency of the military department concerned, in the case of a new system that is not a major defense acquisition program.
- (d) Impartiality of contractor testing personnel.** In the case of a major defense acquisition program (as defined in subsection (a)(2)), no person employed by the contractor for the system being tested may be involved in the conduct of the operational test and evaluation required under subsection (a). The limitation in the preceding sentence does not apply to the extent that the Secretary of Defense plans for persons employed by that contractor to be involved in the operation, maintenance, and support of the system being tested when the system is deployed in combat.
- (e) Impartial contracted advisory and assistance services.** (1) The Director may not contract with any person for advisory and assistance services with regard to the test and evaluation of a system if that person participated in (or is participating in) the development, production, or testing of such system for a military department or Defense Agency (or for another contractor of the Department of Defense).
- (2) The Director may waive the limitation under paragraph (1) in any case if the Director determines in writing that sufficient steps have been taken to ensure the impartiality of the contractor in providing the services. The Inspector General of the Department of Defense shall review each such waiver and shall include in the Inspector General's semi-annual report an assessment of those waivers made since the last such report.
- (3) A contractor that has participated in (or is participating in) the development, production, or testing of a system for a military department or Defense Agency (or for another contractor of the Department of Defense) 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.
- (f) Source of funds for testing.** The costs for all tests required under subsection (a) shall be paid from funds available for the system being tested.
- (g) Director's annual report.** As part of the annual report of the Director under section 138 of this title, the Director shall describe for each program covered in the report the status of test and evaluation activities in comparison with the test and evaluation master plan for that program, as approved by the Director. The Director shall include in such annual report a description of each waiver granted under subsection (e)(2) since the last such report.
- (h) Definitions.** In this section:
- (1) The term "operational test and evaluation" has the meaning given that term in section 138(a)(2)(A) of this title. For purposes of subsection (a), that term does not include an operational assessment based exclusively on—
- (A) computer modeling;
 - (B) simulation; or
 - (C) an analysis of system requirements, engineering proposals, design specifications, or any other information contained in program documents.
- (2) The term "congressional defense committees" means the *Committees on Armed Services* and the *Committees on Appropriations* of the Senate and House of Representatives.

(Added Nov. 29, 1989, P. L. 101-189, Div A, Title VIII, Part A, §802(a)(1),
103 Stat. 1414.)