

# TEST & EVALUATION MANAGEMENT GUIDE

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# **TEST AND EVALUATION MANAGEMENT GUIDE**

## Contents

<b>Foreword</b>	8
<b>Chapter 1:</b>	9
1.1 Introduction	9
1.2 Congress	9
1.3 OSD Oversight Structure	10
1.4 Service T&E Management Structures	14
1.5 Summary	22
<b>Chapter 2: The T&amp;E Process</b>	23
2.1 Introduction	23
2.2 Defense Systems Acquisition Process	23
2.3 T&E And SE Processes	35
2.4 Five-Step Illustrative T&E Process	40
2.5 Scientific Test and Analysis Techniques (STAT)	42
2.6 Summary	44
<b>Chapter 3: Program Office Responsibilities for T&amp;E</b>	45
3.1 Introduction	45
3.2 Relationship To The PM	47
3.3 Early Program Stages	48
3.4 PMO/Contractor Test Management	51
3.5 Test Program Funding/Budgeting	52
3.6 Contractor Testing	53
3.7 Specifications	53
3.8 Independent Test And Evaluation Agencies	54
3.9 PMO Involvement In Operational T&E Activities	54
3.10 Summary	60
<b>Chapter 4: Test - Related Documentation</b>	61
4.1 Introduction	61
4.2 Requirements Documentation	62
4.3 Program Decision Documentation	64
4.4 Program Management Documentation	65
4.5 Test Program Documentation	68
4.6 Other Test-Related Status Reports	74
4.7 Summary	75
<b>Chapter 5: Test &amp; Evaluation</b>	76
5.1 Introduction	76
5.2 "Test" and "Evaluation"	76
5.3 The Evaluation Process	76
5.4 Distinction Between Issues and Criteria	77
5.5 MOEs	81
5.6 Evaluation Planning	82

5.7 Evaluating Developmental And Operational Tests	84
5.8 Summary	85
<b>Chapter 6: Introduction to DT&amp;E</b>	<b>86</b>
6.1 Introduction	86
6.2 DT&E and The System Acquisition Cycle	87
6.3 DT&E Responsibilities	90
6.4 Test Program Integration	92
6.5 Areas Of DT&E Focus	92
6.6 System Design For Testing	94
6.7 DT&E OF Limited Procurement Quantity Programs	95
6.8 Summary	95
<b>Chapter 7: DT&amp;E Support of Technical Reviews and Milestone Decision</b>	<b>96</b>
7.1 Introduction	96
7.2 DT&E and The Review Process	96
7.3 Tailoring Reviews to Specific Needs	106
7.4 Summary	107
<b>Chapter 8: Integrated Testing</b>	<b>108</b>
8.1 Introduction	108
8.2 Integrated Testing	108
8.3 Early Involvement	109
8.4 Evaluation Framework	112
8.5 Test Data	115
8.6 Summary	115
<b>Chapter 9: Production - Related Testing Activities</b>	<b>116</b>
9.1 Introduction	116
9.2 Quality In Design	116
9.3 Production Management	116
9.4 Role Of The PRR	117
9.5 Production Qualification Testing	117
9.6 Transition To Production	119
9.7 LRIP	120
9.8 PAT&E	120
9.9 Summary	121
<b>Chapter 10: Introduction to Operational Test and Evaluation</b>	<b>122</b>
10.1 Introduction	122
10.2 Purpose and Scope of OT&E	122
10.3 Test Participants	124
10.4 OT&E as it Relates to DT&E	125
10.5 Types of OT&E	125
10.6 Test Planning	128
10.7 Test Execution	130
10.8 Test Reporting	130
10.9 Summary	130



<b>Chapter 11: OT&amp;E to Support Decision Reviews</b>	132
11.1 Introduction	132
11.2 OT&E During the TD Phase	132
11.3 OT&E During the EMD Phase	132
11.4 OT&E During the P&D Phase	133
11.5 OT&E During the O&S Phase	133
11.6 Summary	135
 <b>Chapter 12: TEMP</b>	 136
12.1 Introduction	136
12.2 Temp Development	136
12.3 Temp Requirements	141
12.4 Temp Format	141
12.5 Summary	143
 <b>Chapter 13: Test Resources</b>	 144
13.1 Introduction	144
13.2 Obtaining Test Resources	144
13.3 Test Resource Planning	149
13.4 Test Resource Funding	154
13.5 Summary	157
 <b>Chapter 14: Introduction to Acquisition of Defense Business Systems (DBSs)</b>	 159
14.1 Introduction	159
14.2 DBSs	159
14.3 BCL Model	159
14.4 Incremental Acquisition Approach For DBSs	160
14.5 Summary	164
 <b>Chapter 15: Software and IT Testing Considerations</b>	 165
15.1 Introduction	165
15.2 Role Of The Software Specification Review	165
15.3 Role Of The TRR For Software	169
15.4 Software Development Process	170
15.5 Potential Power Of Human-Based Testing	171
15.6 "Black Box" Versus "White Box" Testing	172
15.7 On the Impossibility of Exhaustive Software Testing	173
15.8 Software Error Categorization And Priority	174
15.9 Overview of Software Measurement With T&E Applications	175
15.10 Independent Verification and Validation (IV & V)	184
15.11 T&E Issues Associated With Spiral and Agile Development Approaches	185
15.12 COTS Considerations	188
15.13 Mature Software	189
15.14 Summary	190

<b>Chapter 16: Testing for Vulnerability and Lethality</b>	191
16.1 Introduction	191
16.2 LFT	191
16.3 Nuclear Weapons Testing	196
16.4 Testing For NH&S	196
16.5 Summary	198
<b>Chapter 17: Logistics Support T&amp;E</b>	200
17.1 Introduction	200
17.2 Planning For Logistics T&E	204
17.3 Aspects of LOG T&E	209
17.4 Limitations to LOG T&E	217
17.5 Summary	217
<b>Chapter 18: M&amp;S Support to T&amp;E</b>	218
18.1 Introduction	218
18.2 Types of Models and Simulations	218
18.3 Scope of M&S	221
18.4 Support to Test Design and Planning	222
18.5 Support to Test Execution	224
18.6 Support to Analysis and Test Reporting	224
18.7 Simulation Integration	226
18.8 Simulation Planning	227
18.9 Summary	227
<b>Chapter 19: Electromagnetic Environmental Effects (E3) Testing and Spectrum Supportability (SS)</b>	228
19.1 Introduction	228
19.2 Key Definitions and Concepts	228
19.3 E3/SS Planning, Analysis, Systems Engineering, and T&E For the Systems Acquisition Process	233
19.4 Summary	244
<b>Chapter 20: Special Topics: Interoperability and Cyber Security</b>	248
20.1 Policy	248
20.2 Interoperability Testing	248
20.3 "Operationalizing" the NR KPP	251
20.4 Role of JITC	252
20.5 Supporting Integrated Architecture Products	253
20.6 Cyber Security and IA Requirements	255
20.7 Agile Development and T&E	259
20.8 Summary	260
<b>Chapter 21: Multi-Service and Joint Testing</b>	263
21.1 Introduction	263
21.2 Background	263
21.3 Test Program Responsibilities	264
21.4 Test Team Structure	265
21.5 Test Planning	265
21.6 Deficiency Reporting	266

21.7 Test Reporting	267
21.8 Joint Test and Evaluation	267
21.9 Summary	269
<b>Chapter 22: International T&amp;E Programs</b>	<b>270</b>
22.1 Introduction	270
22.2 FCT Program	270
22.3 NATO Comparative Test (NCT) Program	272
22.4 T&E Management in Multi-National Programs	272
22.5 U.S. and NATO Acquisition Programs	273
22.6 Summary	273
<b>Chapter 23: Commercial Off-The-Shelf and Non-Developmental Items Considerations</b>	<b>274</b>
23.1 Introduction	274
23.2 Market Investigation and Procurement	276
23.3 COTS and NDI Testing	277
23.4 Resources and Funding	279
23.5 Summary	279
<b>Chapter 24: Testing the Special Cases</b>	<b>280</b>
24.1 Introduction	280
24.2 Testing with Limitations	280
24.3 Space System Testing	283
24.4 Cyber Warfare	284
24.5 Operations Security and T&E	288
24.6 Joint Concept Technology Demonstrations	289
24.7 Chemical and Biological Agent (CBA) Testing	289
24.8 Summary	290
<b>Appendix A - Acronyms</b>	<b>291</b>
<b>Appendix B - References</b>	<b>307</b>

## List of Figures

Figure 1-1 DoD Test and Evaluation Organization	10
Figure 1-2 Army Test and Evaluation Organization	15
Figure 1-3 Navy Test and Evaluation Organization	18
Figure 1-4 Air Force Test and Evaluation Organization	21
Figure 2-1 Defense Acquisition System Model	24
Figure 2-2 Improving Milestone Process Effectiveness	25
Figure 2-3 Key Technical Activities and Technical Reviews/Audits during the Acquisition Lifecycle	30
Figure 2-4 Illustrative Systems Engineering Activities (EMD Phase)	38
Figure 2-5 Impact of Decision Timing on Lifecycle Costs	40
Figure 2-6 Five Step Test and Evaluation Process	41
Figure 3-1 T&E WIPT Focus Areas	47
Figure 3-2 Examples of T&E Lessons Learned	55
Figure 4-1 Examples of T&E-related Program Plans and Documentation	61
Figure 4-2 Example of Requirements Evolution	63
Figure 4-3 Example of Typical Test Plan Format	71
Figure 4-4 Types of Information in a Final Test Report	73
Figure 5-1 Illustrative Generic Evaluation Process	77
Figure 5-2 Example of Key Topics in an Evaluation Plan	78
Figure 5-3 Example of Dendritic Analysis Showing Critical Issue Decomposition	83
Figure 6-1 Examples of Testing Activities Throughout the Acquisition Life Cycle	87
Figure 7-1 Example DT&E Activities Across Phases of the Acquisition Life Cycle	01
Figure 7-2 Example of Technical Review Timing Across the Acquisition Life Cycle	98
Figure 7-3 Specifications Summary	99
Figure 8-1 Integrated Testing as Part of an Overall T&E Continuum	111
Figure 8-2 Top-Level Evaluation Framework Matrix	114
Figure 9-1 Typical Criteria Evaluated as Part of a PRR	118
Figure 10-1 Illustrative Scope of the Operational Test and Evaluation Effort	123
Figure 10-2 Comparisons of DT and IOT&E Differences Highlighted	125
Figure 12-1 TEMP Format	142
Figure 13-1 DoD MRTFB by DoD Component	148
Figure 13-2 TEMP Part IV - Resource Summary	150
Figure 13-3 Resourcing Cycle Overlaps in the DoD Budget Process	155
Figure 14-1 BCL Acquisition Business Model	161
Figure 15-1 "Error Avalanche" Showing How Software Errors Can Accumulate	164
Figure 15-2 Software Error Distribution Summary (Notional)	166
Figure 15-3 Illustrative Software Test Planning Activities	168
Figure 15-4 Illustrative Software Development Activities in System WBS Context	171
Figure 15-5 Testing Example	174
Figure 15-6 Priority Classification Scheme for Software Errors	175
Figure 15-7 Example of Requirements Stability Measure	177
Figure 15-8 Example of Computer Resource Utilization Measure	178
Figure 15-9 Test Progress Measure Indicating Schedule Slip	179
Figure 15-10 Test Facility Under-Utilization Example	180
Figure 15-11 Problem Report Closure Rate Status Problems	181
Figure 15-12 Problem Report Aging Example	182



Figure 15-13 Problem Report Open Status Example	183
Figure 15-14 Tracking Problem Report Severity	183
Figure 15-15 Spiral Model Software Development Approach	186
Figure 15-16 Notional Agile Development Model Depicting Testing	198
Figure 15-17 Example of Software “Maturity” Criteria	190
Figure 16-1 Summary of Key Parts of the U.S.C. Regarding LFT	192
Figure 16-2 Summary of Degrees of LFT	193
Figure 16-3 Illustrative LFT&E Planning and Execution Process	195
Figure 16-4 Nuclear Weapons Effects vs. System Survivability	197
Figure 17-1 Illustrative Scope of LOG T&E	200
Figure 17-2 IPS Elements	202
Figure 17-3 Logistics Supportability Objectives in the Overall T&E Program	206
Figure 17-4 Example RGC	213
Figure 18-1 The Simulation Spectrum	219
Figure 18-2 Criteria Values Conducive to Use of M&S	221
Figure 18-3 Illustrative Use of M&S in T&E	224
Figure 19-1 Key E3/SS Terms and Definitions	232
Figure 19-2 S-Diagram	233
Figure 20-1 RMF Process	257
Figure 20-2 Procedures for OT&E for IA in Acquisition Programs	258
Figure 21-1 Multi-Service OT&E (MOT&E) Team Composition	261
Figure 21-2 Deficiency Report Summary Format	266
Figure 21-3 JT&E Process	267
Figure 23-1 Spectrum of COTS/NDI Applicability (not to scale)	274

## Test & Evaluation Management Guide

### Foreword

This 6th edition of the Test and Evaluation Management Guide (TEMG) was updated with the cooperation and support of the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation (DASD(DT&E)), the Director of Operational Test and Evaluation (DOT&E), the President of the Defense Acquisition University (DAU), and the DoD Component test and evaluation (T&E) representatives. The TEMG is one of many technical management educational guides developed for use by DAU. Although some Service-specific processes are included as illustrative examples, the TEMG, like all DAU products, is written primarily from a Department of Defense (DoD) perspective, i.e., non-Service specific.

The TEMG is intended primarily for use in courses at DAU and secondarily as a generic desk reference for program and project management, and T&E personnel. It is written for current and potential acquisition management personnel and assumes some familiarity with basic terms, definitions, and processes as employed by the DoD acquisition process. The TEMG is designed to assist Government and industry personnel in executing their management responsibilities relative to the T&E support of defense systems and facilitate learning during DAU coursework.

The objective of a well-managed T&E program is to provide timely and accurate information to decision makers and program managers (PMs). The TEMG was developed to assist the acquisition community in obtaining a better understanding of who the decision makers are and determining how and when to plan T&E events so that they are efficient and effective.

Although the TEMG includes some references to DoD policies, it is not a policy document and should not be viewed as such. The latest versions of the DoD 5000 series, as well as the Defense Acquisition Guidebook (DAG) (Chapter 9, Test and Evaluation), should be consulted for specific policies and DoD recommended practices.

References to Military Handbooks (MIL-HDBKs) appear throughout the TEMG: however, these handbooks are for guidance only and cannot be cited as a requirement.

For additional learning materials about DoD T&E, consult the DAU Website ([www.dau.mil](http://www.dau.mil)), for reviewing T&E continuous learning modules and accessing T&E courses, and go to the DAU Acquisition Community Connection, T&E Community of Practice (CoP) available at <https://acc.dau.mil/t&e>.

Comments, updates, changes, and/or comments to this guide should be provided to Office of the DASD(DT&E) T&E Competency and Development Directorate and to DAU.

# Test & Evaluation Management Guide

## Chapter 1

### 1.1 Introduction

This chapter provides an introduction to the policy and organizations that govern the conduct of T&E activities within the DoD and discusses congressional legislation of T&E activities for compliance by DoD. It outlines the responsibilities of DoD test organizations at the Office of the Secretary of Defense (OSD) and Service levels and describes related T&E policy.

### 1.2 Congress

Congress requires the DoD to provide the following reports that include information on T&E:

- **Selected Acquisition Report (SAR).** This report consists of cost, schedule, and performance data. The SAR describes Acquisition Category (ACAT) I system characteristics required and outlines significant progress and problems encountered. It lists tests completed and issues identified during testing. The program manager (PM) uses the Consolidated Acquisition Reporting System software to prepare the SAR.
- **DOT&E Annual Report.** This report is provided by the DOT&E to the Secretary of Defense (SecDef) and the committees on Armed Services, National Security, and Appropriations. The report provides a narrative and resource summary of all operational test and evaluation (OT&E) and related issues, initiatives, other interest areas, activities, and assessments in the previous fiscal year. When oversight of live-fire testing (LFT) was moved to DOT&E, this issue was added to the report.
- **Beyond Low-Rate Initial Production (BLRIP) Report.** Before proceeding to BLRIP for each major defense acquisition program (MDAP), the DOT&E must report to the SecDef, Deputy Secretary of Defense, Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)), Secretaries of the Military Departments, and Congress. This report addresses the adequacy of the Service initial operational test & evaluation (IOT&E) and whether the T&E results confirm that the tested item or component is effective, suitable, and survivable for combat. When oversight of live-fire test & evaluation (LFT&E) was moved to the DOT&E, the LFT Report was added to the BLRIP report content.
- **Foreign Comparative Testing (FCT) Report.** The USD(AT&L) should notify Congress a minimum of 30 days prior to the commitment of funds for initiation of new FCT evaluations of equipment produced by select allied and friendly foreign countries.
- **Joint DASD(DT&E) and Deputy Assistant Secretary of Defense for Systems Engineering (DASD(SE)) Annual Report.** This report is required by statute to be provided to the committees on Armed Services and Appropriations. The joint report includes the significant Developmental Test and Evaluation (DT&E) and systems engineering (SE) activities for the Department's MDAPs, major automated information systems (MAIS), and special interest programs. The report

evaluates the progress of weapon systems' performance for programs designated for OSD T&E oversight.

### 1.3 OSD Oversight Structure

The DoD organization for the oversight of T&E is illustrated in Figure 1-1. For the USD(AT&L), DT&E oversight is performed by the DASD(DT&E), within the Office of the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)). The DOT&E provides OT&E oversight for the SecDef. The management of MDAPs in OSD is performed by the Defense Acquisition Executive (DAE), who uses the Defense Acquisition Board (DAB) and Overarching Integrated Product Teams (OIPTs) to process information for decisions.

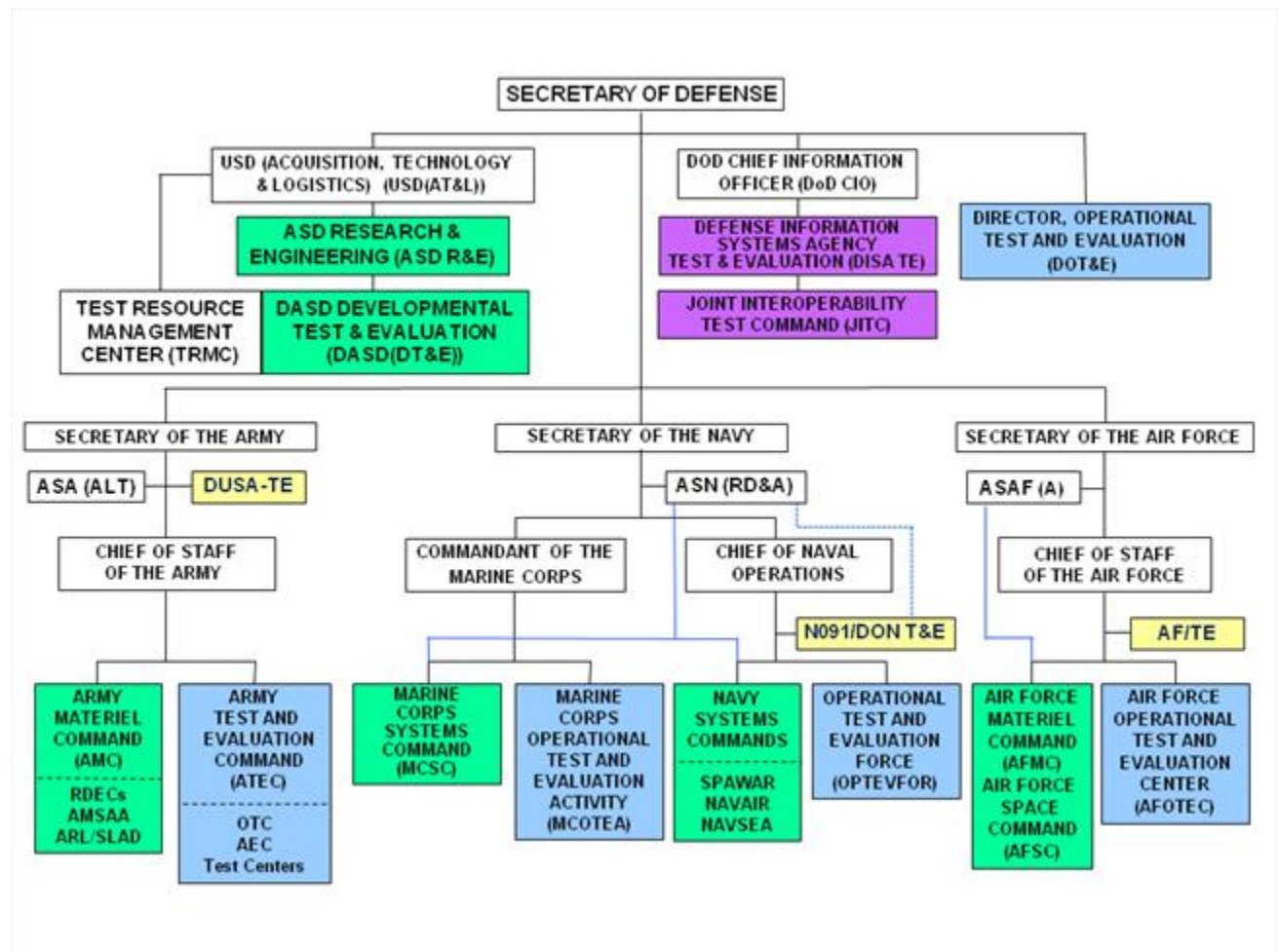


Figure 1-1 DoD Test and Evaluation Organizations

#### 1.3.1 DAE

The DAE position, established in September 1986, is held by the USD(AT&L). As the DAE, the USD(AT&L) uses the DAB and its OIPTs to provide the senior-level decision process for the acquisition of weapon systems. DAE responsibilities include establishing policies for acquisition (including procurement,



research and development (R&D), logistics, developmental testing (DT), and contracts administration) for all elements of DoD. The DAE's charter includes the authority over the Services and Defense Agencies on policy, procedure, and execution of the weapon systems acquisition process.

### 1.3.2 DAB

The DAB is the senior advisory board for the DoD acquisition system. The board includes the Vice Chair of the Joint Chiefs, the service Secretaries, and a number of Undersecretaries of Defense. Members of the DAB are responsible for approving the MDAPs and serve as the most important executive review of the most expensive acquisition projects in the DoD. The DAB is also the principal review forum enabling the USD(AT&L) to fulfill 10 USC Chapter 144 responsibilities concerning ACAT ID MDAPs.

The USD (AT&L) is the Milestone Decision Authority (MDA) for ACAT ID programs and ACAT IAM programs that have not been delegated. The USD(AT&L) conducts DAB Reviews for ACAT ID and IAM programs at major milestone decision points, at the Full-Rate Production Decision Review, at Interim Program Reviews, and at other times as necessary.

### 1.3.3 DASD(DT&E)

In accordance with DoD Instruction [\(DoDI\) 5134.17](#) (Reference (a)), the DASD(DT&E) shall be the focal point for all policy, practice, procedures, and acquisition workforce issues relating to DT&E within DoD. The DASD(DT&E) is the principal advisor to the SecDef and the USD(AT&L) on DT&E in the DoD in accordance with section [139b of Title 10, United States Code](#) (U.S.C.) (Reference (b)). See [Figure 1-1](#).

#### 1.3.3.1 Responsibilities of the DASD(DT&E)

Some of the key duties of the DASD(DT&E) include:

- Develops policies and guidance for the following:
  - The planning, execution, and reporting of DT&E in the DoD, including integration and DT&E of software;
  - The integration of developmental and operational tests in coordination with the DOT&E;
  - The planning, execution, and reporting of DT&E executed jointly by more than one Military Department or Defense Agency;
  - The use of DT&E planning principles and best practices; and
  - The development of test and evaluation strategies (TESs) and test and evaluation master plans (TEMPs) in conjunction with the DOT&E.
- Provides guidance to defense acquisition programs for developing and documenting the program's evaluation strategy and management approach in the TES and TEMP throughout the program's life cycle.

- Reviews and approve DT&E portions in the TES and TEMP for each program on the OSD T&E oversight list.
- Monitor and review, beginning with the materiel development decision, the DT&E and development planning activities of the pre-MDAPs and pre-MAIS programs.
- Monitor and review the DT&E activities of all MDAPs and MAIS programs and special interest programs identified on the OSD T&E oversight list.
- In accordance with (IAW) [DTM 09-027](#) (Reference (ac)), ensure access to all test data and program information relevant to the execution of testing and fulfillment of DASD(DT&E) responsibilities.
- Serves as the DoD functional leader for the T&E acquisition career field. Provide advocacy, oversight, and guidance to the acquisition workforce responsible for T&E.
- As an advisory member of the DAB and other key acquisition bodies, provides independent assessments, planned and ad hoc, of programs' DT&E, execution, and risk.
- Periodically review the organizations and capabilities of the Military Departments with respect to DT&E. Identify needed changes or improvements to such organizations and capabilities, and provide input regarding needed changes or improvements for the T&E strategic plan.
- Submit to the congressional defense committees an annual report, jointly with the DASD(SE).
- Conduct an independent assessment of operational test readiness (AOTR) for all MDAPs and special interest programs.
- Jointly with the DOT&E, and in consultation with the T&E executives of the cognizant DoD Components, determine the programs designated for OSD T&E oversight.
- Serve concurrently as the Director, Test Resource Management Center (TRMC), and in this capacity, report directly to the USD(AT&L) (as illustrated in Figure 1-1) in accordance with [section 196\(f\)](#) of reference (b).

### 1.3.3.2 DASD (DT&E) and Service Reports

During the testing of ACAT I and designated weapon systems, the DASD(DT&E) and Services interaction includes the following reporting requirements:

- A TES must be provided for Milestone (MS) A and a TEMP (either preliminary or updated, as appropriate) must be provided for consideration and approval before each milestone review, starting with MS B.
- A technical assessment of DT&E is provided to the ASD(R&E) and DOT&E listing the T&E results, conclusions, and recommendations prior to a milestone decision or the final decision to proceed to BLRIP.

### 1.3.4 DOT&E

The DOT&E reports to the SecDef (as illustrated in Figure 1-1) and has special reporting requirements to Congress. The DOT&E must provide to Congress independent analysis and insight into the operational effectiveness, suitability, and survivability of new weapon systems.

#### 1.3.4.1 Duties and Authority of the DOT&E

Some of the key duties and authority of the DOT&E as outlined in DoD Directive ([DoDD 5141.2](#) (Reference (c))); [DODI 5000.02](#) (Reference (d)); and sections [139](#) , [2366](#) , [2399](#) , and [2400](#) of Reference (b) are as follows:

- Comply with requests from Congress for information relating to operational OT&E in the DoD.
- In conjunction with the DASD(DT&E), co-approve the TEMP and TES for major and other designated defense acquisition programs, special interest programs, and other designated automated information system (AIS) programs.
- Approve operational test plans, and OT&E portions of test planning documents for major and other designated defense acquisition programs, special interest programs, and major and other designated AIS programs.
- Approve the TEMP and T&E portions of integrated program management documents for programs that are solely under DOT&E oversight. Approve test plans for operational test events of acquisition systems under DOT&E oversight.
- Approve LFT&E strategies and management plans and, if developed in support of waivers of full-up system-level LFT, alternative LFT&E strategies.
- Following consultation with the PM, determine the number of production or production-representative test articles required for LFT&E and IOT&E of programs on the OSD T&E oversight list.
- Obtain reports and information, as necessary in carrying out assigned responsibilities and functions.
- Provide independent oversight, independent evaluation, and objective reporting of the results of operational test and LFT&E.
- Determine adequacy of operational test capabilities.
- Monitor all OT&E activities.
- Coordinate Military Services planning and execution of OT&E.
- Review and make recommendations to the SecDef on all budgetary and financial matters.

- Provide early involvement in the acquisition cycle (integrated product team (IPT), informal reviews, etc.).
- Submit special reports to the SecDef and Congress.

#### **1.3.4.2 DOT&E and Service Interactions**

For DoD and DOT&E-designated oversight acquisition programs, the Service provides the DOT&E the following:

- A draft copy of the operational test plan for review and approval.
- Significant test plan changes.
- The final Service IOT&E report, which must be submitted to DOT&E before the Full-Rate Production Decision Review (FRPDR) for incorporation in the BLRIP report.
- The LFT&E plan for approval, and the Service LFT report for review.

#### **1.3.5 Defense Information Systems Agency (DISA)**

The DISA is responsible for planning, engineering, acquiring, testing, fielding, and supporting global net-centric information and communications solutions to serve the needs of the President, the Vice President, the SecDef, and the DoD Components, under all conditions of peace and war. The DISA supports national security communications requirements as identified in the National Security Presidential Directive 28 (Reference (e)) and [Executive Order 12472](#) (as amended) (Reference (f)).

In accordance with [DoDD 5105.19](#) (Reference (g)), the DISA maintains a major field independent operational test capability (See Figure 1-1) through the Joint Interoperability Test Command (JITC). Under the direction of the Director, DISA, the JITC conducts operational test and evaluation, consistent with [DoD Directive 5000.1](#) (Reference (h)) and [Reference \(d\)](#) .

### **1.4 Service T&E Management Structures**

#### **1.4.1 Army T&E Organizational Relationship**

[Army Regulation \(AR\) 73-1](#) (Reference (i)) prescribes implementing policies and assigns responsibilities for T&E activities during the systems acquisition processes. It applies to all systems (materiel and command, control, communications, and computers (C4), intelligence (I), and information technology (IT) (C4I/IT) developed, evolved, acquired, and managed under the auspices of AR 701 and the [DAG](#) (Reference (j)). Reference (i) applies to Army participation in joint test and evaluation (JT&E) and multi-Service operational test and evaluation (MOT&E). The Army management structure for T&E is depicted in Figure 1-2.



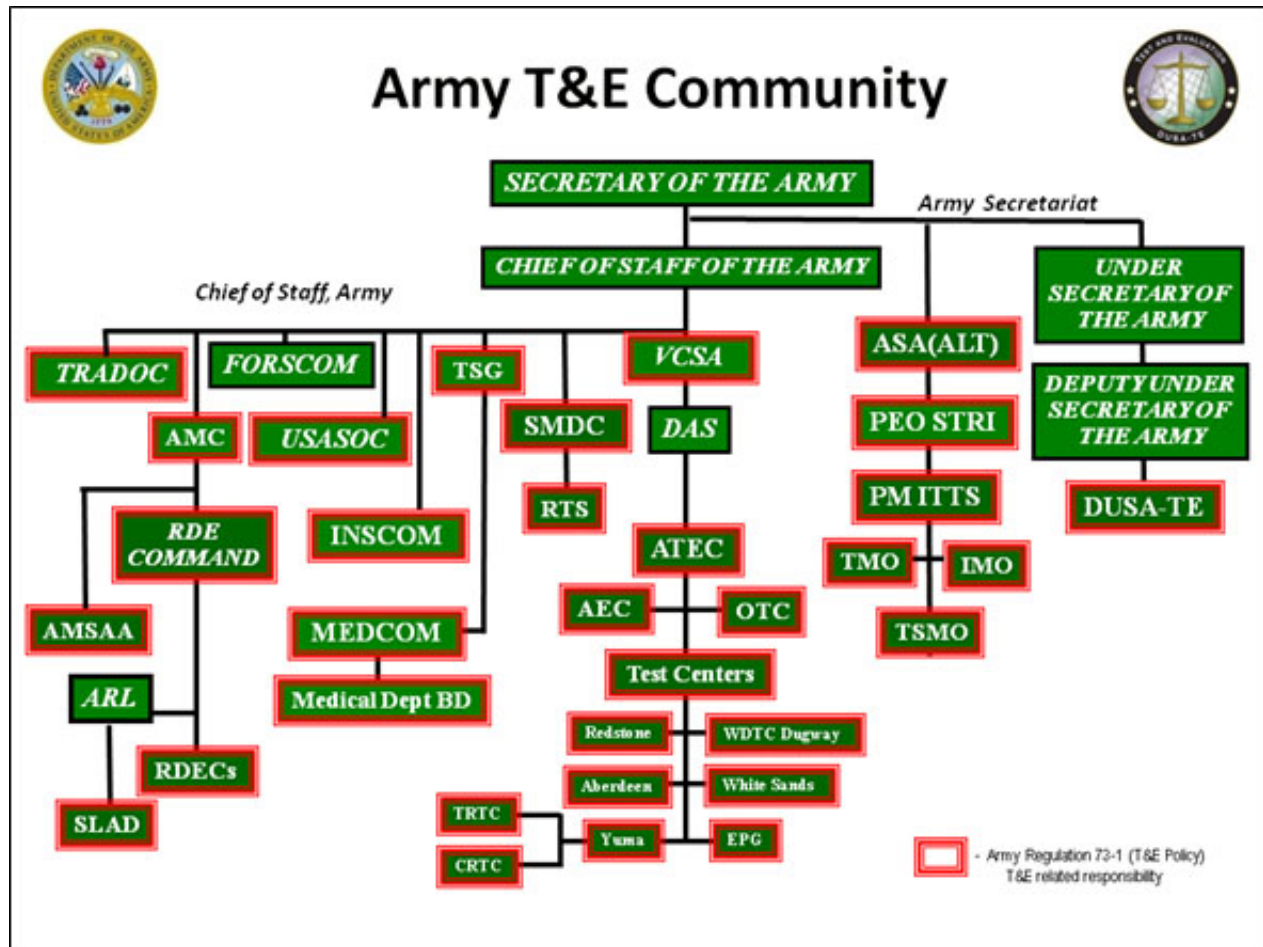


Figure 1-2 Army T&E Organization

#### 1.4.1.1 Army Acquisition Executive (AAE)

The Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) has the principal responsibility for all Department of the Army matters and policy related to acquisition, logistics, technology, procurement, the industrial base, and security cooperation. Additionally, the ASA(ALT) serves as the AAE. The AAE administers acquisition programs by developing/promulgating acquisition policies and procedures as well as appointing, supervising, and evaluating assigned program executive officers (PEOs) and direct-reporting PMs .

#### 1.4.1.2 Army T&E Executive

The Army T&E Executive establishes, reviews, enforces, and supervises Army T&E policy and procedures including overseeing all Army T&E associated with the system research, development, and acquisition of all materiel systems and C4/IT systems. As delegated by the AAE, the Army T&E Executive is the sole Headquarters, Department of the Army (HQDA) approval authority for TEMPs.

The Test and Evaluation Office within the Office of the Deputy Under Secretary of the Army, known as the Deputy Under Secretary of the Army for Test and Evaluation (DUSA-TE), provides support for the

Army T&E Executive. In this capacity, it has the mission to establish policy and resources that are disciplined and flexible enough to support safe and reliable equipment for the current and future Army and DoD chemical and biological defense. DUSA-TE also provides T&E subject matter expertise and oversight of Army and DoD chemical and biological acquisition programs and represents Army T&E interests at OSD and tri-Service committees and forums.

#### **1.4.1.3 Army Test and Evaluation Command (ATEC)**

ATEC supports the systems acquisition, force development, and experimentation processes through overall management of the Army's T&E programs. In this role, ATEC manages the Army's developmental and operational testing, all system assessments and evaluations, and management of joint T&E. ATEC is the Army's independent operational test agency (OTA) reporting directly to the Vice Chief of Staff of the Army (VCSA) through the Director of the Army Staff (DAS).

ATEC has the primary responsibility for conducting (DTs) for the Army. Responsibilities include the following:

- Perform the duties of Government developmental tester for all Army systems except for those systems assigned to the Communications-Electronics Research, Development, and Engineering Center of the Army Materiel Command (AMC) Research, Development and Engineering Command (RDECOM) by HQDA (Deputy Chief of Staff, G-6); Medical Command (MEDCOM); Intelligence and Security Command (INSCOM); Space and Missile Defense Command (SMDC); and Army Corps of Engineers (ACE).
- Provide test facilities and testing expertise in support of the acquisition of Army and other defense systems.
- Operate and maintain the Army's portion of the Major Range and Test Facility Base (MRTFB) (except for the United States Army Kwajalein Atoll in accordance with [DoDD 3200.11](#) , (Reference (k)).
- Provide testers with a safety release for systems before the start of pretest training for tests that use Soldiers as test participants.
- Provide safety confirmations for milestone acquisition decision reviews and the materiel release decision.
- Manage the Army Test Incident Reporting System.

##### **1.4.1.3.1 Army Operational Testers**

The U.S. Army Operational Test Command (OTC) within ATEC has the primary responsibility for conducting most Operational Tests (OTs) for the Army and supporting Army participation in Joint T&E. OTC responsibilities include the following:

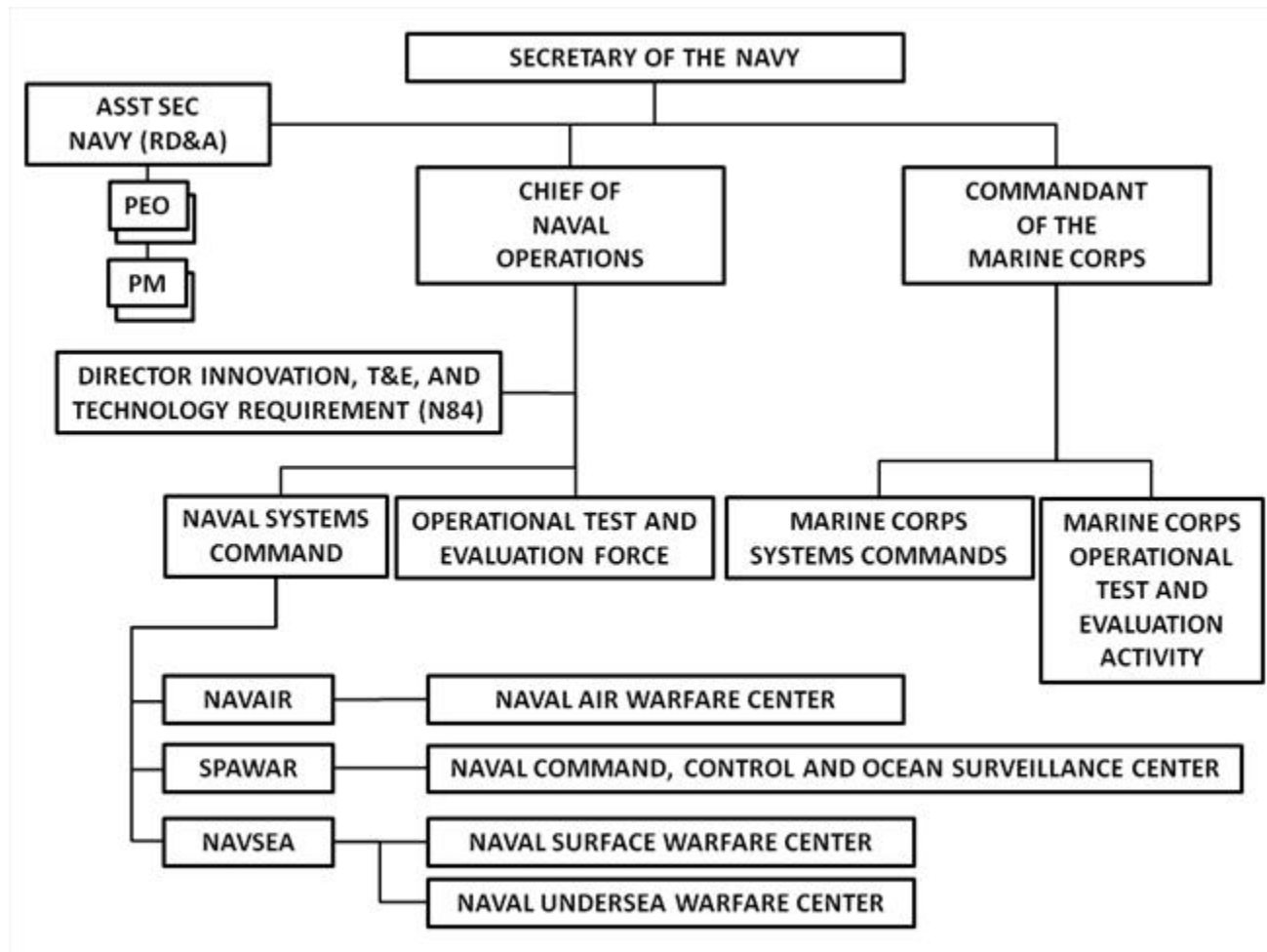
- Perform the duties of operational tester for all Army systems except for those systems assigned to MEDCOM, INSCOM, SMDC, and United States Army Special Operations Command (USASOC).
- Perform the duties of operational tester for assigned multi-Service OTs and (on a customer service basis) for Training and Doctrine Command (TRADOC) force development tests and/or experimentation (FDT/E).
- Provide test facilities and testing expertise in support of the acquisition of Army and other defense systems, and for other customers on a cost-reimbursable and as-available basis.
- Program and budget the funds to support OT except out-of-cycle tests (which are usually paid for by the proponent).
- Develop and submit OT and FDT/E test resource plans (TRPs) to the Army's Test Schedule and Review Committee (TSARC).

#### **1.4.1.3.2 Army Evaluation Center (AEC)**

The AEC is an independent subordinate element within ATEC that has the primary responsibility for conducting Army system evaluations and system assessments in support of the systems acquisition process. Decision makers use AECs independent report addressing an Army systems operational effectiveness, suitability, and survivability. AEC responsibilities include the following:

- Perform the duties of system evaluator for all Army systems except for those systems assigned to MEDCOM, INSCOM, and the commercial items (CI) assigned to ACE; conduct continuous evaluation (CE) on all assigned systems.
- Develop and promulgate evaluation capabilities and methodologies.
- Coordinate system evaluation resources through the TSARC.
- Preview programmed system evaluation requirements for possible use of modeling and simulation (M&S) to enhance evaluation and reduce costs.
- Perform manpower and personnel integration assessments in coordination with Deputy Chief of Staff, G-1 Army Research Laboratory (ARL)-Human Research and Engineering Directorate.
- Perform the integrated logistics support (ILS) program surveillance for Army systems. Perform independent logistics supportability assessments and report them to the Army logistician and other interested members of the acquisition community .

## 1.4.2 Navy T&E Organizational Relationship



**Figure 1-3 Navy Test and Evaluation Organization**

The organizational structure for T&E in the Navy is illustrated in Figure 1-3. Within the Navy Secretariat, the Secretary of the Navy (SECNAV) has assigned general and specific research, development, test, and evaluation (RDT&E) responsibilities to the Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN(RD&A)) and to the Chief of Naval Operations (CNO). The CNO has responsibility for the TEMP process. T&E policy and guidance are exercised through the Director, Innovation, Test and Evaluation, and Technology Requirements (CNO (N84)).

### 1.4.2.1 Navy DT&E Organizations

The Navy's senior systems development authority is divided among the commanders of the system commands with Naval Air Systems Command (NAVAIR) developing and performing DT&E on aircraft and their essential weapon systems; Naval Sea Systems Command (NAVSEA) developing and performing DT&E on ships, submarines, and their associated weapon systems; and Space and Naval Warfare Systems Command (SPAWAR) developing and performing DT&E on all other systems. System acquisition is controlled by a chartered PM or by the commander of a systems command. In both cases, the

designated developing agency is responsible for DT&E and for the coordination of all T&E planning in the TEMP. Developing agencies are responsible for the following:

- Develop test issues based on the thresholds established by user requirements.
- Identify the testing facilities and resources required to conduct the DT&E.
- Develop the DT&E test reports.

Reporting directly to the CNO, the President of the Board of Inspection and Survey is responsible for conducting acceptance trials of new ships and aircraft acquisitions and is the primary Navy authority for Production Acceptance Test and Evaluation (PAT&E) of these systems.

#### **1.4.2.2 Navy Operational Test and Evaluation Force (OPTEVFOR)**

The Commander, Operational Test and Evaluation Force (COMOPTEVFOR) commands the Navy's independent OT&E activity and reports directly to the CNO. The functions of the OPTEVFOR include the following:

- Establish early liaison with the developing agency to ensure an understanding of the requirements and plans.
- Review acquisition program documentation to ensure that documents are adequate to support a meaningful T&E program.
- Plan and conduct realistic OT&E.
- Develop tactics and procedures for the employment of systems that undergo OT&E (as directed by the CNO).
- Provide recommendations to the CNO for the development of new capabilities or the upgrade of ranges.
- Conduct OT&E on Marine Corps aviation systems.

#### **1.4.3 Marine Corps T&E Organizational Relationship**

The Office of Program, Budget, and Execution, Headquarters Marine Corps, directs the total Marine Corps program effort to support the acquisition of new systems. The Marine Corps does not have a position that is analogous to that of the Director, Innovation, T&E and Technology Requirements (CNO (N84)). The Commanding General (CG), Marine Corps Systems Command (MCSC) is the sponsor for RDT&E and is responsible for DT&E within the Marine Corps. The CG MCSC also reports directly to the ASN(RD&A). Figure 1-3 illustrates the Marine Corps organization for T&E management.

#### 1.4.3.1 Marine Corps DT&E Organizations

The CG MCSC is the Marine Corps materiel developing agent and directly interfaces with the Navy Systems Commands. The CG MCSC implements policies, procedures, and requirements for DT&E of all systems acquired by the Marine Corps. The Marine Corps also uses DT&E and OT&E performed by other Services, which may develop systems of interest to the Corps.

#### 1.4.3.2 Marine Corps Test and Evaluation Activity (MCOTEA)

MCOTEA is responsible for the independent OT&E of assigned Navy, Marine Corps, and joint acquisition programs to ensure that all events are effectively planned, conducted, and reported. MCOTEA coordinates the scheduling of resources for OT requiring Marine operating forces support through the Marine forces synchronization conferences. Aviation programs sponsored by the CNO undergo independent OT&E by the COMOPTEVFOR.

#### 1.4.4 Air Force T&E Organizational Relationships

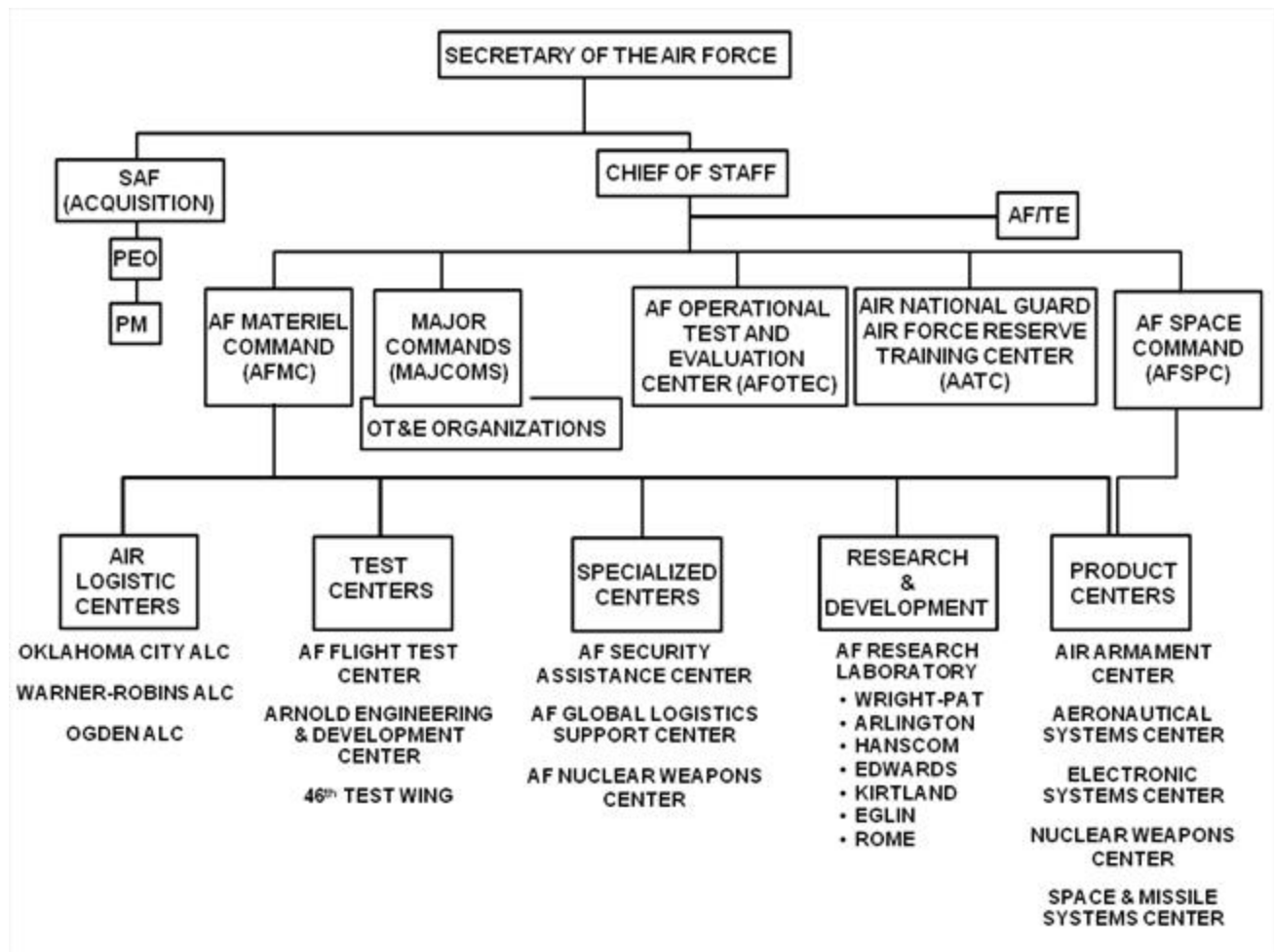
[Air Force Policy Directive \(AFPD\) 99-1](#) (Reference (I)) and the Air Force 99-series of Instructions establishes policies for the T&E process and infrastructure.

The Assistant Secretary of the Air Force for Acquisition (SAF/AQ) is the senior-level authority for research, development, and acquisition (RDA) within the Air Force. As illustrated in Figure 1-4, the SAF/AQ is an advisor to the Secretary of the Air Force and interfaces directly with the DASD(DT&E) and the DOT&E. The SAF/AQ receives DT&E and OT&E results as a part of the acquisition decision process. Within the SAF/AQ structure, there is a military deputy (acquisition) who is the Air Force primary staff officer with responsibility for RDA. The Director, Air Force Test and Evaluation (AF/TE), provides T&E policy and oversight and reports directly to the Chief of Staff of the Air Force (CSAF). AF/TE processes DT&E and OT&E documentation, resolves T&E issues for the Air Force, and manages the review of the TEMP.

##### 1.4.4.1 Air Force DT&E Organization

The Air Force Materiel Command (AFMC) and Air Force Space Command (AFSPC) are implementing commands that conduct Government DT&E and manage acquisition programs. AFMC and AFSPC perform all levels of research; develop weapons systems, support systems, and support equipment. Within these implementing commands are product centers, logistics centers, test centers, and laboratories as well as a wide variety of test ranges.

Once the weapon system is fielded, AFMC and AFSPC retain management responsibility for developing and testing system improvements and upgrades. The AFSC is responsible for DT&E of **space and missile systems**.



**Figure 1-4 Air Force Test and Evaluation Organization**

#### 1.4.4.2. Air Force Operational Test and Evaluation Center (AFOTEC)

As the Air Force OTA, AFOTEC conducts independent OT&E of all programs on the OSD OT&E Oversight List and other programs as directed. AFOTEC also conducts OTs in support of joint urgent operational needs and Warfighter rapid acquisition programs. The AFOTEC commander reports directly to the CSAF. In preparation for OT&E, AFOTEC reviews all relevant operational and training requirements, employment and maintenance concepts, and tactics. Operational and implementing major commands (MAJCOMs) provide operational concepts, personnel, and resources to assist AFOTEC in performing OT&E.

#### 1.4.4.3 MAJCOM Operational Test Organizations

OT organizations (squadrons and wings) are embedded in each operating MAJCOM to conduct follow-on operational test and evaluation (FOT&E) for systems past AFOTEC-conducted IOT&E and to conduct OT&E on all systems in sustainment. Force development evaluations (FDEs), which are a type of OT&E, are performed by MAJCOM OT organizations in support of MAJCOM-managed system acquisition-related decisions prior to initial fielding or for MAJCOM sustainment or upgrade activities.



### 1.5 Summary

An increased emphasis on T&E has placed greater demands on the OSD and DoD Components to carefully structure organizations and resources to ensure maximum effectiveness. Renewed interest by Congress in testing as a way of assessing systems utility and effectiveness, reports by a variety of organizations on improving acquisition effectiveness, and continuing acquisition reform initiatives have resulted in reorganizations within the DoD and the Services to improve the management of T&E resources, planning, execution, and reporting, in support of acquisition programs.

## **Test & Evaluation Management Guide**

### **Chapter 2 - The T&E Process**

#### **2.1 Introduction**

The fundamental purpose of T&E is to provide essential information to decision makers, verify and validate performance capabilities documented as requirements, assess attainment of technical performance parameters, and determine whether systems are operationally effective, suitable, survivable, and safe for intended use. During the early phases of development, T&E is conducted to demonstrate the feasibility of conceptual approaches, evaluate design risk, identify design alternatives, compare and analyze trade-offs, and estimate satisfaction of operational requirements. As a system undergoes design and development, the iterative process of testing moves gradually from a concentration on DT&E, which is concerned chiefly with attainment of engineering design goals and verification of technical specifications, to increasingly comprehensive OT&E, which focuses on questions of operational effectiveness, suitability, and survivability. Although there are usually separate DT and OT events, DT&E and OT&E are not necessarily serial phases in the evolution of a weapon system development. Integrated DT and OT are encouraged when appropriate; i.e., conferring possible cost or time savings.

The discipline of T&E has its origins in the testing of hardware. This tradition is heavily embedded in its vocabulary and procedures. The advent of software-intensive systems has brought new challenges to testing, and new approaches are discussed in Chapter 15. Remaining constant throughout the T&E process, whether testing hardware or software, is the need for thorough, logical, systematic, and early test planning followed by feedback of well-documented and unbiased T&E results to system developers, users, and decision makers.

T&E provides useful information to many customers and value to the PM. DT&E and OT&E must be integrated into an efficient continuum of testing as much as practical without compromising the objectives of either T&E activity. Information assurance (IA) and interoperability testing as well as reliability analysis, planning, tracking, and reporting must also be integrated into this continuum.

#### **2.2 Defense Systems Acquisition Process**

The primary objective of the defense acquisition process is the acquisition of quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable cost. As it is now structured, the defense system life cycle is to replicate the preferred acquisition strategy of an evolutionary acquisition process that uses incremental development or rapid acquisition processes. The three major elements—pre-system acquisition, system acquisition, and sustainment—may include the following five phases:

1. Materiel Solution Analysis (MSA).
2. Technology Development (TD).
3. Engineering and Manufacturing Development (EMD).

4. Production and Deployment (P&D).
5. Operations and Support (O&S).

As Figure 2-1 shows, these phases are separated by key decision points when a MDA reviews a program, considers its development maturity, and determines authorization to advance to the next phase in the cycle. Thus, T&E planning and test results play an important part in the MDA review process.

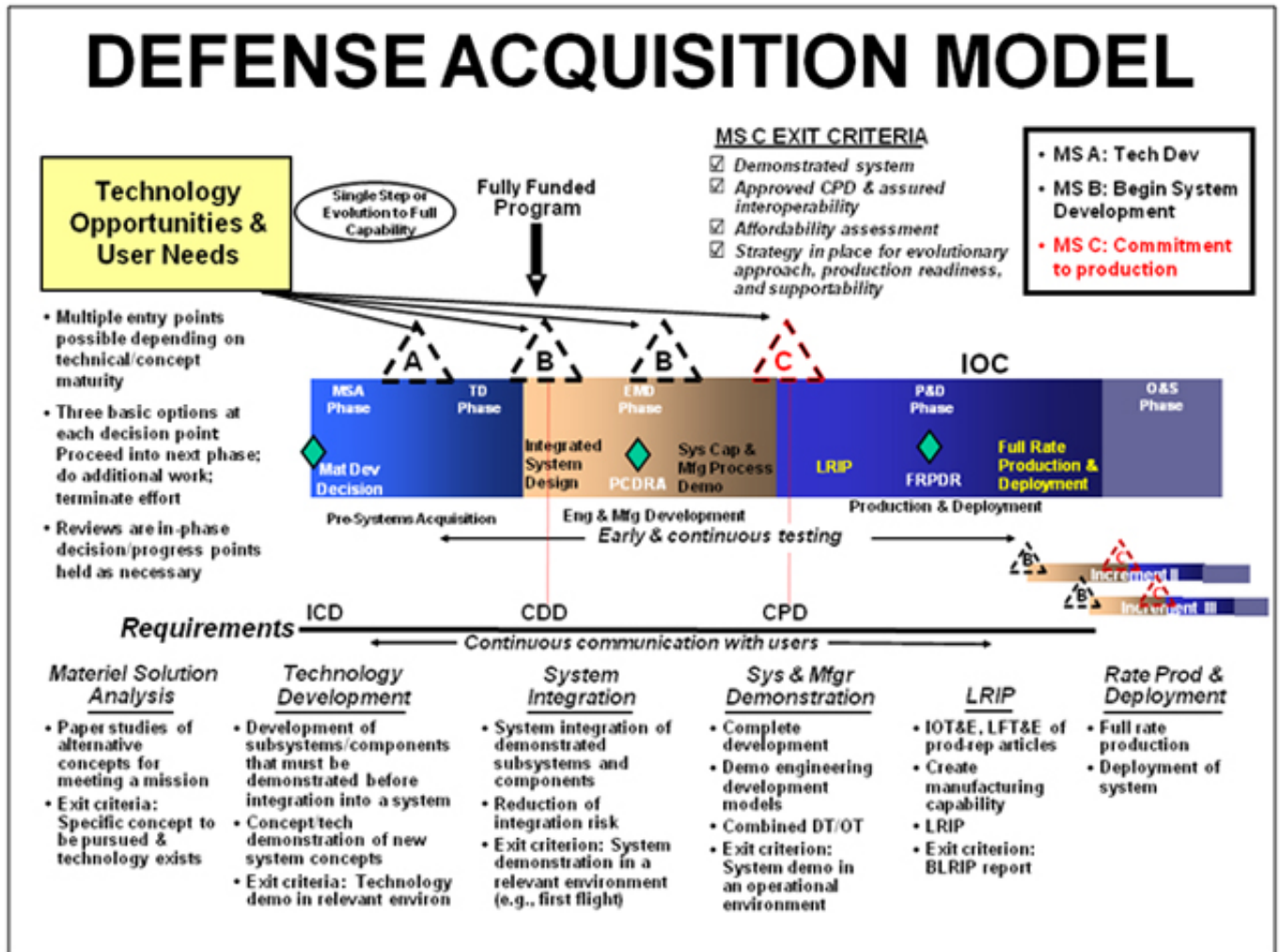


Figure 2-1 Defense Acquisition System Model

[USD\(AT&L\) memorandum](#) (Reference (m)) provided supplementary guidance which introduced procedural changes to the acquisition model. These changes included, for example, the addition of a Pre-EMD phase as well as directing that the substance of milestone reviews (e.g. SEPs and TEMPs) be addressed earlier at each point of the milestone decision process. Figure 2-2 shows this process and its relationship with T&E processes. USD(AT&L) memorandum (Reference (m)) provided supplementary guidance which introduced procedural changes to the acquisition model. These changes included, for example, the addition of a Pre-EMD phase as well as directing that the substance of milestone reviews

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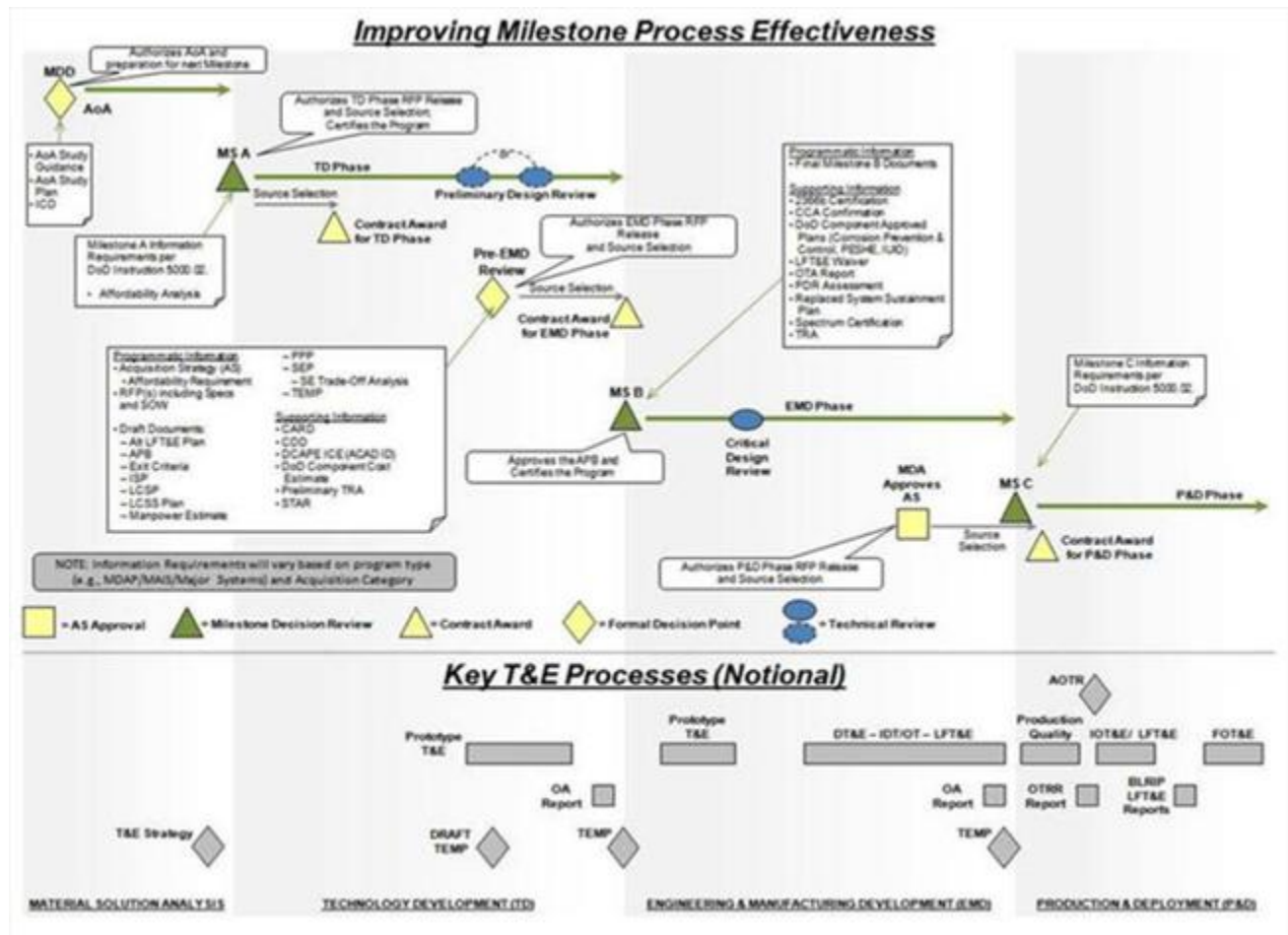


Figure 2-2 Improving Milestone Process Effectiveness

### 2.2.1 The T&E Contribution at Major Milestones

The following description of the defense system acquisition process, summarized from [Reference \(d\)](#), shows how T&E fits within the context of the larger process.

T&E progress is monitored by OSD throughout the acquisition process. OSD oversight extends to MDAPs, MAIS programs, or designated acquisition programs to include defense business systems as defined in [Directive-Type Memorandum \(DTM\) 11-009](#) (Reference (n)). T&E officials within OSD render independent assessments-based on participation in test events, direct observation of test events, and continuous oversight of activities-to the DAB, the DAE, and the SecDef at each system milestone review. These assessments are based on the following T&E information:

Test planning documents, such as the TEMP and more detailed supporting documents, developed by the responsible DoD Component activities.

Test reports and briefings prepared by the Component test activities.

Data from tests, M&S, and data from other sources such as Component PMs, laboratories, industry developers, studies, and analyses.

At MS B, the OSD T&E assessments reflect an evaluation of system concepts and technology alternatives using early performance parameter objectives and thresholds found in an approved preliminary TEMP. At MS C, assessments include an evaluation of system-level test plans and test results. At the FRPDR, assessments include consideration of the operational effectiveness and suitability evaluations of low-rate initial production (LRIP) systems.

In accordance with [DTM 11-003](#) (Reference (o)), PMs formulate a comprehensive reliability, availability, and maintainability (RAM) program using an appropriate reliability growth strategy to improve RAM performance until RAM requirements are satisfied. The program consists of engineering activities including RAM allocations, block diagrams, and predictions; failure definitions and scoring criteria; failure mode, effects, and criticality analysis (FMECA); maintainability and built-in test demonstrations; reliability growth testing at the system and subsystem level; and a failure reporting and corrective action system maintained through design, development, production, and sustainment. In accordance with [USD\(AT&L\) Memorandum](#) (Reference (p)), it is DoD policy for programs to be formulated to execute a viable RAM strategy that includes a reliability growth program as an integral part of design and development. The RAM program is an integral part of the systems engineering (SE) process.

A key contribution made by T&E in the acquisition process is the early detection and reporting of deficiencies that may adversely impact the performance capability or availability and supportability of a system. A comprehensive and repeatable deficiency reporting process should be used throughout the acquisition process to report, evaluate, and track system deficiencies and to provide the impetus for corrective actions that improve performance to desired levels. The lead DoD Component and the PM, or equivalent, prepares a preliminary RAM and cost rationale report in support of the MS A decision.

In accordance with [Reference \(d\)](#), there shall be only one MS B per program or evolutionary increment. Each increment of an evolutionary acquisition shall have its own MS B unless the MDA determines that the increment will be initiated at MS C.

## 2.2.2 MSA and TD Phases

A defense pre-system acquisition process begins with the requirements process identification of a materiel need and the development of the Initial Capabilities Document (ICD). A decision is made to start MSA phase, and the Technology Development Strategy (TDS) evolves with the development of initial test planning concepts in the TES. MSA ends when the MDA approves the preferred solution resulting from the Analysis of Alternatives (AoA), identifying measures of effectiveness (MOEs), and

approves the associated TDS. NOTE: A useful reference on such items as MOEs and measures of performance (MOPs) and their relationship to the overall technical measurement process including technical performance measurement (TPM) can be found in International Council on Systems Engineering ([INCOSE-TP-2003-020-01](#)) (Reference (q)) which is a technical report developed as a collaborative effort between the DoD Practical Software and Systems Measurement organization and INCOSE. The TD phase follows a MS A decision during which the risks of the relevant technologies of the alternative selected for satisfying the user's needs are investigated. Shortly after the milestone decision, an integrated team begins transitioning the test planning in the TES into the evaluation strategy for formulation of a TEMP.

The integrated team that supports the PM and program management office (PMO) is the T&E Working-level Integrated Product Team (WIPT). The T&E WIPT is a defined forum serving the PM and PMO as the T&E subject matter experts (SMEs) responsible for supporting the PM and other program WIPTs on all aspects of a programs T&E effort. This effort includes T&E program strategy, design, development, oversight, analysis, assessment, and reporting of test results. The T&E WIPT should be established and chartered as early as possible around MS A so it can be involved in program strategy discussions and plans.

The lead DoD Component and the PM, or equivalent, should prepare a preliminary RAM and cost rationale report in support of the MS A decision. This report provides a quantitative basis for reliability requirements and improves cost estimates and program planning. The report should be attached to the Systems Engineering Plan (SEP) at MS A and updated in support of MS B and MS C.

As stated in the [ASD\(R&E\) Guidance](#) (Reference (r)), a Technology Readiness Assessment (TRA) is a systematic, metrics-based process that assesses the maturity of and the risk associated with critical technologies to be used in MDAPs. It is conducted by the PM with the assistance of an independent team of SMEs. It is provided to the ASD(R&E) and will provide part of the basis upon which the ASD(R&E) advises the MDA at MS B or at other events designated by the MDA to assist in the determination of whether the technologies of the program have acceptable levels of risk-based in part on the degree to which they have been demonstrated (including demonstration in a relevant environment)-and to support risk-mitigation plans prepared by the PM. The plan for conducting a TRA is provided to the ASD(R&E) by the PM upon approval by the Component Acquisition Executive (CAE).

A TRA is required by [Reference \(d\)](#) for MDAPs at MS B (or at a subsequent milestone if there is no MS B). It is also conducted whenever otherwise required by the MDA. A TRA is required for space systems by [DTM 09-25](#) (Reference (s)). The TRA final report for MDAPs must be submitted to the ASD(R&E) for review to support the requirement that the ASD(R&E) provide an independent assessment to the MDA.

A TRA focuses on the programs critical technologies (i.e., those that may pose major technological risk during development, particularly during the EMD phase of acquisition). Technology Readiness Levels (TRLs) can serve as a helpful knowledge-based standard and shorthand for evaluating technology maturity, but they must be supplemented with expert professional judgment.

To reduce the risk associated with entering EMD, [Reference \(d\)](#) requires requests for proposals (RFPs) to incorporate language that prevents the award of an EMD contract if it includes technologies that have not been demonstrated adequately. Adequate demonstration in a relevant environment (TRL 6) is one benchmark that is evaluated, but it is not the only consideration, nor necessarily dispositive. As such, a generic TRA not based on the planned specific technical solution is insufficient. Since the TRA must be based on the technologies of the program that entail some element of risk, TRAs may have to be performed on all the competitors' proposals in a source selection.

The TRAs described in [USD\(AT&L\) Memorandum](#) (Reference (t)) replace the former TRAs described in the [Director, Research Directorate, Deskbook](#) (Reference (u)). TRAs that must be submitted to the ASD(R&E) are required only for MDAPs that require certification under [section 2366b](#) of [Reference \(b\)](#) or other provisions of law, or when otherwise directed by the MDA. Generally, TRAs are not required for MDAPs at MS C. Independent of the elimination of the formal requirement to conduct a TRA for a MAIS, MS C, and ACAT IIIV programs, all PMs and their chains of command retain complete responsibility for assessing, managing, and mitigating acquisition program technology risk. MDAs for non-ACAT I programs should consider requiring TRAs for those programs when technological risk is present.

The TD effort concludes with a decision review at MS B when an affordable increment of militarily useful capability has been identified, the technology for that increment has been demonstrated in a relevant environment, and a system can be developed for production within a reasonable time frame or the MDA decides to terminate the effort.

Typical T&E-related documents at the MS B review are the Acquisition Decision Memorandum (ADM) (exit criteria), ICD, Capability Development Document (CDD) (performance parameters), Acquisition Strategy, System Threat Assessment (STA), an Early Operational Assessment (EOA), and the TEMP. Additional program management documents prepared before MS B include the AoA, Independent Cost Estimate, and the concept baseline version of the Acquisition Program Baseline (APB), which summarizes the weapons functional specifications, performance parameters, and cost and schedule objectives.

The program office for major programs (OSD oversight) must give consideration, if relevant, to requesting a waiver for full-up, system-level (FUSL) LFT and identification of LRIP quantities for IOT&E.

### **2.2.3 T&E Contributions Prior to MS B**

During MSA and TD activities prior to MS B, laboratory testing and M&S are conducted by the contractors and the development agency to demonstrate and assess the capabilities of key subsystems and components. The test and simulation designs are based on the operational needs documented in the ICD. Studies, analyses, simulation, and test data are used by the development agency to explore and evaluate alternative concepts proposed to satisfy the user's needs. Also during this period, the OTA monitors MSA and TD activities to gather information for future T&E planning and to provide effectiveness and suitability input desired by the PM. The OTA also conducts EOAs, as feasible, to assess the operational impact of candidate technical approaches and to assist in selecting preferred alternative system concepts.



The development agency prepares the TDS in conjunction with the early T&E strategy for DT&E and M&S. The TES presents T&E plans for system design(s) engineering and performance evaluations. The strategies also include the tasks and processes to be stated in the RFP that the contractor will be required to employ to demonstrate the achievement of reliability design requirements. The TES and TEMP specify how reliability will be tested and evaluated during the associated acquisition phase. The OTA may provide an EOA. This information is incorporated into the PMs TEMP that documents the programs T&E strategy that supports the MS B decision to proceed to the next phase.

#### **2.2.4 EMD Phase**

The MS B decision is program initiation for systems acquisition; establishes broad objectives for program cost, schedule, and technical performance; and starts the EMD phase of the acquisition life cycle. The EMD phase is divided into two sub phases: Integrated Systems Design (ISD) and System Capability and Manufacturing Process Demonstration (SC&MPD).

After the MS B decision for a program start, the ISD work effort begins during which a selected concept, typically brassboards or early prototypes, is refined through SE, analysis, and design. SE must manage all requirements as an integrated set of design constraints that are allocated down through the various levels of design and other technical activities (see example in Figure 2-2). This work effort ends when the integration of the system components during DT of prototypes demonstrates adequate maturity and readiness to either enter into SC&MPD or make a change to the acquisition strategy.

The SC&MPD work effort is intended to demonstrate the ability of the system to operate consistent with the approved key performance parameters (KPPs). Work advances the design to an engineering development model (EDM) that is evaluated for readiness to enter LRIP. The EDM should have demonstrated acceptable performance in DT&E and the Operational Assessment (OA), with acceptable interoperability and operational supportability. DT&E results include systems meeting KPPs and key system attributes (KSAs) as part of the exit criteria for EMD.

Preparation for the MS C decision establishes more refined cost, schedule, and performance objectives and thresholds, and the Capability Production Document (CPD) establishes the criteria for testing of LRIP items. Documents of interest to the T&E manager at the time of the MS C review include the ADM (exit criteria), updated TEMP, updated STA, AoA, Development Baseline, DT results, and the OA.

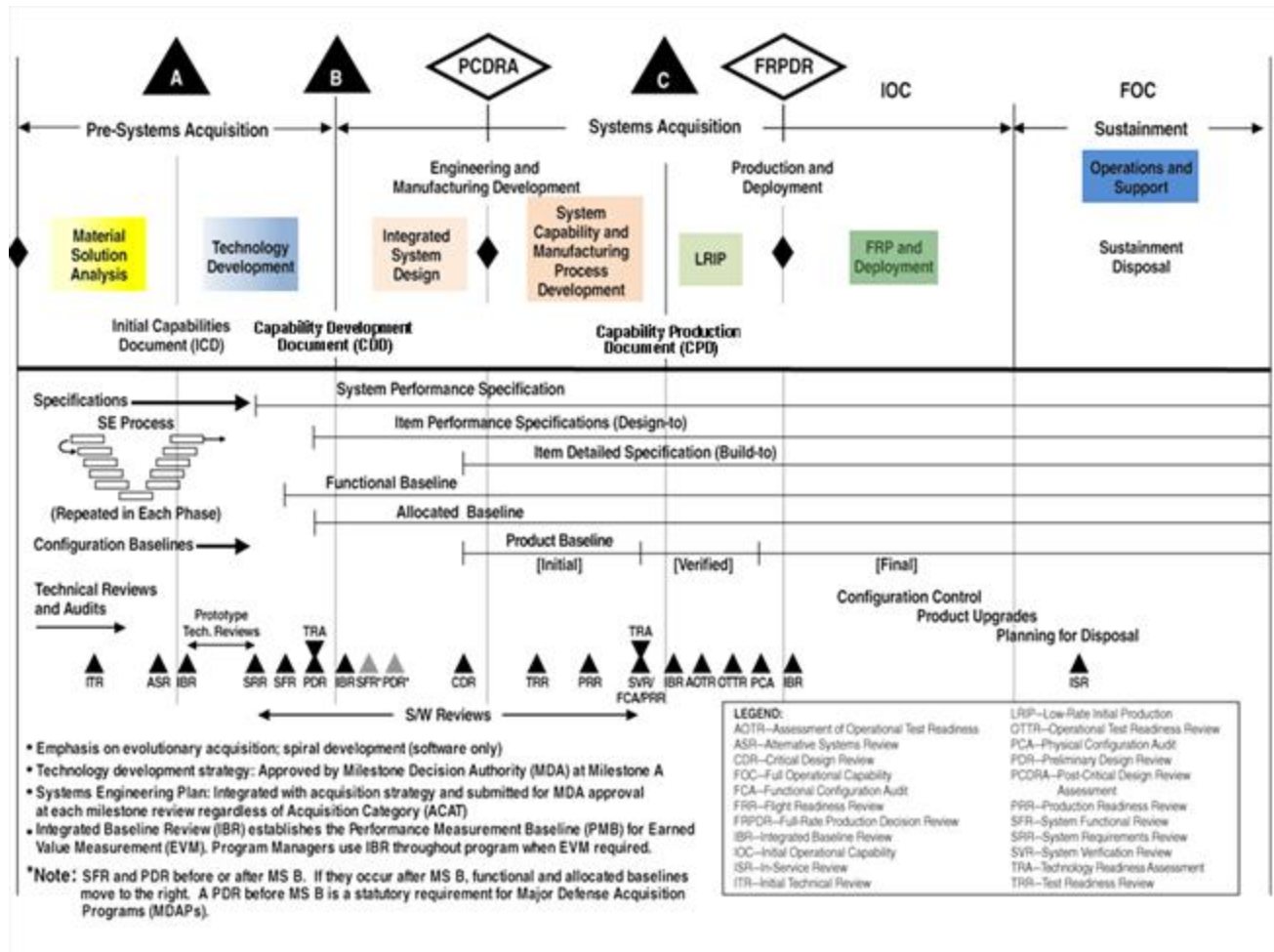


Figure 2-3 Key Technical Activities and Technical Reviews/Audits during the Acquisition Lifecycle

### 2.2.4.1 T&E Contributions During ISD

During the EMD phase, concepts approved for prototyping form the baseline that is used for detailed test planning. The design is matured into an EDM, which is tested in its intended environment prior to MS C.

In ISD, the development agency conducts DT&E to assist with engineering design, system development, and risk identification and to evaluate the contractors' ability to attain desired technical performance in system specifications and achieve program objectives. The DT&E includes T&E of components, subsystems, and prototype development models. T&E of functional compatibility, interoperability, and integration with fielded and developing equipment and systems is also included. During this phase of testing, adequate DT&E is accomplished to ensure that engineering is reasonably complete (including survivability/vulnerability, compatibility, transportability, interoperability, reliability, maintainability, safety, human factors, and logistics supportability). Also, this phase confirms that all significant design problems have been identified and solutions to these problems are in place.

The Service OT&E agency should conduct an OA for the Post-Critical Design Review Assessment (PCDRA) to estimate the systems potential to be operationally effective and suitable; identify needed modifications; and provide information on tactics, doctrine, organization, and personnel requirements. The early OT&E program is accomplished in an environment containing limited operational realism. Typical operational and support personnel are used to obtain early estimates of the user's capability to operate and maintain the system. Some of the most important products of user assessments of system maintainability and supportability are human factors and safety issues.

#### **2.2.4.2 T&E Contributions During SC&MPD**

In SC&MPD, the objective is to design, fabricate, and test a preproduction system that closely approximates the final product. T&E activities of the EDM during this period yield much useful information. For example, data obtained during EDM T&E can be used to assist in evaluating the systems maintenance training requirements and the proposed training program. Test results generated during EDM T&E also support the user in refining and updating employment doctrine and tactics.

T&E activities intensify during SC&MPD and make significant contributions to the overall acquisition decision process. During SC&MPD, T&E is conducted to satisfy the following objectives:

- As specified in program documents, assess the critical technical issues by:
  - Determining how well the development contract specifications have been met.
  - Identifying system technical deficiencies and focus on areas for corrective actions.
  - Determining whether the system is compatible and interoperable and can be integrated with existing and planned equipment or systems.
  - Estimating the RAM of the system.
  - Determining whether the system is safe and ready for LRIP.
  - Evaluating effects on performance of any configuration changes caused by correcting deficiencies, modifications, or product improvements (PIs).
  - Assessing human systems integration (HSI) and identify limiting factors.
- Assess the technical risk and evaluate the trade-offs among specifications, operational requirements, life cycle costs (LCCs), and schedules.
- Assess the survivability, vulnerability, and logistics supportability of the system.
- Verify the accuracy and completeness of the technical documentation developed to maintain and operate the weapons system.
- Gather information for training programs and technical training materials needed to support the weapons system.

- Provide information on environmental issues for use in preparing environmental impact assessments.
- Determine system performance limitations, capabilities, and safe operating parameters.

The development agency evaluates the results of T&E for review by the Service headquarters and the Service acquisition review council prior to system acquisition review by the MDA. The evaluation includes the results of testing and supporting information, conclusions, and recommendations for further engineering development. At the same time, the OT&E agency prepares an independent OA, which contains estimates of the systems potential operational effectiveness and suitability. The OA provides a permanent record of OT&E events, an audit trail of OT&E data, test results, conclusions, and recommendations. This information is used to prepare for MS C and supports a recommendation of whether the design and performance of the system in development justifies proceeding into LRIP.

### 2.2.5 P & D Phase

During the LRIP work effort, the purpose is to achieve an operational capability that satisfies mission needs. The selected system design and its principal items of support are fabricated as production configuration models. Test articles normally are subjected to qualification testing, interoperability certification, full-up LFT, and IOT&E. This work effort ends with the FRPDR or a Full-Rate Production Deployment Decision Review for MAIS or software-intensive systems with no production components. Timing of deployment of the system for initial operational capability (IOC) is usually determined by the Service. Key documents for the T&E manager at the time of the FRPDR are the updated TEMP, DT results, the Service IOT&E report, and LFT report. For ACAT I and designated oversight systems, the DOT&E is required by law to document the assessment of the adequacy of IOT&E and the reported operational effectiveness and suitability of the system. This is done in the BLRIP report. Also mandated by law is the requirement for the DOT&E to submit the LFT report prior to the program proceeding beyond LRIP. These DOT&E reports may be submitted as a single document.

The DOT&E will evaluate whether systems are production representative. Wherever practicable, IOT&E will be conducted using LRIP systems assembled using the parts, tools, and manufacturing processes intended for use in full-rate production (FRP).

The system will also utilize the intended production versions of software. In addition, the logistics system and maintenance manuals intended for use on the fielded system should be in place. When the use of LRIP articles is impractical, the system used in T&E should, at a minimum, incorporate the same parts and software to be used in LRIP articles. In particular, the hardware and software should be as defined by the system-level Critical Design Review (CDR), Functional Configuration Audit (FCA), and System Verification Review (SVR), including correction of appropriate major deficiencies identified during DT. Manufacturing processes to be used in FRP should also be adhered to as closely as possible.

### 2.2.5.1 T&E Contributions Prior to FRPDR

The development agency transitions the final design to LRIP while fixing and verifying any technical problems discovered during the final testing of the EDM in its intended environment. The maturity of the hardware and software configurations and logistics support system available from LRIP are assessed when the development agency considers certifying the systems readiness for IOT&E.

The DOT&E must be provided detailed information describing any process differences in order to independently evaluate whether the differences are acceptable. The Office of the DOT&E will assess adherence to DoD guidelines as part of its responsibility for reviewing and approving TEMPs and test plans. Proposals to use articles that are not from LRIP to conduct IOT&E will be considered.

IOT&E is conducted prior to the production decision at FRPDR to:

- Estimate system operational effectiveness, operational suitability, and survivability.
- Identify operational deficiencies.
- Evaluate changes in production configuration.
- Provide information for developing and refining logistics support requirements for the system and training, tactics, techniques, and doctrine.
- Provide information to refine O&S cost estimates and identify system characteristics or deficiencies that can significantly impact O&S costs.
- Determine whether the technical publications and support equipment are adequate in the operational environment.

Before the certification of readiness for IOT&E, the Service Acquisition Executive (SAE) should have obtained the JITC certification of interoperability for the system components. For the sake of efficiency and completeness, the AOTR should be conducted in conjunction with the DoD Components certification of readiness review. In parallel with IOT&E, LFT&E may be used to evaluate vulnerability or lethality of a weapon system as appropriate and as required by public law. The PMs briefing and the BLRIP report address the risks of proceeding into FRP.

### 2.2.5.2 T&E Contributions After the FRPDR

After FRPDR, when the FRP decision is normally made, T&E activities continue to provide important insights. Tests described in the TEMP but not conducted during earlier phases are completed. The residual DT&E may include extreme weather testing and testing corrected deficiencies. System elements are integrated into the final operational configuration, and DT is completed when all system performance requirements are met. During FRP, Government representatives normally monitor or conduct the PAT&E. Each system is verified by PAT&E for compliance with the requirements and specifications of the contract.

Post-production testing requirements may result from an acquisition strategy calling for increment changes to accommodate accumulated engineering changes or the application of preplanned product improvements (P3Is). Using a P3I strategy allows parallel development of new technology and modular insertion of system upgrades into production equipment. Technology breakthroughs and significant threat changes may require system modifications. The development of the modifications will require DT and an assessment of performance change to determine the need or appropriate level of OT.

OT&E activities continue after the FRP decision in the form of FOT&E. The initial phase of FOT&E may be conducted by either the OT&E agency or user commands, depending on Service directives. FOT&E verifies the operational effectiveness and suitability of the production system, determines whether deficiencies identified during IOT&E have been corrected, and evaluates areas not tested during IOT&E due to system limitations. Additional FOT&E may be conducted over the life of the system to refine doctrine, tactics, techniques, and training programs and to evaluate future increments, modifications, and upgrades.

The OT&E agency prepares an OA report at the conclusion of each FOT&E. This report records test results, describes the evaluation accomplished to satisfy critical issues and objectives established for FOT&E, and documents its assessment of resolved deficiencies. Deficiencies that are not corrected are recorded.

A final report on FOT&E may also be prepared by the using command test team, emphasizing the operational utility of the system when operated, maintained, and supported by operational personnel using the concepts specified for the system. Specific attention is devoted to the following:

- The degree to which the system accomplishes its missions when employed by operational personnel in a realistic scenario (natural, electronic, threat) with the appropriate organization, doctrine, supportability, survivability, vulnerability, and threat (including countermeasures; nuclear threats; effects; and nuclear, biological, and chemical (NBC)) environment using the tactics and techniques developed during earlier FOT&E.
- The degree to which the system can be placed in operational field use, with specific evaluations of availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, natural environmental effects and impacts, logistics supportability, and documentation and training requirements.
- The conditions under which the system was tested including the natural weather and climatic conditions, terrain effects, battlefield disturbances, and enemy threat conditions.
- The ability of the system to perform its required functions for the duration of a specified mission profile.
- System weaknesses such as the vulnerability of the system to exploitation by countermeasures techniques and the practicality and probability of an adversary exploiting the susceptibility of a system in combat.

A specific evaluation of the personnel and logistics changes needed for the effective integration of the system into the user's inventory is also made. These assessments provide essential input for the later acquisition phases of the system development cycle.

## 2.2.6 O&S Phase

The production continues at full rate allowing continued deployment of the system to operating locations and achievement of full operational capability (FOC). This phase may include major modifications to the production configuration, increment upgrades, and related FOT&E. Block upgrades, P3I, and similar efforts that provide a significant increase in operational capability are to be managed as separate increments with their own MS B and MS C in accordance with [Reference \(d\)](#). Evolutionary acquisition permits incremental development of capability and modification, but it is still necessary to ensure that appropriate planning is in place to sustain readiness and support of all fielded increments, and for some major modifications, it may require initiation of a new program. To determine whether major upgrades/modifications are necessary or deficiencies warrant consideration of replacement, the MDA may review the impact of proposed changes on system operational effectiveness, suitability, and readiness.

## 2.3 T&E and SE Processes

T&E activities are the cornerstone of the verification and validation (V&V) of technical processes used in SE, as well as supporting technical assessment efforts that are a key part of the overall DoD SE processes used for managing systems development. NOTE: DoD systems engineering processes are derived from [IEEE Std 15288-2008](#) (Reference (v)) and documented in [Chapter 4 \(Systems Engineering\)](#) of Reference (j). They consist of technical processes used for systems development and technical management processes used for controlling development efforts. The technical processes include stakeholder requirements definition, requirements analysis, architectural design, implementation (fabricate or code), integration, verification, validation, and transition. The technical management processes include requirements management, interface management, risk management, configuration management, technical data management, technical planning, technical assessment, and decision analysis.

Engineering T&E processes are a significant element in the decision-making process, providing data that support trade-off analysis, performance verification, risk reduction, and requirements refinement. Program decisions on system performance maturity and readiness to advance to the next phase of development take into consideration demonstrated performance. The T&E process provides data that tell the developer and user how well the system is performing during development and if it is ready for fielding. The PM must balance the risks of cost, schedule, and performance to keep the program on track to production and fielding. The responsibility of decision-making authorities centers on assessing risk trade-offs. T&E results provide key information in this regard.

As stated in [Reference \(d\)](#), T&E shall be integrated throughout the defense acquisition process. T&E shall be structured to provide essential information to decision makers, assess attainment of technical performance parameters, and determine whether systems are operationally effective, suitable, survivable, and safe for intended use. The conduct of T&E, integrated with M&S, shall facilitate learning,



assess technology maturity and interoperability, facilitate integration into fielded forces, and confirm performance against documented capability needs and adversary capabilities as described in the STAR.

SE is an interdisciplinary approach to evolve and verify an integrated and optimally balanced set of product and process designs that satisfy user needs and provide information for management decision making. Some of the systems engineering activities for one phase of the acquisition life cycle are illustrated in Figure 2-3.

A systems life cycle begins with the user's needs, which are expressed as constraints, and the required capabilities needed to satisfy mission objectives. Systems engineering is essential in the earliest planning period, in conceiving the system concept and defining performance requirements for system elements. As the detailed design is prepared, systems engineers ensure balanced influence of all required design specialties, including testability. Systems engineers resolve interface problems, perform design reviews, perform trade-off analyses, and assist in verifying performance.

System engineers coordinate the many specialized engineers involved in the concurrent engineering process and use integrated product and process development as an essential tool. IPTs are responsible for the integration of the components into a system.

Through interdisciplinary integration, a systems engineer manages the development efforts and progress of product definition from system level to configuration-item level, detailed level, deficiency correction, and modifications/PIs. Test results provide feedback to analyze the design progress toward performance goals. Technical management processes used as an integral part of systems engineering include technical design reviews, configuration management (CM), M&S, TPM, and trade-off analysis. Developmental and operational testing support the technical reviews by providing feedback to the systems engineering process. More information on the reviews is contained in later chapters.

### **2.3.1 Importance of the SEP**

Systems engineering is the iterative logical sequence of analysis, design, test, and decision activities that transforms an operational need into the descriptions required for production and fielding of all operational and support system elements. The SEP is a mandatory program-unique life-cycle document that describes key aspects of the programs systems engineering efforts. The SEP, TEMP and other T&E related program plans should be aligned to ensure that they are mutually supportive and consistent.

### **2.3.2 Technical Planning Process Activities**

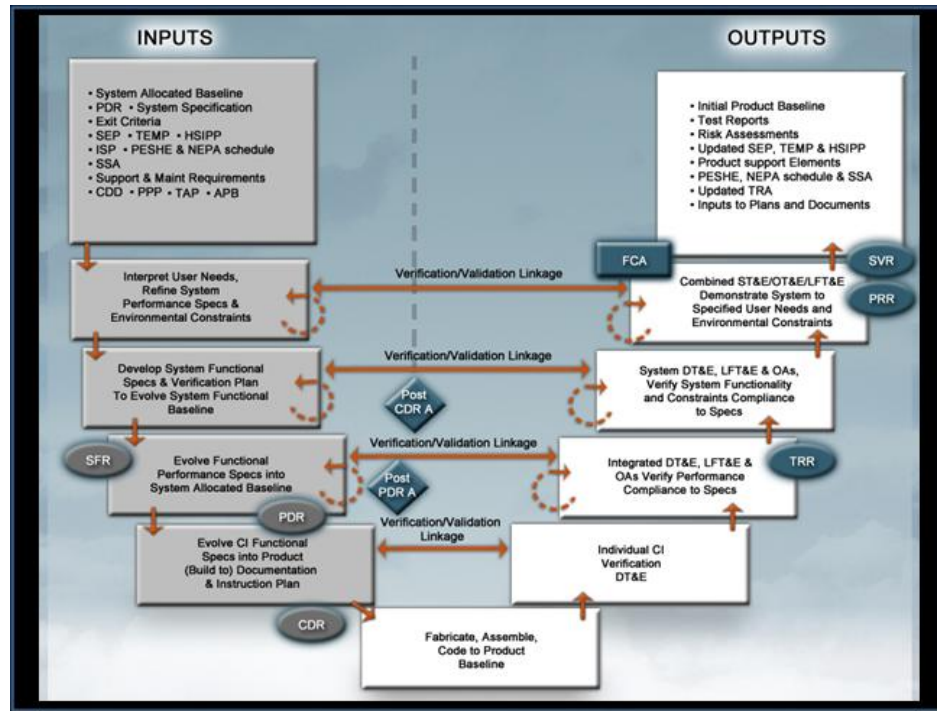
The technical management aspect of the technical planning process incorporates management planning for the integration of all system design activities. Its purpose is to develop the organizational mechanisms and document them in various plans, for direction and control, and identify personnel for the attainment of program objectives. Technical planning defines and describes the type and degree of systems engineering management, the SEP, the integration of several related program plans, and the TEMP.

The TEMP must be consistent with other program technical management planning efforts. The testing program outlined in the TEMP must ultimately be structured so as to provide the evaluation data required for all design decision points, audits, and reviews that are a part of the systems engineering process. A supporting process, the CM process, controls the systems baseline for the test programs to help ensure consistent test results over time as the design evolves and incorporates design modifications to the product baseline determined to be necessary by T&E.

The TEMP and other technical management planning documents, especially the SEP, must be traceable to each other and consistent. Key functions and interfaces of the system with other systems must be described and correlated with the systems engineering documentation and the system specification. Technical thresholds and objectives include specific performance requirements that become test planning limits. They must be traceable through the planned systems engineering documentation and can be correlated to the content of the measurement program. For example, failure criteria for reliability thresholds during OT&E must be delineated and agreed upon by the PM and the operational test director (OTD) and reflected in the TEMP.

### **2.3.3 T&E Role in Technical Reviews and Audits**

The role of T&E changes slightly during the technical reviews, design reviews, physical and functional configuration audits, etc., that are performed over the development life cycle (see Figure 2-4). Typically, the program office Chief Developmental Tester, or equivalent, plans, directs, or monitors DT&E activities. In technical reviews and audits, the role of the Chief Developmental Tester is to examine the contractor's approach to testing and evaluate the validity of the process and the accuracy of the contractor's results as presented during the reviews. The Chief Developmental Tester uses personal experience and background in T&E to assess whether the contractor did enough or too little testing; whether the tests were biased in any way; and whether they followed a logical progression using the minimum amount of time, effort, and funds while still gathering and providing adequate data for an informed decision. Each type of technical review or audit will have a different focus/orientation and specific entry and exit criteria, but the Chief Developmental Tester will always be concerned with the testing process and how it is carried out. After each review, the Chief Developmental Tester should always document all observations for future reference.



**Figure 2-4 Illustrative Systems Engineering Activities (EMD Phase)**

A pictorial roadmap of key activities in the systems acquisition processes-the Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System chart-is available at <https://ilc.dau.mil>. The short title for this chart is Integrated Life Cycle Chart. The chart is a training aid for DAU courses and illustrates the interaction of the three key processes that must work in concert to deliver the capabilities required by the Warfighters: the requirements process (Joint Capabilities Integration and Development System (JCIDS) process); the acquisition process (Defense Acquisition System process); and the program and budget development process (Planning, Programming, Budgeting, and Execution (PPBE) process).

### 2.3.4 TPM

TPM identifies critical technical parameters that are at a higher level of risk during design and forecasts their future values over time. TPM programs track T&E data, makes predictions about whether the parameter can achieve final technical success within the allocated resources, and assists in managing the technical program.

The TPM program is an integral part of the T&E program. TPMs programs are product design assessments and are part of the backbone of the DT program. TPMs programs estimate, through engineering analyses and tests, the future values of essential performance parameters of the current program design.

### 2.3.5 System Baselines and T&E

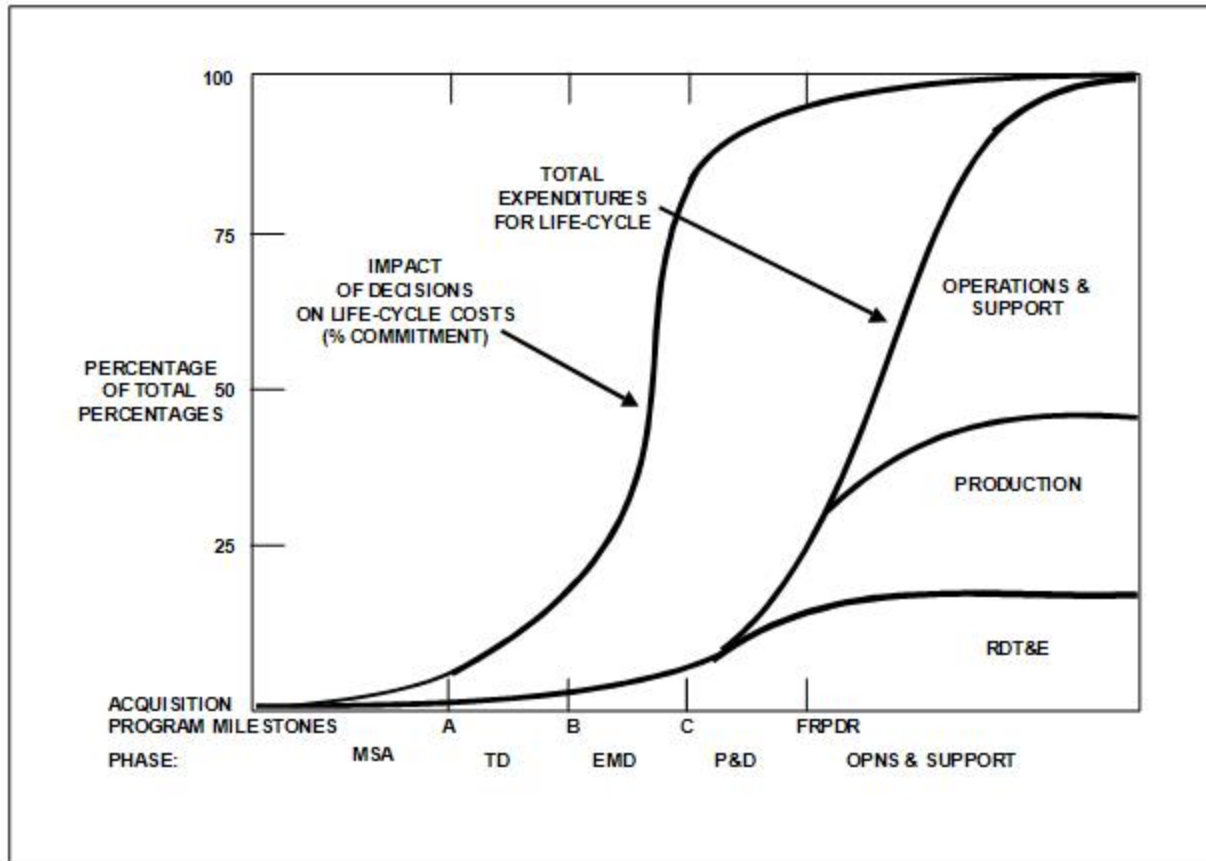
The SEP describes the process for establishing phase technical baselines and addresses how they will be controlled throughout the acquisition life cycle. These baselines (functional, allocated, product) can be modified with the results of engineering and testing. Management of such changes is controlled by CM activities.

An essential part of baseline control is CM. CM, one of the systems engineering technical management processes, benefits the T&E community in three ways: (1) the baseline to be used for testing is determined; (2) changes that occur to the baseline as a result of testing and design reviews are incorporated into the test article before the new phase of testing (to prevent retest of a bad design); and (3) CM produces statistically significant sample sizes that give greater confidence in the final T&E results.

### 2.3.6 T&E in support of Risk Management

Correcting defects later in the system development life cycle has been estimated to add from 10 percent to 30 percent to the cost of each item. Such costly redesign and modification efforts can be reduced if carefully planned and executed T&E helps to detect and fix system deficiencies early in the acquisition process. Fixes instituted during early work efforts cost significantly less than those implemented later, when most key design decisions have already been made.

T&E figures prominently in the decisions reached at design and milestone reviews. However, the fact that T&E results are required at major decision points does not presuppose that T&E results must always be favorable. The final decision responsibility lies with the decision maker who must examine the critical issues and weigh the facts. Only the decision maker can determine the weight and importance that is to be attributed to a systems capabilities and shortcomings and the degree of acceptable risk. The decision-making authority will be unable to make this judgment without a solid base of information provided by T&E. Figure 2-4 illustrates the LCC of a system and how the timing of key decisions impacts program expenditures.

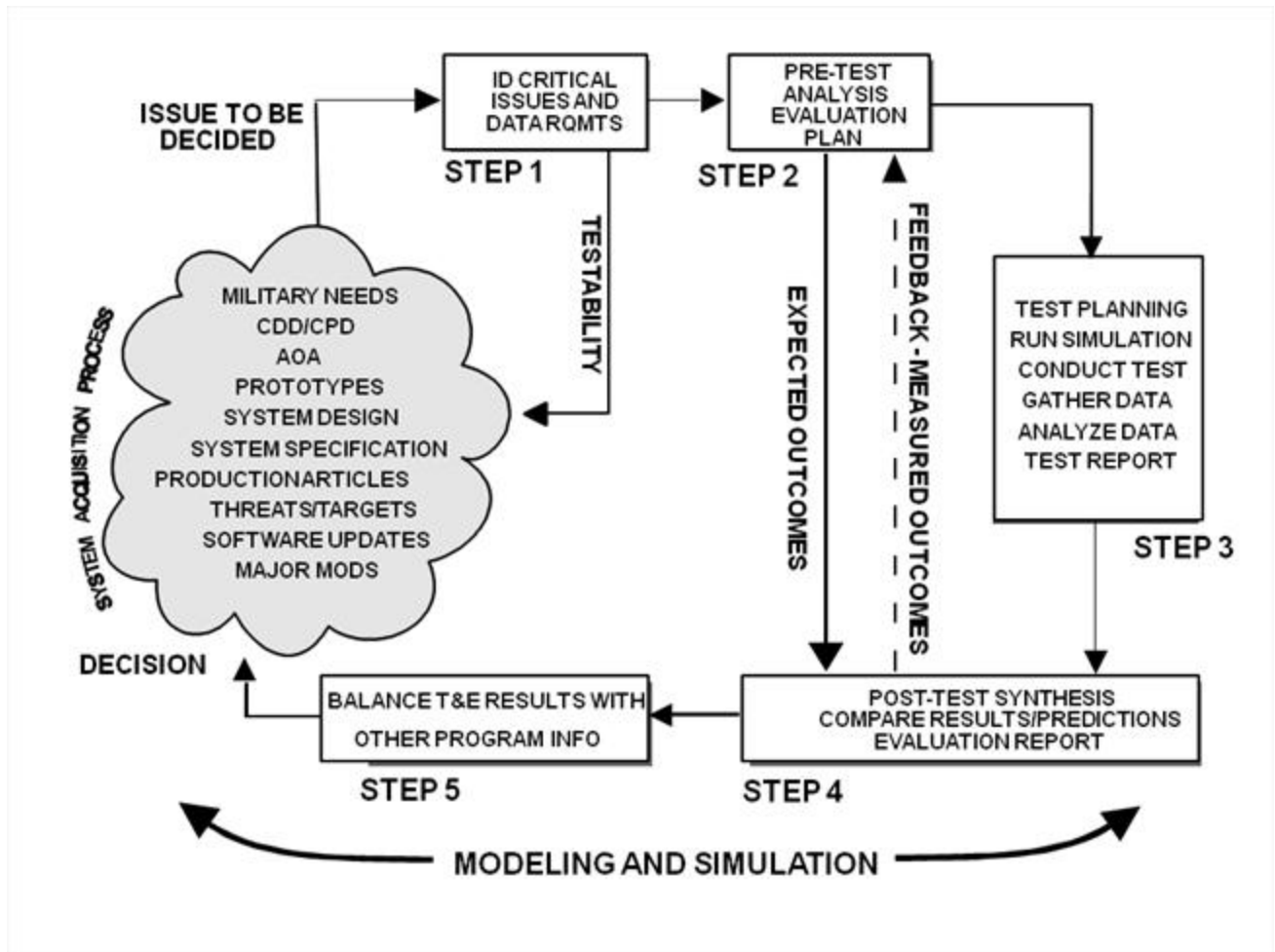


**Figure 2-5 Impact of Decision Timing on LCCs**

## 2.4 Five-Step Illustrative T&E Process

Outlined below and in Figure 2-6 is an illustrative five-step T&E process. This process can provide answers to critical T&E questions for decision makers at various times during a system acquisition. The T&E process should begin during the formative stages of a program with a T&E coordination function, in which the information needs of the various decision makers are formulated in conjunction with the development of the program requirements, acquisition strategy, and other analyses.

- In Step 1, T&E involvement begins with early feedback on measurability and testability of certain foundation documents that describe the capability needed. Feedback on test requirements and resources needed to support critical issue evaluation and data requirements should help shape the rationale for the given foundation documents that will baseline Step 1 identification of T&E information required for the decision maker. The required information usually centers on the current system under test, which may be in the form of concepts, prototypes, EDMs, or production-representative/production systems, depending on the acquisition phase. The required information consists of performance evaluations of effectiveness and suitability, providing insights into how well the system meets the user's needs at a point in time.



**Figure 2-6 Five Step Test and Evaluation Process**

- Step 2 is the pre-test analysis of the evaluation objectives from Step 1 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. The use of validated models and simulation systems during pre-test analysis can aid in determining how to design test scenarios, how to set up the test environment, how to properly instrument the test, how to staff and control test resources, how best to sequence the test trials, and how to estimate outcomes.
- Step 3, test activity and data management, is the actual test activity planning. Tests are conducted and data management for data requirements is identified in Step 2. T&E managers determine what valid data exist in historical files that can be applied and what new data must be developed through testing. The necessary tests are planned and executed to accumulate sufficient data to support analysis. Data are screened for completeness, accuracy, and validity before being used for Step 4.
- Step 4, post-test synthesis and evaluation, is the comparison of the measured outcomes (test data) from Step 3 with the expected outcomes from Step 2, tempered with technical and

operational judgment. This is where data are synthesized into information. When the measured outcomes differ from the expected outcomes, the test conditions and procedures must be reexamined to determine whether the performance deviations are real or were the result of test conditions, such as lack of fidelity in computer simulation, insufficient or incorrect test support assets, instrumentation error, or faulty test processes. The assumptions of tactics, operational environment, systems performance parameters, and logistics support must have been carefully chosen, fully described, and documented prior to test. M&S may normally be used during the data analysis to extend the evaluation of performance effectiveness and suitability.

- Step 5 is when the decision maker weighs the T&E information against other programmatic information to decide a proper course of action. This process may identify additional requirements for test data and iterate the DoD T&E process again.

## **2.5 Scientific Test and Analysis Techniques (STAT)**

STAT implements the use of scientific and statistical methods in developing rigorous, defensible test plans and the evaluation of their results. STAT assists the test community in improving the planning, execution, analysis, and reporting of integrated testing. One example of STAT is design of experiments (DOE).

### **2.5.1 DOE**

DOE, an application under STAT, is a structured process that provides the scientific and statistical methods needed to rigorously plan and execute testing. By following this process, testers gain the following benefits:

- An understanding of the likelihood of successfully identifying, as well as the likelihood of mistakenly identifying, significant performance drivers.
- A sound method for determining and justifying the number of tests planned and assets needed to obtain required information.
- The ability to make informed trade-offs of test costs (assets) versus information gained.
- A rigorous method of determining specific scenarios that provide the most useful data for characterizing system performance including deficiencies and for identifying drivers of system performance.
- The ability to identify interactions between test factors. This is seldom possible with other methods of developing test matrices.

DOE is sequential in nature, where each series of tests informs the next series of tests. Evaluations should take into account all available and relevant data and information from contractor test, DT, and



OT. DT results will be used to support OT findings and scope OT events. When utilized early in system development, DOE provides the most efficient method of identifying system deficiencies so that appropriate and timely corrective actions can be taken when costs of correcting deficiencies are minimized.

The DOE process involves the following steps:

1. Determine the purpose of the test to include output variables (results) that will be measured.
2. Determine the input variables (factors) that are expected to have an impact on results.
3. Determine the levels for each factor (e.g., for a factor range to target, levels may be 2 km and 10 km).
4. Determine constraints that must be considered when creating the test matrix. For example, a missile fired from an unmanned aerial vehicle (UAV) may have a maximum range to target of 10 km from a UAV at high altitude but only a 5-km range from low altitude. A constraint to prevent tests that would fire a missile from low altitude at a target 10 km away must be in place when creating the test matrix.
5. Create the test matrix and review it with interested parties/SMEs.
6. Execute tests.
7. Analyze test data.
8. Make decisions based on analysis.

In reality, steps 15 are an iterative process for several reasons that include the following:

- Constraints are not always easy to identify and SMEs may notice impossible/impractical test scenarios in a matrix that were not identified in advance.
- The number of test assets determined to be necessary may not be affordable. At this point, trade-offs of cost vs. information must be made.

Use of DOE in testing is appropriate for anything other than a simple demonstration of capability. It is useful in planning and executing component tests, simulation, hardware-in-the-loop (HWIL), and full-system testing. Ideally, because DOE is most powerful when applied sequentially, DOE will be utilized throughout development and testing in all areas. For example, early in a program, digital simulation is often the most mature tool available for evaluating system performance and making design decisions. DOE is used to create simulation test matrices to identify factors that should be tested in HWIL. A DOE for HWIL is then created that addresses these factors. Then data from HWIL is used to modify or validate the digital simulation. Because DOE was used, factors for which results in digital simulation and HWIL are different can be identified more accurately than if the tests were planned using another method.

DOE is a topic within DAU course TST 203, Intermediate Test and Evaluation. See the DAU interactive catalog of courses at <http://icatalog.dau.mil> . The Services also conduct courses (from basic to advanced) about DOE; the command or Service T&E office can provide more details. For additional reading and reference on DOE, many books are commercially available online.

During the approval process for TEMP's and test plans, elements of experimental design and the scientific and rigorous approach to testing will be reviewed. The TEMP (i.e., Parts III and IV) must include this information. See [Reference \(d\)](#) for specific guidance on required TEMP content at each milestone.

## **2.6 Summary**

T&E is an essential and critical discipline and an engineering tool. T&E is used to identify technical risk, verify performance, and validate system utility throughout the defense system acquisition life cycle. This iterative cycle consists of formally defined acquisition phases separated by discrete, decision-point milestones.

The DoD T&E process consists of developmental and operational integrated testing that is used to support assessment of engineering design maturity risk and programmatic milestone reviews. The T&E process forms an essential part of the development activities used by system developers and aids in the decision process used by senior decision authorities in DoD.

## Test & Evaluation Management Guide

### Chapter 3 - Program Office Responsibilities for T&E

#### 3.1 Introduction

In Government acquisition programs, there should be an element dedicated to the management of T&E. This element has the overall test program responsibility for all phases of the acquisition process. T&E expertise may be available through matrix support or reside in the PMO engineering department.

In accordance with [section 835 of Public Law 112-81 \(Reference \(w\)\)](#), each MDAP will be supported by a chief developmental tester and a governmental test agency that serves as the lead DT&E organization for the program. PMs for MDAP and MAIS ACAT I and IA programs shall designate a chief developmental tester (i.e., T&E key leadership position (KLP)) who will be responsible for:

Coordinating the planning, management, and oversight of all DT&E activities for the program.

Maintaining insight into contractor activities under the program and overseeing the T&E activities of other participating Government activities under the program.

Helping PMs make technically informed objective judgments about contractor DT&E results under the program.

PMs for all programs on OSD DT&E oversight shall designate a Government test agency to serve as the lead DT&E organization for the program. The lead DT&E organization has responsibility for:

Providing technical expertise on T&E issues to the chief developmental tester.

Conducting DT&E activities for the program, as directed by the chief developmental tester.

Assisting the chief developmental tester in providing oversight of contractors under the program.

PMs for all programs should establish a T&E WIPT to include SE, DT&E, OT&E, and representatives of all applicable certification authorities. All membership designations should be made as soon as practical after the Materiel Development Decision (MDD) and should be maintained until the program is removed from OSD T&E oversight.

The T&E WIPT should be established and chartered as early as possible during the MSA phase. The T&E WIPT is a defined forum supporting the PM/PMO as the T&E SMEs responsible for all aspects of a programs T&E effort. This effort includes T&E program strategy, design, development, oversight, support to other program WIPTs, and the analysis assessment and reporting of test results. Membership consists of the PM (Chair), Chief Developmental Tester (the PM may designate the Chief Developmental Tester as Chair (for ACAT I and ACAT IA programs, the Chief Developmental Tester is the chief developmental tester)), OSD (DASD(DT&E) and DOT&E), invited SMEs, functional representatives, certifying agencies, and contractors. The PM may form lower level functional working groups, which report to the T&E WIPT, to focus on specific areas such as integrated test planning, IA, software T&E,

reliability, M&S development and verification, validation, and accreditation (VV&A), and threat support. The T&E WIPT is established to:

- Provide a forum for all key organizations to be involved in the T&E effort.
- Develop and maintain the program T&E strategy.
- Develop and manage an integrated test program for M&S, DTs, and OTs to support evaluations.
- Develop and maintain the integrated test schedule.
- Identify and resolve issues.

Document a quality TES/TEMP schedule as quickly and as efficiently as possible, which necessitates that all interested parties are afforded an opportunity to contribute to the TES/TEMP development.

Typically, a Chief Developmental Tester position is established in a program office to act as the focal point for all T&E efforts. The Chief Developmental Tester normally leads the T&E WIPT, uses the SMEs to accomplish all tasks related to T&E, and consults with other T&E stakeholders on the T&E WIPT to obtain correct, accurate, and up-to-date information on T&E best practices. The Chief Developmental Tester uses the T&E WIPT to accomplish the T&E mission and carry out the responsibilities of the position. The five blocks in Figure 3-1 list the major T&E items or areas for each of the five acquisition phases in which a T&E WIPT must be involved. The items listed are not the only items of T&E WIPT concern. Items may be added depending on the nature of the product/system under development. For example, if the product/system is for multi-Service/Defense Agency use, there may be memorandums of agreement (MOAs) and/or memorandums of understanding (MOUs) regarding integrated testing, evaluation, and assessments.

Ideally, the PMO engages a T&E SME during the MSA phase to assist in early assessments of materiel solutions and development of test strategies that will support the acquisition strategy at MS A. By the start of the TD phase, a PMO should have a Chief Developmental Tester. In the PMO, the Chief Developmental Tester would be responsible for defining the scope and concept of the test program, establishing the overall program test objectives, and managing test program funds and coordination. The Chief Developmental Tester should develop the RFP language regarding testing, in close coordination with systems engineering, RAM, and logistics activities

Materiel Solution Analysis	Technology Development	Engineering & Manufacturing Development	Production & Deployment	Operations & Support
<ul style="list-style-type: none"> <li>•Technology Development Strategy (TDS)</li> <li>•Test Evaluation Strategy (TES)</li> <li>•ID emerging T&amp;E capability requirements</li> <li>•ID T&amp;E resources</li> <li>•Develop T&amp;E requirements in RFP</li> <li>•Annual Report</li> </ul>	<ul style="list-style-type: none"> <li>•Test and Evaluation Master Plan (TEMP)</li> <li>•Execute T&amp;E Program</li> <li>•Provide T&amp;E results for OIPT/DAB</li> <li>•CDD requirements for testability and evaluation</li> <li>•TRL Evaluation</li> <li>•T&amp;E requirements in RFP</li> <li>•Annual Report</li> </ul>	<ul style="list-style-type: none"> <li>•Test and Evaluation Master Plan (TEMP)</li> <li>•Execute T&amp;E Program</li> <li>•Provide T&amp;E results for OIPT/DAB</li> <li>•Support SE Tech Review (PDR)</li> <li>•CPD requirements for testability and evaluation</li> <li>•Define system capabilities and limitations</li> <li>•Discovery and deficiencies</li> <li>•Annual Report</li> </ul>	<ul style="list-style-type: none"> <li>•Test and Evaluation Master Plan</li> <li>•Verification of corrections for deficiencies</li> <li>•T&amp;E results for OIPT/DAB</li> <li>•OTRR</li> <li>•IOT&amp;E</li> <li>•Annual Report</li> </ul>	<ul style="list-style-type: none"> <li>•Follow-on DT and OT</li> <li>•Verification of corrections for deficiencies</li> <li>•Develop T&amp;E programs to support upgrades, modifications, increments</li> </ul>

**Figure 3-1 T&E WIPT Focus Areas**

and closely coordinate schedule and resources with his or her logistics (training, logistics demonstrations) and RAM counterparts. The Chief Developmental Tester will typically be responsible for setting up data collection at various field activities that will support RAM, logistics, and quality team members, as well as allocating test assets to support various activities. The Chief Developmental Tester should provide test directors for detailed planning of DT phases and test events as required and coordinate test resources, facilities, and their support required for each phase of testing. In addition, the Chief Developmental Tester or a staff member will be responsible for managing the TEMP and planning and managing any special test programs required for the program. The Chief Developmental Tester will also review, evaluate, approve, and release for distribution contractor-prepared test plans and reports, and review and coordinate all appropriate Government test plans. The Chief Developmental Tester prepares criteria, coordinates test readiness reviews (TRRs), and participates in systems engineering technical reviews (SETRs) and milestone reviews by providing results of test reports and relevant information on updates to future testing based on current system development progress. After the system is produced, the Chief Developmental Tester will be responsible for supporting PAT&E and the test portions of later increments, upgrades, or enhancements to the weapon system/acquisition.

### 3.2 Relationship To The PM

The PM is ultimately responsible for all aspects of system development, including testing. The Chief Developmental Tester, a highly experienced T&E professional, is normally authorized by the PM to conduct all duties in the area of T&E. Inputs from the Chief Developmental Tester to the contract, engineering specifications, systems engineering efforts, budget, program schedule, etc., are essential if the PM is to manage T&E aspects of the program efficiently. The Chief Developmental Tester requires strong personal communication and teaming skills to ensure that independent testing and reporting effectively contribute to the overall goals that the PM establishes for cost, schedule, and performance. In accordance with the [USD\(AT&L\) Memorandum](#) (Reference (x)), the Program Lead Test and Evaluation (chief developmental tester) for ACAT I and IA programs shall be designated as the T&E KLP. This section

contains typical suggested activities that such an individual would accomplish in support of the PM mission.

Before the initial draft of the RFP is created, the Chief Developmental Tester must form an IPT, a test planning/integration working group. This group should include members from the OTA, DT agency, organizations that may be jointly acquiring the same system, test supporting agencies, operational users, oversight authorities (e.g., DASD(DT&E), DOT&E), and any other organizations that will be involved in the test program by providing test support or by conducting, evaluating, or reporting on testing. The Chief Developmental Tester should stand up the T&E WIPT prior to the development of the RFP, if possible. When a program has joint interoperability requirements, a DISA capability test team (CTT) chairman represents the DISA commander and JITC at program T&E WIPT and similar working groups. The functions of the groups are to facilitate the use of testing expertise, instrumentation, facilities, simulations and models; integrate test requirements; accelerate the TES/TEMP coordination process; resolve test cost and scheduling problems; implement a STAT process that maximizes the use of data to increase the use of scientific and statistical methods in developing rigorous, defensible test plans and in evaluating their results; and provide a forum to ensure that T&E of the system is coordinated. The existence of a test coordinating group does not alter the responsibilities of any command or headquarters; and in the event of disagreement within a group, the issue is resolved through the normal command/staff channels. In later meetings, the contractor participates in this test planning group; however, the contractor may not be selected by the time the first meetings are held.

The purpose of these meetings is to develop early test documentation, the TES documents, and to agree on basic test program schedules, scope, support, etc. The TEMP serves as the top-level test management document for the acquisition program, requiring updates when necessary and at specific milestones.

### 3.3 Early Program Stages

In the early stages of a program, the T&E function is often handled by matrix support from the sponsoring materiel command. Matrix T&E support or the Chief Developmental Tester should be responsible for development of T&E plans and planning documents and the T&E sections of the RFP in accordance with the Office of the [DASD\(DT&E\) Guidebook](#) (Reference (y)) for developing sections of the RFP. The ultimate responsibility for the RFP is between the PM and the primary contracting officer (PCO), however, the Chief Developmental Tester is responsible for several areas, for example: the test schedule, test program funding (projections), test data requirements for the program (test reports, plans, procedures, quick-look reports, etc.), determination of appropriate verification methods and their documentation in part 4 of the systems specification, coordination with logistics and RAM regarding test assets and resources needed to support their efforts, the test section of the statement of work (SOW), portions of the acquisition plan, information for proposal preparation, feedback on the CDD, and if a joint acquisition program, integration of multiple Services requirements.

### 3.3.1 Role of Memorandums

Early in the program, another task of the Chief Developmental Tester is the arrangement of any MOAs/MOUs or program-level agreements between the Services, North Atlantic Treaty Organization (NATO) countries, test organizations, etc., which outline the responsibilities of each organization. The RFP and SOW outline contractor/Government obligations and arrangements on the access and use of test facilities (contractor or Government owned).

### 3.3.2 Test Data Management

The Chief Developmental Tester will have approval authority for selected contractor-created test plans, procedures, and reports. The Chief Developmental Tester must have access to selected contractor testing and test results, and the Chief Developmental Tester is responsible for disseminating the results to Government agencies that need this data. The DASD(DT&E), the DOT&E, and their designated representatives shall have full and immediate access to all records, reports, and data including but not limited to data from all tests, system logs, execution logs, test director notes, user/operator assessments, etc. All data include but are not limited to classified, unclassified, and competition-sensitive data, or proprietary data when available. Data may be preliminary and shall be identified as such. Additionally, the Chief Developmental Tester creates report formats and timelines for contractor submittal, Government approval, etc. ( [Reference \(d\)](#) )

The data requirements for the entire test program are outlined in the contract data requirements list (CDRL). The Chief Developmental Tester should review the Acquisition Streamlining & Standardization Information System (ASSIST) which is now the official source of all documents listed in the DoDISS and all DIDS. The ASSIST database is maintained by the Defense Automated Printing Service (DAPS) in Philadelphia, PA. A feature called "QuickSearch" lets users search the ASSIST database for defense and federal specifications and standards, military handbooks, Qualified Products Lists (QPLs), and other documents listed in the DoDISS and DIDS. "Assist Online" offers the features of QuickSearch, plus analyses, reports, SD-1 contracts, project and other information. New users must complete the online registration. Log In Accounts for the ASSIST are free to DoD and to the public. The address to ASSIST is <https://assist.daps.dla.mil> . The Chief Developmental Tester provides input to this section of the RFP early in the program. The Chief Developmental Tester ensures that the office and all associated test organizations requiring the information receive the required test documentation on time. Usually, the contractor sends the data packages directly to the Chief Developmental Tester, who in turn has a distribution list trimmed to the minimum number of copies for agencies needing that information to perform their mission and oversight responsibilities. It is important for the Chief Developmental Tester to use an integrated test program and request contractor test plans and procedures well in advance of the actual test performance to ensure that the office of the Chief Developmental Tester has time to approve the procedures or implement modifications.

The Chief Developmental Tester must receive the test results and reports on time to enable the office of the Chief Developmental Tester, the PM, and higher authorities to make program decisions. The data received should be tailored to provide the minimum information needed. The Chief Developmental

Tester must be aware that data requirements in excess of the minimum needed may lead to an unnecessary increase in overall program cost. For data that are needed quickly and informally (at least initially), the Chief Developmental Tester can request quick-look reports that give test results immediately after test performance. The Chief Developmental Tester is also responsible for coordinating with the contractor on all report formats and the specific format requirements in the contract. In general, the in-house contractor format is acceptable in most cases and the Chief Developmental Tester must determine the reports utility before adding cost to contracts for using other specific T&E formats.

The contract must specify what data the contractor will supply, which organizations will receive the data, and whether any outside agencies will be included in direct distribution. The PMO Chief Developmental Tester should include the OTA on the distribution list for all test documents that are of concern during the DT&E phase of testing so they will be informed of test item progress and previous testing. In this way, the OTA will be informed when developing its own test plans and procedures for OT&E. In fact, OTA representatives should attend the CDRL Review Board meeting and provide the PMO with a list of the types of documents the OTA will need. The Chief Developmental Tester should coordinate the test sections of this data list with the OTA and indicate concerns at that meeting. All contractor test reports should be made available to the OTA. In return, the Chief Developmental Tester must stay informed of all OTA activities, understand the test procedures, and plan and receive the test reports. Unlike DT&E and contractor documentation, the PMO Chief Developmental Tester will not have report or document approval authority for OT&E items. The Chief Developmental Tester is responsible for keeping the PM informed of OT&E results. Additional information is available in [Reference \(y\)](#).

### 3.3.3 Test Schedule Formulation

An important task the Chief Developmental Tester has during the creation of the RFP is a test program schedule that supports the evaluation framework (contractor and Government DT&E plus OT&E events). Initially, the PM will need contractor predictions of the hardware availability dates for models, prototypes, mock-ups, full-scale models, etc., once the contract is awarded. The Chief Developmental Tester uses this information and the early test planning in the TES to create a realistic front-end schedule of the in-house testing the contractor will conduct before Government testing (DT&E, OT&E, and interoperability, IA, and security testing). Then, a draft integrated schedule is developed upon which the Government testing schedules can be formulated and contractor support requirements can be determined. The Chief Developmental Tester can use past experience in testing similar weapon systems/acquisition items or contract test organizations that have the required experience to complete the entire test schedule. Because the test schedule is a critical contractual item, contractor input is very important. The test schedule will normally become an item for negotiation once the RFP is released and the contractor's proposal is received. Attention must be given to ensure that the test schedule is not so success oriented that retesting of failures will cause serious program delays for either the Government test agencies or the contractor.

Another important early activity to be performed by the Chief Developmental Tester is to coordinate the OT&E test schedule. Since the contractor may be required to provide support, the OT&E test support may need to be contractually agreed upon before contract award. Sometimes, the Chief Developmental



Tester can formulate a straw-man schedule (based on previous experience) and present this schedule to the OT representative at the initial T&E IPT meeting for review, or the Chief Developmental Tester can contact the OTA and arrange a meeting to discuss the new program. In the meeting, time requirements envisioned by the OTA can be discussed. Input from that meeting then goes into the RFP and to the PM.

Before setup of IOT&E, certification of readiness for IOT&E may require a time gap for review of DT&E test results and refurbishment or corrections of deficiencies discovered during DT&E. Time is also needed for the OTA to make final arrangements to start its portion of the T&E program. The test schedule for DT&E should not be overrun so that the IOT&E test schedule is adversely impacted, reducing program schedule time with inadequate OT or rushing the reporting of IOT&E results. For example, if the DT&E schedule slips 6 months, the OT&E schedule and milestone decision should slip also. IOT&E should not be shortened just to make a milestone decision date.

### **3.3.4 Programmatic Environmental Analysis**

PMO personnel should be sensitive to the potential environmental consequences of system materials, operations, and disposal requirements. Public Laws (parts 15001508 of [Title 40, Code of Federal Regulations](#) (Reference (z)); National Environmental Policy Act (NEPA) regulations; [Executive Order 12114](#) (Reference (aa)); DoD 5000 Series; etc.) require analysis of hazardous materials and appropriate mitigation measures during each acquisition phase. As indicated in [Reference \(j\)](#), planning should consider the potential testing impacts on the environment.

Litigation resulting in personal fines and imprisonment against Government employees has raised the environmental awareness at test ranges and facilities. Environmental impact statements (EISs) (supported by long, thorough, and costly studies and public testimony) or environmental analysis and assessments are generally required before any system testing can be initiated.

### **3.4 PMO/Contractor Test Management**

The PMO will, in most cases, have a contractor test section counterpart. With this counterpart, the Chief Developmental Tester works out the detailed test planning, creation of schedules, etc., for the system end-to-end test program. The PMO uses input from all sources (contracts, DT agencies, OTAs, higher headquarters, etc.) to formulate the test programs length, scope, and necessary details. The Chief Developmental Tester ensures that the RFP:

Describes exactly how the contractor will support Government T&E and the contractor's role in the acquisition and T&E processes.

Requires Government review of contractor test plans before test execution and that the contractor's deficiency reporting (DR) system is compatible with and feeds into the Governments DR system.

Includes provisions for Government attendance at contractors' tests and that contractor test results, consistent with the contract, are provided to the Government.

See [Reference \(y\)](#) for additional guidance.

Experience indicates that most programs use a success based timeline when planning the integrated program schedule, meaning that each event or activity is based on positive results and moving to the next activity or phase of the acquisition effort. Experience also indicates that this concept is a major fault in most program planning. Although T&E is best managed as event driven, in most cases it is not practical in practice; therefore, the Chief Developmental Tester must provide realistic timelines for preparation, execution, analysis, and reporting to enable the PM to effectively balance cost, schedule, and performance. The most significant impact of success-based planning is the IOT&E. This is a statutorily mandated requirement that comes near the end of the development cycle, and meant to provide the Head of the Component and MDA with an independent evaluation of the operational effectiveness, operational suitability, and survivability of the system. The Chief Developmental Tester must keep the PMO informed of pending risks to the adequacy of schedule in completing post-DT&E analysis, reporting, and system corrections before proceeding into IOT&E with its subsequent timeline for preparations, execution, analysis, and reporting before the milestone date. Major delays to any testing schedule require full consideration of the PMO and MDA in slipping milestone decisions a corresponding amount of time.

Once agreement on the contractor's technical approach is reached, the Chief Developmental Tester is responsible for providing inputs to the Government contracting officer during negotiations. The T&E contract deliverables are assigned contract line item numbers, which are created by the Chief Developmental Tester. This assignment will ensure that the contractor delivers the required performances at specified intervals during the life of the contract. Usually, there will be separate contracts for development and production of the acquisition item. For each type of contract, the Chief Developmental Tester is responsible for providing the PCO and PM with T&E input.

For programs on DT&E oversight, the PM must identify each test phase or major event in the TEMP as contractor or Government DT&E. All programs must plan for the conduct of DT&E or integrated testing that includes or is led by Government personnel, so as to provide confidence that the system design solution is on track to execute the operational scenarios identified by the OTAs.

### **3.5 Test Program Funding/Budgeting**

The PMO must identify funds for testing early so that test resources can be obtained. The Chief Developmental Tester uses the acquisition schedule, TEMP, and other program and test documentation to identify test resource requirements. The Chief Developmental Tester coordinates these requirements with the contractor and Government organizations that have the test facilities to ensure that the facilities are available for testing. The Chief Developmental Tester ensures that test costs include contractor and Government test costs. The contractor's test costs are normally outlined adequately in the proposal; however, the Government test ranges, instrumentation, and test-support resource costs must be determined by other means. Usually, the Chief Developmental Tester contacts the test organization and outlines the test program requirements, and the test organization sends the program office an estimate of the test program costs. The Chief Developmental Tester then obtains cost estimates from all test sources that the Chief Developmental Tester anticipates using and supplies this information to the PM. Programs should use DoD Government T&E capabilities and invest in

Government T&E infrastructure unless an exception can be justified as cost-effective to the Government. The Chief Developmental Tester should also ensure that any program funding reductions are not absorbed entirely by the test program. Some cutbacks may be necessary and allowable, but the test program should supply decision makers with enough information to make rational program milestone decisions.

### 3.6 Contractor Testing

The Chief Developmental Tester is responsible for ensuring that contractor-conducted tests are monitored by the Government to allow for evaluation of the design solution. The Chief Developmental Tester must be given access to appropriate contractor data, test results, and test reports, consistent with the technical data rights and access provisions that have been contractually specified. The Chief Developmental Tester should be judicious in deciding whether to require Government approval of contractor test plans and whether the Government has the right to witness all contractor-run test events, take delivery of all contractor test data, and approve contractor test reports. All such Government involvement adds cost and schedule to the contractor test program and should be carefully planned and managed.

Usually, the contract requires that Government representatives be informed ahead of time of any testing the contractor conducts so that the Government can arrange to witness certain testing or receive results of the tests. Further, the contractor's internal data should be available as a contract provision. The Chief Developmental Tester must ensure that Government test personnel (DT&E/OT&E) have access to contractor test results. It would be desirable to have all testers observe some contractor tests to help develop confidence in the results and identify areas of risk. NOTE: The Defense Contract Management Agency (DCMA), as part of its mission, has in-plant representatives at various defense manufacturing facilities. As part of their support to the program office, a formal MOA is negotiated with the PMO. That MOA may include support from DCMA to witness various in-plant tests, which can be an essential resource in this area. Additional information is available in [Reference \(y\)](#).

### 3.7 Specifications

Within the program office, the engineering section usually is responsible for the system performance specification(s) as released with the RFP. The contractor is then tasked with creating the detailed design specification documentation as called out by the contract, which will be delivered once the item/system design is formalized for production.

The Chief Developmental Tester performs an important function in specification formulation by reviewing the specifications to determine whether performance parameters and stated capability needs are testable; whether current, state-of-the-threat technology can determine (during the DT&E test phase) whether the performance specifications are being met by the acquisition item; or whether the specified parameters are too tight. A specification is too tight if the requirements (section 3) are impossible to meet or demonstrate, or if the specification has no impact on the form, fit, or function of the end-item, the system of which it will become a part, or the system with which it will interact. The Chief Developmental Tester must determine whether test objectives can be adequately formulated from

those specifications that will provide thresholds of performance, minimum and maximum standards, and reasonable operating conditions for the end-items final mission and operating environment. The specifications shape the DT&E scenario, test ranges, test support, targets, etc., and the way in which the specifications are developed and stated is very important to the Chief Developmental Tester.

Among other quality attribute criteria, a key part of any specification requirement is that it be stated in such a way that it can be verified (i.e., testable). The Chief Developmental Tester should be involved in specification development and ideally review system stated requirements from this perspective. In this regard, paragraph 5.8 of [Military Standard MIL-STD-961E](#) (Reference (ab)), establishes the following criteria for stating requirements:

- Each requirement shall be stated in such a way that an objective verification can be defined for it.
- Each requirement shall be cross-referenced to the associated verification.
- Only requirements that are necessary, measurable, achievable, and verifiable shall be included.
- Requirements shall be worded to provide a definitive basis for acceptance or rejection.
- Requirements shall be described in a manner to encourage competition.
- Requirements shall be worded such that each paragraph only addresses one requirement or topic.

### **3.8 Independent T&E Agencies**

The PMO Chief Developmental Tester does not have direct control over Government-owned test resources, test facilities, test ranges, test range personnel, etc. Therefore, the Chief Developmental Tester must depend on those DT or OT organizations controlling them and stay involved with the test agency activities to maximize opportunities for integrated testing.

The amount of involvement depends on the item being tested; its complexity, cost, and characteristics; the length of time for testing; the amount of test funds; etc. Usually, the nuts and bolts detailed test plans and procedures are written by the test organizations controlling the test resources with input and guidance from the PMO Chief Developmental Tester. The Chief Developmental Tester is responsible for ensuring that the tests (DT&E) are performed using test objectives based on the specifications and that the requirements of timeliness, accuracy, and minimal costs are met by the test program design. During the testing, the Chief Developmental Tester monitors test results. The test agencies (DT/OT) submit a copy of their report to the program office at the end of testing, usually to the office of the Chief Developmental Tester. The Army is the only Service to have a designated independent evaluation agency, which provides test data analysis and feedback to the program office.

### **3.9 PMO Involvement In OT&E Activities**

In the Government PMO, there should be a group responsible for integrating T&E. Besides being responsible for DT&E support to the PM, this group should be responsible for program coordination with the OT&E agency. Program T&E metrics for success and OT&E entrance criteria should be developed considering lessons learned from T&E (see Figure 3-2). The offices of the systems engineer or

the Chief Developmental Tester may be designated to provide this support to the PM. In some Services, responsibilities of the Chief Developmental Tester include coordination of test resources for all phases of OT&E.

### 3.9.1 Contractor Responsibilities

- Understand the policies
- Organize for T&E
- Keep system requirements documents current
- Agonize over system thresholds
- Work closely with the operational test director
- Don't forget about operational suitability
- Make final DT&E a rehearsal for IOT&E
- Prepare interfacing systems for your IOT&E
- Manage software testing closely
- Track availability of test resources and test support personnel/facilities
- Identify the lack of any test resource capability to DASD(TT&E) and DOT&E

Source: Matt Reynolds, NAVSEA

**Figure 3-2 Some T&E "Lessons Learned"**

The Deputy for T&E or a T&E representative ensures that certain sections of the RFP contain sufficient allowance for T&E support by contractors. This applies whether the contract is for a developmental item, a production item (limited production, such as LRIP or FRP), or the enhancement/upgrade of portions of a weapons system. Where allowed within the law, contractor support for OT&E should be considered to help resolve basic issues such as data collection requirements, test resources, contractor test support, and funding. Chief Developmental Tester or a T&E representative ensures that certain sections of the RFP contain sufficient allowance for T&E support by contractors. This allowance applies whether the contract is for a developmental item, a production item (limited production, such as LRIP or FRP), or the enhancement/upgrade of portions of a weapons system. Where allowed within the law,

contractor support for OT&E should be considered to help resolve basic issues such as data collection requirements, test resources, contractor test support, and funding.

In the overall portion of the RFP, Government personnel, especially those in the OTAs, must be guaranteed access to the contractor's development facilities, particularly during the DT&E phase. Government representatives must be allowed to observe selected contractor in-house testing and have access to contractually deliverable test data and reports.

### **3.9.2 Technical Data Requirements**

The contract must specify what data the contractor will supply to the OTA. Unlike DT&E, the contractor will not be creating the OT&E plans, procedures, or reports. These documents are the responsibility of the OTA. Section 2399d of Title 10, U.S.C. (Reference (b)), restricts the contractor from creating the OT&E plans, procedures, or reports or participating in the development of those documents. The PMO Chief Developmental Tester should include the OTA on the distribution list for all test documents that are of concern during the DT&E phase of testing so they will be informed of test item progress and previous testing. In this way, the OTA will be informed when developing its own test plans and procedures for OT&E. In fact, the OTA should provide the PMO with a list of the types of documents the OTA will need, and an OTA representative should attend the CDRL Review Board meeting. The Chief Developmental Tester should coordinate the test sections of this data list with the OTA and indicate concerns at that meeting. All contractor test reports should be made available to the OTA. In return, the Chief Developmental Tester must stay informed of all OTA activities, understand the test procedures and plans, and receive the test reports. Unlike DT&E, the PMO Chief Developmental Tester will not have report or document approval authority as does the Chief Developmental Tester over contractor documentation. The Chief Developmental Tester is always responsible for keeping the PM informed of OT&E results.

### **3.9.3 Test Schedules**

Another important early activity that the Chief Developmental Tester must accomplish is to coordinate the OT&E test schedule. If the contractor is required to provide support to the OT&E, then that support must be included in the SOW and RFP and placed in the contract. Sometimes, the Chief Developmental Tester can formulate a draft schedule (based on previous experience) and present this schedule to the operational test representative at the initial Test Planning Working Group (TPWG) for review, or the Chief Developmental Tester can contact the OTA and arrange a meeting to discuss the new program. In the meeting, time requirements envisioned by the OTA can be discussed. Input from that meeting then goes into the RFP and to the PM.

The test schedule must allow time for DT&E and OT&E if testing is not combined or test assets are limited. Before setup of IOT&E, the certification of readiness for IOT&E process may require a time gap for review of DT&E test results and refurbishment or corrections of deficiencies discovered during DT&E, etc. The test schedule for DT&E should not be so success oriented that the IOT&E test schedule is adversely impacted, not allowing enough time for adequate OT or the reporting of IOT&E results. Additionally, the overall program schedule must allow for sufficient evaluation time following an OT

event to allow the OTA to make a well-informed recommendation for the coming acquisition program decision.

### **3.9.4 Contractor Support**

[Sections 2399\(d\) and \(e\)](#) of Reference (b), place limits on contractor involvement in IOT&E of ACAT I and II programs. A long-standing DoD best practice has been to apply these limitations to all OT&E programs regardless of ACAT. The Chief Developmental Tester and the T&E IPT must recognize some key distinctions between different types of contractors and the limitations placed on each type. The Chief Developmental Tester and the T&E IPT must provide inputs to the SOW, RFP, and other documents with regard to contractor support. Some contractor involvement is permitted in OT&E.

#### **3.9.4.1 System Contractors**

According to [section 2399\(d\)](#) of Reference (b), operational testers must strictly avoid situations in which system contractors could reduce the credibility of OT results or compromise the realistic accomplishment of OT scenarios. [Section 2399\(d\)](#) of Reference (b) permits limited system contractor involvement in OT if the operator plans for the contractor to be involved in the operation, maintenance, and support of the system when deployed in combat. If not, no system contractor support is allowed during IOT&E. Any deviations/waivers must be approved by the DOT&E.

#### **3.9.4.2 System Contractor Support to OT**

System contractors may be beneficial in providing logistic support and training, test failure analyses, test data, and unique software and instrumentation support that could increase the value of OT data. Explanations of how this contractor support will be used and the mitigation of possible adverse effects must be described in the TEMP and developmental and operational test plans.

#### **3.9.4.3 Support Contractors**

According to [section 2399\(e\)](#) of Reference (b), support contractors may not be involved in the establishment of criteria for data collection, performance assessment, or evaluation activities for OT. This limitation does not apply to a support contractor that has participated in such development, production, or testing solely in test or test support on behalf of the Government.

### **3.9.5 SOW**

One of the most important documents receiving input from the Chief Developmental Tester is the SOW. The Chief Developmental Tester must outline all required or anticipated contractor support for DT&E and OT&E. The SOW outlines data requirements, contractor-conducted or supported testing, Government involvement (access to contractor data, tests, and results), OT support, and any other specific test requirements the contractor will be tasked to perform during the duration of the contract. Additional information is available in [Reference \(y\)](#).

### 3.9.6 OT&E Funding

The Chief Developmental Tester provides the PM with estimates of PMO test program costs to conduct OT&E. This funding includes contractor and Government test support for which the program office directly or indirectly will be responsible. Because Service OTAs fund differently, program office funding for conducting OT&E varies. The Chief Developmental Tester must determine these costs and inform the PM.

### 3.9.7 T&E Execution

The Chief Developmental Tester is responsible for managing execution of the T&E strategy within the TEMP throughout the test program. The OTA usually is tasked to complete the OT portion of the TEMP and outline its proposed test program through all phases of OT&E. The resources required for OT&E should also be entered in the appropriate section of the TEMP. It is important to keep the TEMP updated regularly so that test organizations involved in OT&E understand the scope of their test support. Furthermore, if any upgrades, improvements, or enhancements to the fielded weapon system occur, the TEMP must be updated or a new one created to outline new integrated testing and OT requirements.

### 3.9.8 PMO Support for OT&E

Even though OT is performed by an independent organization, the PM plays an important role in its planning, reporting, and funding. The PM must coordinate program activities with the test community in the T&E WIPT, especially the OTAs. The OTA ensures that testing can address the critical issues. The PM should provide feedback from OT&E activities to contractors.

At each milestone review, the PM is required to brief the decision authority on the testing planned and completed on the program. It is important that PMO personnel have a good understanding of the test program and that they work with the OT community to ensure that OT&E is well planned and that adequate resources are available. The PMO should involve the test community by organizing test coordinating groups at program initiation and by establishing channels of communication between the PMO and the key test organizations. The PMO can often avoid misunderstandings by aggressively monitoring the system testing and providing up-to-date information to key personnel in OSD and the Services. The PMO staff should keep appropriate members of the test community well-informed concerning system problems and the actions taken by the PMO to correct them. The PMO must ensure that contractor and Government DT&E supports the decision to certify the systems readiness for IOT&E.

### 3.9.9 Support for IOT&E

DASD(DT&E) conducts AOTRs for all MDAPs and programs designated as Special Interest prior to proceeding to IOT&E. Procedurally, DASD(DT&E) produces an assessment memorandum prior to the IOT&Es OTRR, or for Space Systems, prior to consent to ship. The CAE considers the results of the DT&E assessment in order to determine the systems materiel readiness for IOT&E.



The AOTR is a DASD(DT&E) conducted analysis, beginning at Milestone B, that assesses the results of developmental testing and determines readiness to proceed to IOT&E. This analysis is based upon a memorandum signed by DASD(DT&E) and distributed to USD(AT&L), DOT&E, CAEs and Service T&E Executives. Each AOTR evaluates system performance (against key performance measures (e.g. KPP, KSA, CTP, etc.), reliability, interoperability, and information assurance as well as the risks associated with the system's ability to meet its operational suitability, effectiveness, and survivability requirements. The AOTR bases its findings and recommendations on the results of all program T&E conducted to date, including full-up system level DT&E, integrated tests, certifications, and prior operational assessments(s).

The certification of readiness for the IOT&E process provides a forum for a final review of test results and support required by the IOT&E. The Chief Developmental Tester must ensure that the contract portions adequately cover the scope of testing as outlined by the OTA. The program office may want to provide an observer to represent the Chief Developmental Tester during the actual testing. The key mission of Chief Developmental Tester involvement in IOT&E will be to monitor and coordinate; the Chief Developmental Tester will keep the PM informed of progress and problems that arise during testing and will monitor required PMO support to the test organization. Sufficient LRIP items plus spare parts, training materials, and other logistics products must be provided to the OTA to enable it to run a complete and adequate OT&E program. The DOT&E determines the number of LRIP items for IOT&E on oversight programs, and the OTA makes this determination for all others. For problems requiring program office action, the Chief Developmental Tester will be the point of contact.

The Chief Developmental Tester will be concerned with IOT&E of the LRIP units after a limited number are produced. The IOT&E must be closely monitored so that an FRP decision can be made. As in the operational assessments, the Chief Developmental Tester will be monitoring test procedures and results and keeping the PM informed. If the item does not succeed during IOT&E, a new process of DT&E or a modification may result; and the Chief Developmental Tester will be involved (as in any new programs inception). If the item passes IOT&E and is produced at full rate, the Chief Developmental Tester will be responsible for ensuring that testing of those production items is adequate to ensure that the end items physically and functionally resemble the developmental items.

### **3.9.10 FOT&E and Modifications, Upgrades, Enhancements, or Additions**

During FOT&E, the Chief Developmental Tester monitors the testing. The level of contractor involvement, if any, is usually negotiated with the OTA. The Chief Developmental Tester should receive any reports generated by the operational testers during this time. Any deficiencies noted during FOT&E should be evaluated by the PMO, which may decide to incorporate upgrades, enhancements, or additions to the current system or in future increments. If the PM and the engineering section of the program office design or develop modifications that are incorporated into the weapon system design, additional FOT&E may be required.

Once a weapon system is fielded, portions of that system may become obsolete, ineffective, or deficient and may need to be replaced, upgraded, or enhanced to ensure that the weapon system meets current

and future requirements. The Chief Developmental Tester plays a vital role in this process. Modifications to existing weapon systems may be managed as an entire newly acquired weapon system. However, since these are changes to existing systems, the Chief Developmental Tester is responsible for determining whether these enhancements degrade the existing system, whether they are compatible with its interfaces and functions, and whether nondevelopmental items (NDIs) require retest, or the entire weapon system needs reverification. The Chief Developmental Tester must plan the test programs funding, schedule, test program, and contract provisions with these items in mind. A new TEMP may have to be generated or the original weapon system TEMP modified and re-coordinated with the test organizations. The design of the DT&E and FOT&E program usually requires coordination with the engineering, contracting, and program management IPTs of the program office as well as the supporting DT and OT commands, ranges, and agencies.

### 3.9.11 Test Resources

During all phases of T&E, the Chief Developmental Tester must coordinate with the participating Services and the operational testers to ensure that they have the test articles needed to accomplish their mission. Test resources will be provided by the contractor or the Government. The contractor resources must be covered in the contract, whether in the development contract or the production contract. Government test resources needed are estimated by the operational testers. They usually coordinate the test ranges, test support, and the user personnel for testing. The PM programs funding for support of OT. Funding for OT&E is identified in the TEMP and funded in the PMOs budget. Each Service's policy specifies how the OTAs develop and manage their own budgets for OT. See Chapter 13 for more information on test resources.

### 3.10 Summary

Staffing requirements in the PMO vary with the program phase and the T&E workload. The chief developmental tester must be a designated KLP for MDAPs and MAIS programs and ideally should be a separate staff element within the program office. T&E expertise is essential in the early planning stages but can be provided through matrix support.

The PMO should be proactive in its relations with the Service OTA. Many opportunities exist for valuable mutual support, collaboration, and information sharing. Early OTA input to design considerations and requirements clarification can reduce surprises downstream and can facilitate integrated testing efforts. OT is an essential component of the system development and decision-making process. OT should be used to facilitate system development and not become part of an adversarial process.

## Test & Evaluation Management Guide

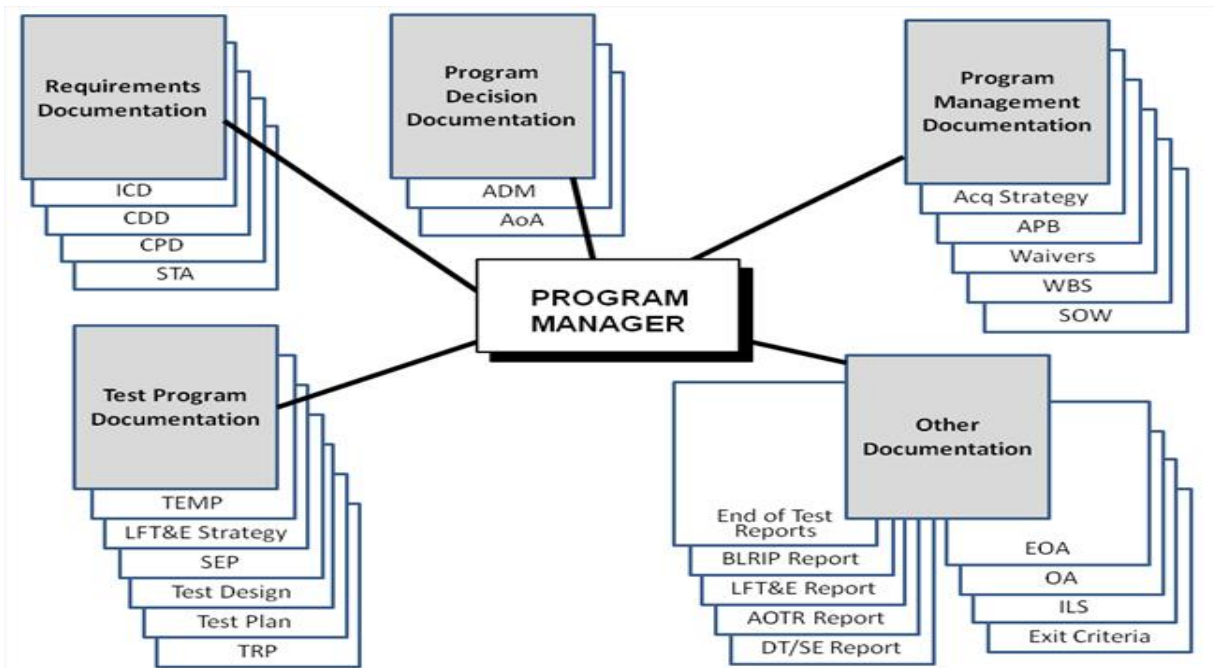
### Chapter 4 - Test - Related Documentation

#### 4.1 Introduction

During the course of a defense acquisition program, many documents are developed that have significance for those responsible for testing and evaluating the system. This chapter provides background on some of these documents. Because the information provided in this chapter may change over time; consequently, the reader should see [Reference \(j\)](#) as well as any Service-unique publications for more current information.

A pictorial roadmap of key activities in the systems acquisition processes-the Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System chart-is available at [https://ilc.dau.mil/html/ILC\\_Main.htm](https://ilc.dau.mil/html/ILC_Main.htm) . The chart is a training aid for DAU courses and illustrates the interaction of the three key processes that must work in concert to deliver the capabilities required by the Warfighters: the requirements process (JCIDS process); the acquisition process (Defense Acquisition System process); and the program and budget development process (PPBE process).

As Figure 4-1 shows, test-related documentation spans a broad range of materials. It includes requirements documentation such as the CDD and CPD; program decision documentation such as the ADM with exit criteria; program management documentation such as the Acquisition Strategy, APB, and waivers (i.e., LFT&E waiver from FUSL testing); and test program documentation such as LFT&E Strategy, the System Evaluation Plan (SEP), and the TEMP.



**Figure 4-1 Examples of T&E-Related Program Plans and Documentation**

Of importance to PMs and to T&E managers are additional test-unique program documents such as specific test designs, test plans, Outline Test Plans (OTP)/Test Program Outlines, evaluation plans, and test reports. Prior to IOT&E, the DASD(DT&E) provides an AOTR showing risks to IOT&E by predicting unfavorable results and eliminating the added time and expense needed when having to retest failures. This chapter concludes with a description of the end-of-test phase and BLRIP reports, and two special-purpose T&E status reports that are used to support the milestone decision process.

## 4.2 Requirements Documentation

### 4.2.1 Continuing Mission Capability Analyses

The Joint Chiefs of Staff, via the Joint Requirements Oversight Council (JROC), are required to conduct continuing mission analyses of their assigned areas of responsibility in accordance with [CJCS Instruction 3170.01H](#) (Reference (ad)). These functional analyses (area, needs, and solutions) may result in recommendations to initiate new acquisition programs to reduce or eliminate operational deficiencies. If a need cannot be met through changes in doctrine, organization, training, leadership and education, personnel, and facilities, and a materiel solution is required, the needed capability is described first in an ICD, and then in the CDD (See Figure 4-2). When the cost of a proposed acquisition program is estimated to meet certain cost limits specified in [Reference \(d\)](#), the proposed program is considered an MDAP and requires JROC approval (JROC Interest). Lesser programs for Service action may be designated as Joint Capabilities Board Interest, Joint Integration, Joint Information, or Independent programs. The ICD is completed at the beginning of the analyses for a mission area (before the MDD and the MSA effort). The CDD at MS B and CPD at MS C are program and/or increment-specific and reviewed to evaluate necessary system modifications periodically.

### 4.2.2 ICD

The ICD makes the case to establish the need for a materiel approach to resolve a specific capability gap. The ICD supports the AoA, development of the TDS, and various milestone decisions. The ICD defines the capability gap in terms of the functional area(s), relevant range of military operations, time, obstacles to overcome, and key attributes with appropriate MOEs. Once approved, the ICD is not normally updated.

### 4.2.3 CDD

The CDD outlines an affordable increment of militarily useful and supportable operational capability that can be effectively developed, produced or acquired, deployed, and sustained. Each increment of capability will have its own set of attributes and associated performance values with thresholds and objectives established by the sponsor (Service) with input from the user. The CDD performance attributes apply to only one increment and include KPPs and other parameters that will scope performance and provide the trade space for development effort (See [Reference \(ad\)](#) ).

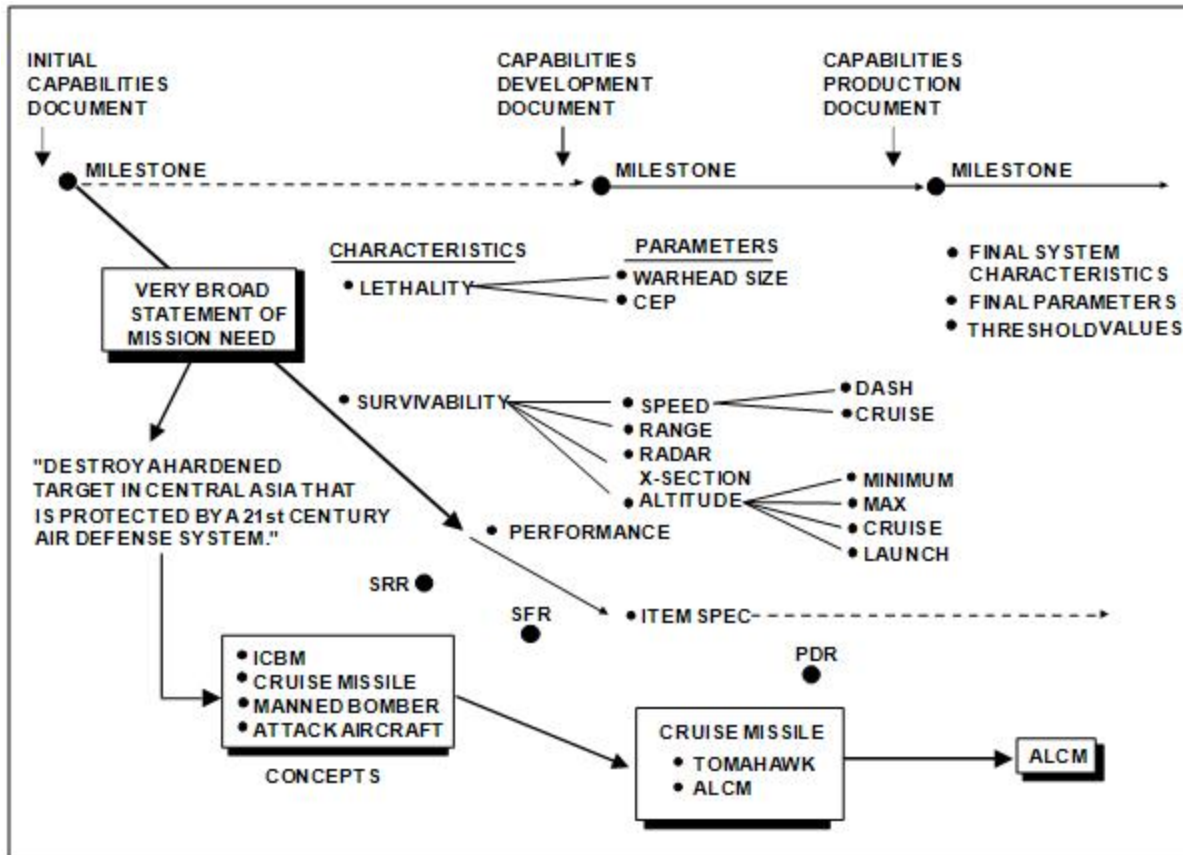


Figure 4-2 Example of Requirements Evolution

#### 4.2.4 CPD

The CPD addresses the production attributes and quantities specific to a single increment and is finalized by the sponsor after the PCDDA, when projected capabilities of the increment in development have been specified with sufficient accuracy to begin production. Design trades during EMD should have led to the final production design needed for MS C. IOT&E will normally test to the values in the CPD. The threshold and objective values from the CDD are therefore superseded by the specific production values detailed in the CPD. Reduction in any KPP threshold value will require reassessment of the military utility of the reduced capability. The CPD will always reference the originating ICD.

#### 4.2.5 STAR

A System Threat Assessment Report (STAR) is prepared, starting at MS B, by the DoD Component Intelligence Command or Agency for ACAT ID programs, and is validated by the Defense Intelligence Agency in accordance with [DoDD 5105.21](#) (Reference (ae)). The STAR is a concise description of the projected future operational threat environment, the system-specific threat, the reactive threat that could affect program decisions, and when appropriate, the results of interactive analysis obtained when evaluating the program against the threat. Threat projections start at IOC and extend over the following 10 years. The STAR provides the basis for the test design of threat scenarios and the acquisition of

appropriate threat targets, equipment, or surrogates. It provides threat data for DT&E and OT&E. Vulnerability and lethality analyses during LFT of ACAT I and II systems are contingent on valid threat descriptions. A summary of the STA should be included in Part I of the TEMP.

#### **4.2.6 Importance of Current Requirements Documents**

Milestone decisions and OSD test plan approval are highly dependent on having the most current approved JCIDS documents. Out-of-date JCIDS documents are unacceptable and put the programs T&E strategy-and ultimately the program itself-at risk. Delays in approval run the risk of having to reschedule milestone decisions or non-approval of critical test plans by DOT&E. The OTA will insist on testing to the latest available threat information, and if that is not reflected in the latest threat and JCIDS documents, conflicts can occur that may derail the program.

#### **4.2.7 Testability of Requirements**

The Chief Developmental Tester and SMEs from the T&E WIPT must participate in early requirements development forums as soon as a new program is considered. The objective is not to write requirements for users but to help the users articulate better requirements as clearly as possible and ensure that the requirements can be tested (i.e., the requirements are testable). DT&E personnel can provide advice about the technical feasibility of proposed new requirements, making the system more affordable and more technologically achievable. Operational testers can help ensure that the system (1) can meet mission requirements, (2) clearly conveys the users' needs, and (3) can be determined to be operationally effective and suitable with a high degree of confidence.

### **4.3 Program Decision Documentation**

#### **4.3.1 ADM**

USD(AT&L) decisions at major defense ACAT ID milestones are recorded in a document known as an ADM. The ADM documents a USD(AT&L) decision on program progress and on the APB at milestones and decision reviews. In conjunction with an ADM, and its included exit criteria for the next phase, the APB is a primary program guidance document providing KPP thresholds/objectives for systems cost, schedule, and performance and phase success criteria.

#### **4.3.2 AoA**

The AoA is an important element of the defense acquisition process. It is an analytical comparison of the operational effectiveness, suitability, and life-cycle cost (or total ownership cost, if applicable) of alternatives that satisfy established capability needs. Initially, after the MDD, the AoA is initiated to examine potential materiel solutions with the goal of identifying the most promising option, thereby guiding the MSA phase. For MDAPs at MS A, the MDA must certify to Congress that the Department has completed an AoA consistent with study guidance developed by the OSD Director of Cost Assessment and Program Evaluation (DCAPE). For MDAPs at MS B, the MDA must certify in writing to Congress that the Department has completed an AoA with respect to the program. An AoA is normally not required at MS C unless significant changes to threats, cost, or technology have occurred, or the analysis is

otherwise deemed necessary by the MDA. The DCAPE develops and approves study guidance for the AoA. The guidance is developed with input from other DoD officials, and DCAPE provides the approved guidance at the MDD review. Following a successful MDD review, the MDA directs initiation of the AoA in the ADM and includes the AoA study guidance as an attachment to the ADM. Following receipt of the AoA study guidance, the lead DoD Component prepares an AoA study plan that describes the intended methodology for the management and execution of the AoA. The study plan is coordinated with the MDA and approved by the DCAPE prior to the start of the AoA. The AoA aids decision makers by examining the relative advantages and disadvantages of program alternatives, shows the sensitivity of each alternative to possible changes in key assumptions, and provides the rationale for each option. There should be a clear linkage between the AoA, system requirements, and system evaluation criteria. One driving factor for ensuring that this linkage exists is the decision maker's acceptance of M&S projections or analytic studies for system performance in the future without actual test data that validate AoA results. In addition to a final briefing, the AoA process and results are usually documented in a final written report.

[Reference \(d\)](#) requires an AoA for MAIS programs at milestone decisions. The AoA for MAIS programs should include a discussion of whether the proposed program (1) supports a core/priority mission or function performed by the DoD Component, (2) needs to be undertaken because no alternative private sector or governmental source can better support the function, and (3) supports improved work processes that have been simplified or otherwise redesigned to reduce costs, improve effectiveness, and make maximum use of commercial off-the-shelf (COTS) technology. Most likely, the effectiveness analysis in a MAIS program AoA will not involve scenario-based analysis as is common for the weapon system AoAs.

## **4.4 Program Management Documentation**

### **4.4.1 Acquisition Strategy**

An event-driven acquisition strategy must be formulated at the start of a development program. Event-driven acquisition strategy explicitly links program decisions to demonstrated accomplishments in development, testing, and initial production. The strategy constitutes a broad set of concepts that provide direction and control for the overall development and production effort. The level of detail reflected in the acquisition strategy can be expected to increase as a program matures. The acquisition strategy serves as a tailored conceptual basis for formulating other program functional plans such as the TEMP.

It is important that T&E interests be represented as the acquisition strategy is formulated because the acquisition strategy should:

- Provide an overview of what requires evaluation for decision points and the planned T&E to ensure that all decisions are supported with adequate T&E results.
- Discuss plans for providing adequate quantities of test hardware.
- Describe test activities and relationships to integrate testing across DT&E and OT&E, and the level of concurrence needed to implement them.

#### 4.4.2 APB

[Reference \(d\)](#) requires each PM to propose and document program goals prior to and for approval at program initiation for all ACAT programs. The APB is an important document for program management and should reflect the approved program being executed. The APB will initially be developed before MS B or program initiation and will be revised for each subsequent milestone. Baseline parameters represent the cost, schedule, and performance objectives and thresholds for the system in a production configuration. Each baseline influences the T&E activities in the succeeding phases. Guidance on the formulation of baselines is found in [Chapter 9](#) of Reference (j). Performance demonstrated during T&E of production systems must meet or exceed the thresholds. The thresholds establish deviation limits (actual or anticipated breach triggers reports) for KPPs beyond which the PM may not trade off cost, schedule, or performance without authorization by the MDA. Baseline and test documentation must reflect the same expectations for system performance. The total number of KPPs shall be the minimum number needed to characterize the major drivers of operational effectiveness and suitability, schedule, technical progress, and cost for a production system intended for deployment. The performance parameters may not completely define operational effectiveness or suitability.

#### 4.4.3 Acquisition Logistics Planning Documentation

All logistics planning must be derived from user-developed JCIDS operational requirement documents and further described and expanded using operating and enabling concepts. These requirements and concepts are expressed in TEMPs and test plans as KPPs, critical operational issues (COIs), measures of suitability (MOSs), MOPs, and operational mission scenarios. A suitability KPP supported by MOEs, MOSs, and MOPs is mandatory.

Supportability analyses are a composite of all support considerations necessary to ensure the effective and economical support of a system at all levels of maintenance for its programmed life cycle. Support concepts describe the overall logistics support program and include logistics requirements, tasks, and milestones for the current and succeeding phases of the program. The analyses serve as the source document for logistics support testing requirements.

[MIL-HDBK-502](#) (Reference (af)) documents guidelines for logistics support analyses (LSAs) and provides information on how T&E programs should be planned to serve the following three logistics supportability objectives:

- Provide measured data for input into system-level estimates of readiness, operational costs, and logistics support resource requirements.
- Expose supportability problems so they can be corrected prior to deployment.
- Demonstrate contractor compliance with quantitative supportability-related design requirements.

Development of an effective T&E program requires close coordination of efforts among all SE disciplines, especially those involved in LSAs. Areas of particular interest include RAM, HSI, environment, safety and occupational health (ESOH), and post-deployment evaluations. The support analyses should be drafted



shortly before program start to provide a skeletal framework for LSA, to identify initial logistics testing requirements that can be used as input to the TEMP, and to provide test feedback to support ILS development.

#### 4.4.4 FUSL LFT and Waiver Process

The term full-up, system-level live-fire testing is the testing that fully satisfies the statutory requirement for realistic survivability testing or realistic lethality testing as defined in [section 2366](#) of Reference (b). The criteria for FUSL LFT differ somewhat depending on whether the testing is for survivability or lethality. FUSL testing consists of the following:

Vulnerability testing conducted, using munitions likely to be encountered in combat, on a complete system loaded or equipped with all the dangerous materials that normally would be on board in combat (including flammables and explosives), and with all critical subsystems operating that could make a difference in determining the test outcome; or

Lethality testing of a production-representative munition or missile, for which the target is representative of the class of systems that includes the threat, and the target and test conditions are sufficiently realistic to demonstrate the lethal effects the weapon is designed to produce.

[Section 2366](#) of Reference (b) requires an LFT&E program to include FUSL testing unless a waiver is granted in accordance with procedures defined by the statute. A waiver package must be sent to the congressional defense committees prior to MS B; or in the case of a system or program initiated at MS B, as soon as practicable after MS B; or if initiated at MS C, as soon as practicable after MS C. Typically, this request for a waiver should occur at the time of TEMP approval.

The waiver package includes certification by the USD(AT&L) or the DoD CAE that FUSL testing would be unreasonably expensive and impractical. It also includes a DOT&E-approved alternative plan for conducting LFT&E in the absence of FUSL testing. Typically, the alternative plan is similar or identical to the LFT&E Strategy contained in the TEMP. This alternative plan should include LFT&E of components, subassemblies, or subsystems and, as appropriate, additional design analyses, M&S, and combat data analyses.

Programs that have received a waiver from FUSL testing are conducted as LFT&E programs (with exception of the statutory requirement for FUSL testing). In particular, the TEMP contains an LFT&E Strategy approved by DOT&E, and DOT&E, as delegated by the SecDef, submits an independent assessment report on the completed LFT&E to the congressional committees as required by [section 2366](#) of Reference (b). LFT&E is discussed in Chapter 16.

#### 4.4.5 System Specification

The system specification is a key technical document that describes both the technical performance requirements and the verification of these requirements for the system. The system includes items, software, processes, materials, and services. Section 3 (Requirements) of the specification describes the required performance parameters and Section 4 (Verification) identifies the procedures (analysis,

demonstration, examination, testing) used to verify these parameters. Other specifications generated over the developmental phases of the program (with increasing levels of detail) include item performance specifications, item detail specifications, process specifications, and material specifications. [Reference \(ab\)](#) provides further details.

#### **4.4.6 Work Breakdown Structure (WBS)**

A program WBS shall be established that provides a framework for program and technical planning, cost estimating, resource allocations, performance measurements, and status reporting. Program offices shall tailor a program WBS for each program using the guidance in MIL-STD-881C (Reference (ag)) Level 2 of the WBS hierarchical structure typically addresses system-level T&E with sublevels for DT&E and OT&E. Additionally, each configuration item (CI) WBS should include details of relevant integration and test requirements.

#### **4.4.7 SOW**

The SOW is that portion of a contract that establishes and defines all non-specification requirements for contractor's efforts either directly or with the use of specific cited documents. The SOW details the work the contractor will perform and, when necessary, specifies how the work is to be performed. Additional information is available in [Reference \(y\)](#) .

### **4.5 Test Program Documentation**

#### **4.5.1 TES/TEMP**

The TES describes the concept for T&E throughout the program life cycle starting with Technology Development and continuing through EMD into Production and Deployment. The TES evolves into the TEMP at Milestone B. Development of a TES requires early involvement of testers, evaluators, user representatives, etc., as a program conducts pre-system activities. These personnel provide the necessary technical, operational, and programmatic expertise to ensure the development of a comprehensive strategy. The TES approval process is explained in section 9.5.4.3 of the DAG.

The TEMP is the basic planning document for DoD system acquisition T&E. It is the PM/PMO contract with the programs stakeholders on how T&E will be conducted and is prepared by the PMO with the OT information provided by the Service OTA. The TEMP is used by OSD and the Services for planning, reviewing, and approving T&E programs and provides the basis and authority for all other detailed T&E planning documents. The evaluation framework in the TEMP identifies the key requirements (KPPs and KSAs), COIs (or COICs for Army TEMPs), critical technical parameters (CTPs), MOEs, MOSs, major T&E resources required, and decision supported. The TEMP format is outlined in detail in [section 9.5.5](#) of Reference (j).

##### **4.5.1.1 LFT&E Strategy**

The objective of LFT&E is to provide a timely and reasonable assessment of the vulnerability/lethality of a system as it progresses through its development and prior to FRP. The LFT&E Strategy for a given

system should be structured and scheduled so that any design changes resulting from the testing and analysis, described in the LFT&E Strategy, may be incorporated before proceeding beyond LRIP. LFT&E testing is discussed in Chapter 16.

The DOT&E approves the adequacy of the LFT&E Strategy before the program begins LFT&E. The program should be driven by LFT&E issues identified in the strategy and be fully integrated with planned DT&E and OT&E. LFT&E typically includes testing at the component, subassembly, and subsystem level and may also draw upon design analyses, M&S, combat data, and related sources such as analyses of safety and mishap data. This approach is standard practice, regardless of whether the LFT&E program culminates with FUSL testing, or a waiver from FUSL testing is obtained.

#### **4.5.1.2 Alternative LFT&E Strategy**

Programs that have received a waiver from FUSL testing are conducted as LFT&E programs (with the exception of the statutory requirement for FUSL testing). The waiver package includes a DOT&E-approved alternative plan for conducting LFT&E in the absence of FUSL testing. Typically, the alternative plan is similar or identical to the LFT&E Strategy contained in the TEMP.

#### **4.5.2 System Evaluation Plan**

[Reference \(d\)](#) requires PMs to prepare a system evaluation plan for each milestone review, beginning with MS A. At MS A, the system evaluation plan supports the TDS; at MS B or later, the system evaluation plan supports the Acquisition Strategy. The system evaluation plan describes the programs overall technical approach, including key technical risks, processes, resources, metrics, and applicable performance incentives. It also details the timing, conduct, and success criteria of technical reviews. The TES should be consistent with and complementary to the system evaluation plan and Acquisition Strategy. The T&E team should work closely with the PM and the system design team to facilitate this process.

#### **4.5.3 Test Design**

Test designers need to ensure that the test is constructed to provide useful information in all areas/aspects that will lead to an assessment of the system performance. A well-designed experiment can lead to reduced development lead time with fewer tests required, provide greater insight to system performance, and ultimately lead to fielding better, more reliable systems. The use of STAT in T&E will generate T&E efficiencies; provide rigorous, defensible T&E strategies and results; and improve the level of knowledge for the DT planning, execution, and analysis process. When used in the proper context, STAT in T&E will enable the PMs to make better-informed decisions based on acceptable risk thresholds. For example, a complicated, even ingenious, test that does not provide the information required by the decision makers is, in many respects, a failed endeavor. Therefore, part of the process of developing a test concept or test design (the distinction between these vary from organization to organization) should be to consider whether the test will provide the information required by the decision makers. In other words: Are we testing the right things in the right way? Are our evaluations meaningful?

The test design should be statistical and analytical in nature and should perform the following functions:

- Structure and organize the approach to testing in terms of specific test objectives.
- Identify key MOEs and MOPs.
- Identify the required data and illustrate how the data will be gathered, stored, analyzed, and used to evaluate MOEs.
- Indicate what part M&S will play in meeting test objectives.
- Identify the number and type of test events and required resources.

The test design may serve as a foundation for the more detailed test plan and specifies the test objectives, events, instrumentation, methodology, data requirements, data management needs, and analysis requirements.

#### **4.5.4 Test Plan**

The testing agent that will be executing the test events described by the TEMP will develop detailed test plans as required by the program contract, Service policy, or the [Reference \(j\)](#) . The test plan is the vehicle that translates a test concept and statistical/analytical test design into concrete resources, procedures, and responsibilities. The size and complexity of a test program and its associated test plan are determined by the nature of the system being tested and the type of testing that is to be accomplished. Some major weapons systems may require large numbers of separate tests to satisfy test objectives and, thus, require a multi-volume test plan; other testing may be well-defined by a relatively brief test plan. The test plan also provides a description of the equipment configuration and known limitations to the scope of testing. An example of typical test plan format is shown in Figure 4-3.

<b>Preliminary Pages</b>
i. Title Page
ii. Approval Page
iii. Conditions for Release of Technical Data
iv. Preface (Abstract)
v. Executive Summary
vi. Table of Contents*
*The actual number of these pages will be determined by the length of preliminary elements (e.g., Table of Contents, Terms and Abbreviations, etc.).
<b>Main Body</b>
1. Introduction
2. Background
3. Test Item Description
4. Overall Test Objectives
5. Constraints and Limitations
6. Test Resources
7. Safety Requirements
8. Security Requirements
9. Test Project Management
10. Test Procedures
11. Test Reporting
12. Logistics
13. Environmental Protection
<b>Annexes</b>
A. Test Condition Matrix
B. Requirements Traceability
C. Test Information Sheets
D. Parameters List
E. Data Analysis Plan
F. Instrumentation Plan
G. Logistics Support Plan
H. -Z As Required
List of Abbreviations
<b>Distribution</b>
Source: AFFTC Test Plan Preparation Guide

**Figure 4-3 Example of Typical Test Plan Format**

#### 4.5.5 TRP

The Army and Air Force TRPs are examples of essential test planning documents. They are formal resource documents specifying the resources required to support the test. Because the TRPs provide the basis for fiscal programming and coordinating the necessary resources, it is important that these documents be developed in advance and kept current to reflect maturing resource requirements as the test program develops. The Navy makes extensive use of the TEMP to document T&E resource requirements. Each Service has periodic meetings designed to review resource requirements and resolve problems with test support.

## **4.5.6 Test Reports**

### **4.5.6.1 Quick-Look Reports**

Quick-look reports are expeditious analyses performed during testing using limited amounts of the database. Such analyses often are used to assist in managing test operations. Quick-look reports are used occasionally to inform higher authorities of test results. Quick-look reports may have associated briefings that present T&E results and substantiate conclusions or recommendations. Quick-look reports may be generated by the contractor or Government agency. They are of particularly critical interest for high-visibility systems that may be experiencing some development difficulties. Techniques and formats should be determined before the start of testing and may be exercised during pretest trials.

### **4.5.6.2 Final Test Report**

The final test report disseminates the test information to decision authorities, program office staff, and the acquisition community. It provides a permanent record of the execution of the test and its results. The final test report should relate the test results to the critical issues and address the objectives stated in the test design and test plan. A final test report may be separated into two sections—a main section providing the essential information about test methods and results, and a second section consisting of supporting appendixes to provide details and supplemental information. The type of information generally included in the final test report is shown in Figure 4-4.

- 1 – Test purpose**
- 2 – Issues and objectives**
- 3 – Method of accomplishment**
- 4 – Results (keyed to the objectives and issues)**
- 5 – Discussion, conclusions, and recommendations**

**Example Appendixes:**

- A – Detailed test description**
- B – Test environment**
- C – Test organization and operation**
- D – Instrumentation**
- E – Data collection and management**
- F – Test data**
- G – Data analysis**
- H – M&S**
- I – RAM information**
- J – Personnel**
- K – Training**
- L – Safety**
- M – Security**
- N – Funding**
- O – Post-test Asset disposition**

**Figure 4-4 Types of Information in a Final Test Report**

The final test report may contain an evaluation and analysis of the results, or the evaluation may be issued separately. The analysis tells what the results are, whereas an evaluation tells what the results mean. The evaluation builds on the analysis and generalizes from it, showing how the results apply outside the test arena. It shows what the implications of the test are and may provide recommendations. The evaluation may make use of independent analyses of all or part of the data; it may employ data from other sources and may use M&S to generalize the results and extrapolate to other conditions. In the case of the Army, a separate system evaluation report is prepared by independent evaluators within the AEC.

## **4.6 Other Test-Related Status Reports**

### **4.6.1 End-of-Test Reports**

The Services are required by [Enclosure 6](#) of Reference (d) to submit to OSD T&E offices copies of their formal DT&E, OT&E, and LFT&E reports that are prepared at the end of each period of testing for ACAT I, IA, and oversight programs. These reports will generally be submitted in a timely manner to permit OSD review.

### **4.6.2 BLRIP Report**

Before an ACAT I or DOT&E-designated program can proceed beyond LRIP, the DOT&E must submit a BLRIP report to the SecDef and the Senate and House of Representatives Committees on Armed Services, National Security, and Appropriations. This report addresses whether the OT&E performed was adequate and whether the IOT&E results confirm that the items or components tested are effective and suitable for use in combat by typical military users. The report may include information on the results of LFT&E for applicable major systems.

### **4.6.3 LFT&E Report**

Before an ACAT I or DOT&E-designated program can proceed beyond LRIP, the DOT&E must submit an LFT&E report to the SecDef and the Senate and House of Representatives Committees on Armed Services, National Security, and Appropriations. This report addresses whether the LFT&E performed was adequate and whether the Service LFT&E results confirm that the items or components tested are lethal or vulnerable considering planned use in combat. The report may be included with the DOT&E BLRIP information on the results of Service IOT&E for applicable MDAP and oversight systems.

### **4.6.4 AOTR**

See page 50, paragraph 3.9.9 of this guide.

### **4.6.5 Annual DT/SE Report**

The DASD(DT&E) and DASD(SE) are required by [Reference \(w\)](#) to provide the SecDef, the USD(AT&L), and Congress with an annual assessment of the weapon system development progress for programs on the OSD T&E oversight list.



#### **4.6.6 OA/EOA**

An OA is an evaluation of operational effectiveness and suitability made by an independent OTA, with user support as required, on other-than-production systems. An OA conducted during system integration is often called an EOA.

#### **4.6.7 ILS**

ILS is a unified and iterative approach to the management and technical activities needed to influence operational and materiel requirements and design specifications, define the support requirements best related to system design and to each other, develop and acquire the required support, provide required operational support at lowest cost, seek readiness and LCC improvements in the materiel system and support systems during the operational life cycle, and repeatedly examine support requirements throughout the service life of the system.

#### **4.6.8 Exit Criteria**

Exit criteria are program-specific accomplishments that must be satisfactorily demonstrated before a program can progress further in the current acquisition phase or transition to the next acquisition phase. Exit criteria are normally selected to track progress in important technical, schedule, or management risk areas. They serve as gates that, when successfully passed or exited, demonstrate that the program is on track to achieve its final program goals and should be allowed to continue with additional activities within an acquisition phase or be considered for continuation into the next acquisition phase. Exit criteria are some level of demonstrated performance outcome (e.g., level of engine thrust), the accomplishment of some process at some level of efficiency (e.g., manufacturing yield), or successful accomplishment of some event (e.g., first flight), or some other criterion (e.g., establishment of a training program or inclusion of a particular clause in the follow-on contract) that indicates that aspect of the program is progressing satisfactorily. Exit criteria are documented in the ADM.

#### **4.7 Summary**

A wide range of documentation is available to the test manager and should be used to develop T&E programs that address all relevant issues. The PM must work to ensure that T&E requirements are considered at the outset when the acquisition strategy and funding requirements are formulated. The PM must also require early, close coordination and a continuing dialogue among those responsible for integration of functional area planning and the TEMP. Service-level programs have their own unique documentation requirements.

## Test & Evaluation Management Guide

### Chapter 5 - Test & Evaluation

#### 5.1 Introduction

This chapter describes the evaluation portion of the T&E process. It stresses the importance of establishing and maintaining a clear audit trail from system requirements through COIs, evaluation criteria, test objectives, and MOEs to the actual evaluation process itself. The importance of the use of data from all sources is discussed as are the differences in approaches to evaluating technical and operational data.

#### 5.2 "Test" and "Evaluation"

**Test** : Test denotes any program or procedure that is designed to obtain, verify, or provide data for the evaluation of any of the following: (1) progress in accomplishing developmental objectives; (2) the performance, operational capability, and suitability of systems, subsystems, components, and equipment items; and (3) the vulnerability and lethality of systems, subsystems, components, and equipment items.

**Evaluation** : Evaluation denotes the process whereby data are logically assembled, analyzed, and compared to expected performance to aid in systematic decision making. It may involve review and analysis of qualitative or quantitative data obtained from design reviews, hardware inspections, M&S, hardware and software testing, metrics review, and operational usage of equipment.

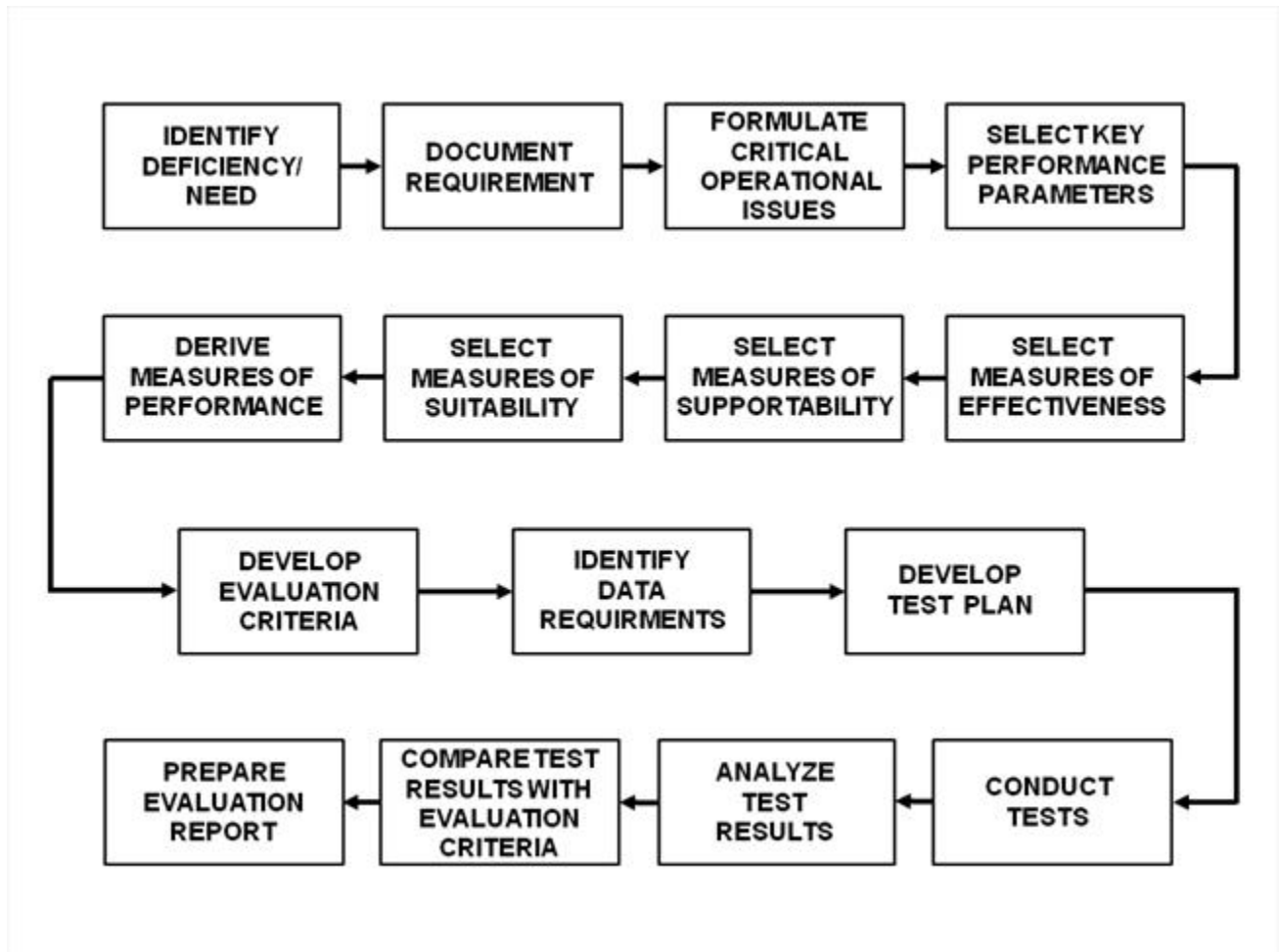
**Test and Evaluation** : T&E is a process by which a system or components are tested and results analyzed to provide performance related information. This information has many uses, including risk identification and mitigation as well as providing empirical data to validate models and simulations. T&E enables an assessment of the attainment of technical performance, specifications, and system maturity to determine whether systems are operationally effective, suitable, and survivable for their intended use. There are three distinct types of T&E defined in statute or regulation: Developmental Test and Evaluation (DT&E), Operational Test and Evaluation (OT&E), and Live Fire Test and Evaluation (LFT&E). These are all covered in subsequent chapters of this guide.

#### 5.3 The Evaluation Process

As illustrated in Figure 5-1, the evaluation process requires a broad analytical approach with careful focus on the development of an overall test plan that will provide timely answers to COIs and questions required by decision authorities throughout all the acquisition phases. Evaluations should focus on KPPs; i.e., those minimum attributes or characteristics considered most essential for an effective military capability. The [DAU Glossary of Defense Acquisition Acronyms & Terms](#) (Reference (ah)) defines an attribute as a quantitative or qualitative characteristic of an element or its actions

A functional block diagram of a generic evaluation process is also shown in Figure 5-1. The process begins with the identification of a deficiency or need and the documentation of an operational requirement. It continues with the identification of COIs that must be addressed to determine the

degree to which the system meets user requirements. Objectives and thresholds must then be established to define required performance or supportability parameters and to evaluate progress in reaching them. Data requirements are then consolidated/integrated in the TEMP evaluation framework to identify distribution of testing activities necessary to support evaluations. T&E analysts then decompose the issues into measurable test elements, conduct the necessary testing, review and analyze the test data, weigh the test results against the evaluation criteria, and prepare an evaluation report for the decision authorities.



**Figure 5-1 Illustrative Generic Evaluation Process**

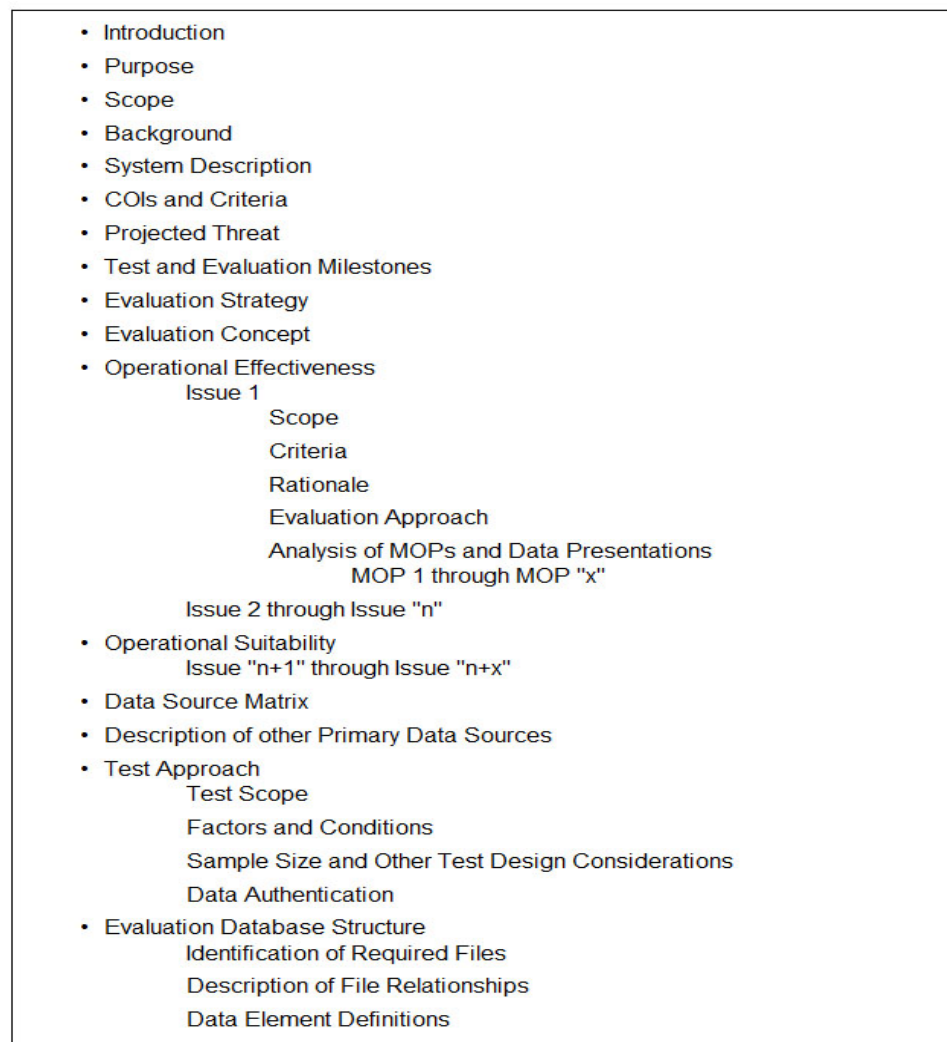
#### 5.4 Distinction Between Issues and Criteria

Issues, as defined in [Reference \(ah\)](#), are questions regarding a system that require answers during the acquisition process. Those answers may be needed to aid in the development of an acquisition strategy, to refine performance requirements and designs, or to support milestone decision reviews. As defined in [Reference \(ah\)](#), Evaluation criteria are the standards by which accomplishments of required technical and operational effectiveness and/or suitability characteristics or resolution of operational issues may be assessed.

The evaluation program may be constructed using a structured approach identifying each issue. For example:

- Issue: a statement of the question to be answered.
- Scope: detailed conditions and range of conditions that will guide the T&E process for this issue.
- Criteria: quantitative or qualitative standards that will answer the issue.
- Rationale: full justification to support the selected criteria.

A formal evaluation plan is typically created to support the overall evaluation effort. These plans vary by Service and Defense Agency, see Figure 5-2 for an example of key topics in an evaluation plan.



**Figure 5-2 Generic Example of Key Topics in an Evaluation Plan**

#### 5.4.1 KPPs/COIs

The KPPs often can support the development of a hierarchy of COIs and less significant issues. COIs are those questions relating to a systems operational, technical, support, or other capability. These issues must be answered before the systems overall worth can be estimated/evaluated, and they are of primary importance to the decision authority in allowing the system to advance to the next acquisition phase.

COIs in the TEMP may be derived from the KPPs found in the capability requirements documents-CDD and CPD. The system requirements and baseline documentation will provide many of the performance parameters required to develop the hierarchy of issues.

#### **5.4.2 Evaluation Issues**

Evaluation issues are those issues addressed in technical or operational evaluations during the acquisition process. Evaluation issues can be separated into technical or operational issues and are addressed in the TEMP.

Technical issues primarily concern technical parameters or characteristics and engineering specifications normally assessed and verified as part of DT. Operational issues concern effectiveness and suitability characteristics for functions to be performed by equipment/personnel. Operational issues pertain to validating the systems operational performance when examined in a realistic operational mission environment. Both technical and operational issues should take joint operating environments into consideration.

#### **5.4.3 Test Issues**

Test issues are a subset of evaluation issues and address areas of uncertainty that require test data to resolve the issue adequately. Test issues may be partitioned into technical issues that are addressed by the DT&E community and operational issues that are addressed by the OT&E community. Test issues may be further divided into critical and noncritical categories. All critical T&E issues, objectives, methodologies, and evaluation criteria should be defined during the initial establishment of an acquisition program. COIs are documented in the TEMP. These evaluation issues serve to define the testing required for each phase of the acquisition process and serve as the structure to guide the testing program so these data may be compared against performance criteria.

#### **5.4.4 Criteria**

Criteria are statements of a systems required technical performance and operational effectiveness and suitability. Criteria are often expressed as objectives and thresholds. These performance measurements provide the basis for collecting data used to evaluate/answer test issues. Criteria must be unambiguous and assessable whether stated qualitatively or quantitatively. For example, they may compare the mission performance of the new system to the one being replaced, compare the new system to a predetermined standard, or compare a system to a similar system. As such, they should be developed in close coordination with the system user, other testers, and specialists in all other areas of operational effectiveness and suitability. These values may be changed as systems develop and associated testing

and evaluation proceed. Every issue should have at least one criterion that is a concise measure of the function. Values must be realistic and achievable within the state of the art of engineering technology. A quantitative or qualitative criterion should have a clear definition, free of ambiguous or imprecise terminology, such as adequate, sufficient, or acceptable.

A threshold for a performance parameter lists a minimum acceptable operational value below which the utility of the system becomes questionable (See [Reference \(ah\)](#) ). Thresholds are stated quantitatively whenever possible. Specification of minimally acceptable performance in measurable parameters is essential to selecting appropriate MOEs, which in turn heavily influence test design. Thresholds are of value only when they are testable; i.e., actual performance can be measured against them. The function of T&E is to verify the attainment of required thresholds. The PM must budget for the attainment of threshold values.

Objectives are the desired operational goal associated with a performance attribute, beyond which any gain in utility does not warrant additional expenditure. The objective value may be an operationally significant increment above the threshold. An objective value as defined by [Reference \(ah\)](#) may be the same as the threshold when an operationally significant increment above the threshold is not significant or useful. Objectives are not normally addressed by the operational tester, whose primary concern is to determine if thresholds in the approved CPD and COIs have been satisfied (See [Reference \(d\)](#) ).

Going into system demonstration, thresholds and objectives are expanded along with the identification of more detailed and refined performance capabilities and characteristics resulting from trade-off studies and testing conducted during the evaluation of EDMs. Along with the CPD, thresholds and objectives should remain relatively stable through production. Testers should:

Review requirements as they are developed to assess whether they are unambiguous, testable, relevant to accomplishing missions in combat, and operationally and technically realistic.

Seek opportunities to be involved in reviews of requirements conducted before those requirements are submitted for consideration within OSD.

For each project under oversight, review the TES and TEMP to ensure that they include testing in realistic operational environments initiated during development and continuing through OT. This continuum of realistic testing will place increasing stress on subsystem components before final integration into a full-up system, thereby identifying problems when they can be fixed cost-effectively.

Identify operational concerns to program offices and DOT&E leadership at the earliest possible time so that they can be resolved in a timely manner.

Identify for action by DOT&E leadership test-critical resource shortfalls.

Ensure that testing in a joint environment is included in TESs and TEMPs as appropriate and feasible.

Ensure that developers and the operational community share a clear, common understanding of the planned concept of operations (CONOPS) or identify for action by DOT&E leadership inconsistencies in

those views. If the CONOPS is not available, work to ensure that a representative set of CONOPS is included in TESSs and TEMPs.

## 5.5 MOEs

Requirements, thresholds, and objectives established in early program documentation form the basis for evaluation criteria. If program documentation is incomplete, the tester may have to develop evaluation criteria in the absence of specific requirements. Evaluation criteria are associated with objectives, sub-objectives, KPPs, and MOEs/MOSs and ultimately devolved into MOPs. MOE refers to the effectiveness of a solution but is independent of any particular solution, while an MOP refers to the actual performance of a specific entity (selected solution). Thus, an MOE can be used to validate that the system meets the user's intended needs/mission objectives, and an MOP can be used to verify that the system meets the user's stated requirements. [Reference \(ah\)](#) further defines the key terms below:

**MOE** : The data used to measure the military effect (mission accomplishment) that comes from the use of the system in its expected environment. That environment includes the system under test and all interrelated systems, that is, the planned or expected environment in terms of weapons, sensors, command and control (C2), and platforms, as appropriate, needed to accomplish an end-to-end mission in combat). See Operational Effectiveness (OE), Measure of Performance (MOP), Operational Suitability (OS), and Measure of Suitability (MOS).

**MOS** : Measure of an items ability to be supported in its intended operational environment. MOSs typically relate to readiness or operational availability and, hence reliability, maintainability, and the items support structure.

**MOP** : System-particular performance parameters such as speed, payload, range, time-on-station, frequency, or other distinctly quantifiable performance features. Several MOPs may be related to achieving a particular Measure of Effectiveness (MOE).

MOEs (and MOSs) are important because they determine how test results will be judged, and because test planning is directed toward obtaining these measures, it is important that they be defined early. For example, an MOE (airspeed) may have an associated evaluation criterion (450 knots) against which the actual performance (425 knots) is compared to arrive at a rating. Generally, the resolution of each critical issue is in terms of the evaluation of some MOE. In this case, the operating, implementing, and supporting commands must agree with the criteria before the test organization makes use of them in assessing test results. Ensuring that MOEs can be related to the user's operational requirements is an important consideration when identifying and establishing evaluation criteria.

Testers must ensure that evaluation criteria and MOEs are updated if requirements change. Testers must determine mission tasks and system-of-systems performance in order to establish links to mission effectiveness measures. Mission end states and desired effects must be predetermined in order to derive MOEs used in system-of-systems testing. The MOEs should be so specific that the systems effectiveness during developmental and operational testing can be assessed using some of the same effectiveness criteria as the AoAs.

## **5.6 Evaluation Planning**

### **5.6.1 Evaluation Planning Techniques**

Techniques that have been proven effective in evaluation planning include process analysis, design or engineering analysis, matrix analysis, and dendritic analysis.

Evaluation planning is an iterative process that requires formal and informal analyses of system operation (e.g., threat environment, system design, tactics, and interoperability). Recognized analytical techniques (including computer models) are used to interpret or explain the behavior/performance of the system element during T&E. Analysis of test data or review and analysis of design data will be used as appropriate to verify the systems requirements. Evaluation planning attempts to identify in advance exactly what is to be evaluated, how the data are to be collected, and at least a qualitative understanding of how the data will be analyzed.

#### **5.6.1.1 Process Analysis Techniques**

Process analysis techniques consist of thinking through how the system will be used in a variety of environments, threats, missions, and scenarios in order to understand the events, actions, situations, and results that are expected to occur. This technique aids in the identification and clarification of appropriate MOEs, test conditions, and data requirements.

#### **5.6.1.2 Design/Engineering Analysis Techniques**

Design or engineering analysis techniques are used to examine all mechanical or functional operations that the system has been designed to perform. These techniques involve a systematic exploration of the systems hardware and software components, purpose, performance bounds, manpower and personnel considerations, known problem areas, and impact on other components. Exploration of the way a system operates compared to intended performance functions often identifies issues, MOEs, specific data, test events, and required instrumentation.

#### **5.6.1.3 Matrix Analysis Techniques**

Matrix analysis techniques are useful for analyzing any situation in which two classifications must be cross-referenced. For example, a matrix of types of data versus means of data collection can reveal not only types of data having no planned means of collection, but also redundant or backup collection systems. Matrix techniques are useful as checklists, as organizational tools, or as a way of identifying and characterizing problem areas. Matrix techniques are effective for tracing a system's operational requirements through contractual specification documents, issues, and criteria to sources of individual data or specific test events.

#### **5.6.1.4 Dendritic Analysis Techniques**

Dendritic analysis is an effective way of decomposing COIs to the point where actual data requirements and test measurements can be identified. In these techniques, issues are successively broken down into



objectives, MOEs, MOPs, and data requirements in a rootlike structure as depicted in Figure 5-3. In this approach, objectives are used to clearly express the broad aspects of T&E related to the COIs and the overall purpose of the test. The MOEs are developed as subsets of the objectives and are designed to treat specific and addressable parts of the objectives. Each MOE is traceable as a direct contributor to one objective and, through it, is identifiable as a direct contributor to addressing one or more COIs. Each test objective and its related MOE(s) is also linked to one or more MOPs (quantitative or qualitative measures of system performance under specified conditions) that in turn are tied to specific data elements. Data elements are observations and/or measurements under specified conditions.

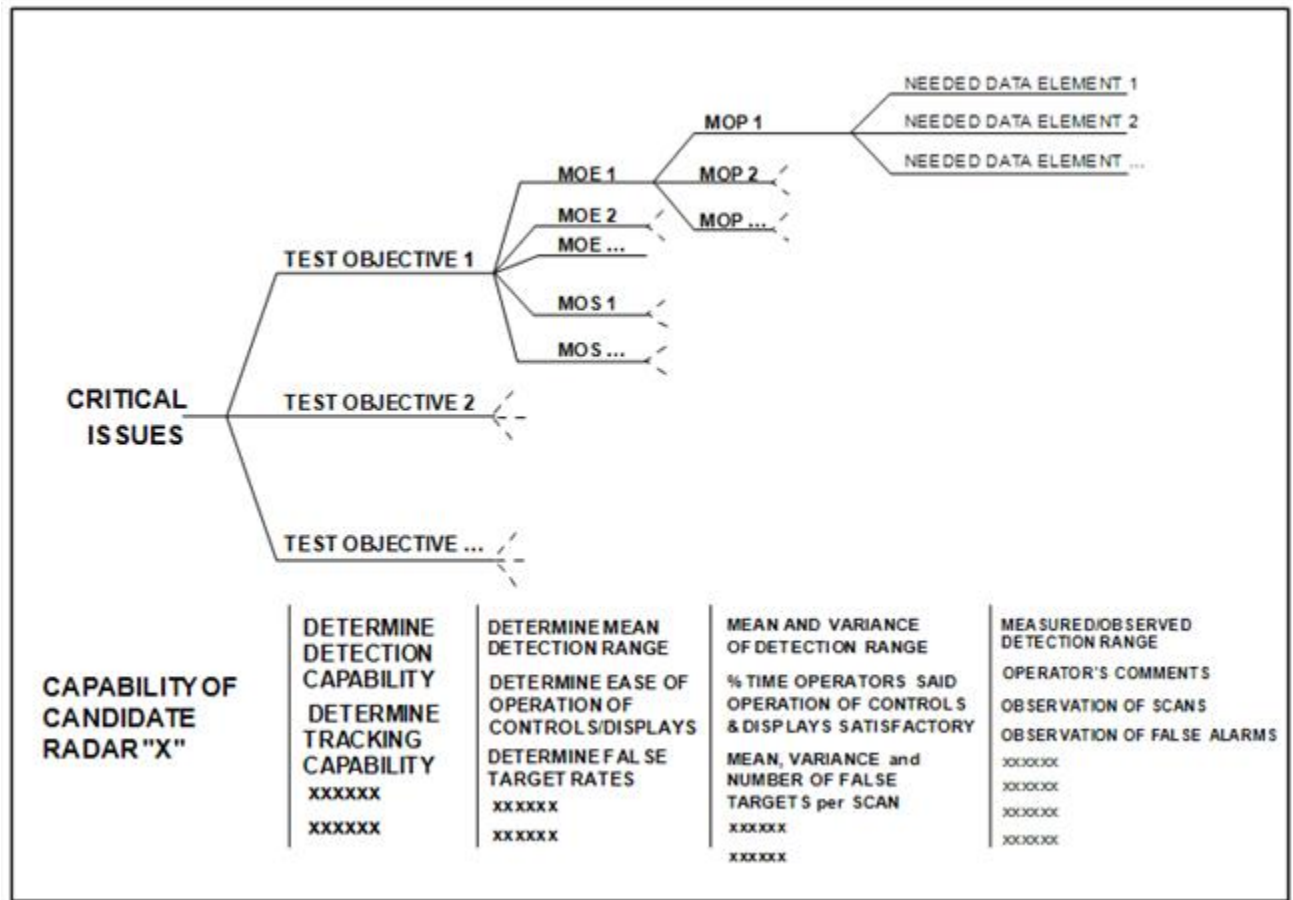


Figure 5-3 Example of Dendritic Analysis Showing Critical Issue Decomposition

### Sources of Data

Data collection requirements should be considered throughout the life cycle of the system. As systems move beyond DT, collecting required data becomes increasingly difficult because the data collection hooks in the system software are often removed. Additional cost and schedule delays can occur if software builds need to be revised to collect the data required for subsequent T&E. In addition, the evaluators need to ensure that the appropriate hardware and software are available to perform data reduction and analysis. These tools need to keep pace with system maturity in parallel rather than serially to maintain schedule; however, these support systems are usually afterthoughts.

As evaluation and analysis planning matures, focus turns toward identifying data sources as a means for obtaining each data element. Initial identification tends to be generic such as engineering study, simulation, modeling, or contractor test. Later identification reflects specific studies, models, and/or tests. A data source matrix is a useful planning tool to show where data are expected to be obtained during the T&E of the system. Many sources of data can contribute to the evaluation. Principal sources include studies and analyses, models, simulations, war games, contractor testing, DT, OT, and comparable systems.

## 5.7 Evaluating Developmental And Operational Tests

Technical and operational evaluations employ different techniques and have different evaluation criteria. DT&E is primarily a technical verification evaluation while OT&E addresses and validates the operational aspects of a system. Technical evaluation deals primarily with instrumented tests and statistically valid data. An operational evaluation deals with operational realism and combat uncertainties. DT&E uses technical criteria for evaluating system performance. These criteria are usually parameters that can be measured during controlled DT&E. They are particularly important to the developing organization and the contractor but are of less interest to the independent operational tester. The operational tester focuses on issues such as demonstrating target acquisition at useful ranges, air superiority in combat, or the probability of accomplishing a given mission. An integrated test strategy strives to ensure collaborative test planning and execution of developmental (both contractor and Government) and operational test events to provide shared data in support of independent analysis, evaluation, and reporting by all stakeholders.

For example, during DT&E, firing may be conducted on a round-by-round basis with each shot designed to test an individual specification or parameter with other parameters held constant. Such testing is designed to measure the technical performance of the system. In contrast, in OT&E, technical performance regarding individual specifications/parameters is de-emphasized and the environment is less controlled. The OT&E authority must assess whether, given this technical performance, the weapon system is operationally effective and operationally suitable when employed under realistic combat (with opposing force) and environmental conditions by typical unit personnel. The emphasis in DT is strictly on the use of quantitative data to verify attainment of technical specifications.

Quantitative data are usually analyzed using some form of statistics. Qualitative data take on increasing importance in OT&E when effectiveness and suitability issues are being explored. Many techniques are used to analyze qualitative data. They range from converting expressions of preference or opinion into numerical values to establishing a consensus by committee. For example, a committee may assign values to parameters such as feel, ease of use, friendliness to the user, and will the user want to use it, on a scale of 1 to 10. However, care should be exercised in the interpretation of the results of qualitative evaluations. When numbers are assigned to average qualitative evaluations and their related statistical measures, meanings and interpretation will differ from statistical measures used to characterize quantitative data.

### 5.7.1 Technical Evaluation

The Services materiel development organizations are usually responsible for oversight of all aspects of DT&E including the technical evaluation. The objectives of a technical evaluation include the following:

- To assist the developers by providing information relative to technical performance, qualification of components, compatibility, interoperability, vulnerability, lethality, transportability, RAM, manpower and personnel, system safety, ILS, correction of deficiencies, accuracy of environmental documentation, and refinement of requirements.
- To ensure the effectiveness of the manufacturing process of equipment and procedures through production qualification testing.
- To confirm readiness for IOT&E by ensuring that the system is stressed beyond the levels expected in the operational environment.
- To provide information to the decision authority at each decision point regarding a systems technical performance and readiness to proceed to the next phase of acquisition.

### 5.7.2 Operational Evaluation

The independent OT&E authority is responsible for the operational evaluation. The objectives of an operational evaluation include the following:

- To assist the developers by providing information relative to operational performance; doctrine, training, logistics, and tactics, techniques and procedures (TTP); safety; survivability; manpower; technical publications; RAM; correction of deficiencies; accuracy of environmental documentation; and refinement of requirements.
- To assist decision makers in ensuring that only systems that are operationally effective and suitable are delivered to the operating forces.
- To provide information to the decision authority at each decision point as to a systems operational effectiveness, suitability, and readiness to proceed to the next phase of acquisition.
- To assess, from the user's viewpoint, a system's desirability, considering capabilities of systems already fielded, and the benefits or burdens associated with system support in an operational environment.
- To determine the systems operability in the required climatic and realistic battlefield environments to include natural, induced, and countermeasure environments.

## 5.8 Summary

A primary consideration in identifying information to be generated by an evaluation program is having a clear understanding of the decisions the information will support. The importance of structuring the T&E program to support the resolution of COIs cannot be overemphasized. It is the responsibility of those involved in the evaluation process to ensure that the proper focus is maintained on key issues, the T&E program yields information on critical technical and operational issues, all data sources necessary for a thorough evaluation are tapped, and evaluation results are communicated in an effective and timely manner. The evaluation process should be evolutionary throughout the acquisition phases.

## Test & Evaluation Management Guide

### Chapter 6 - Introduction to DT&E

#### 6.1 Introduction

Material acquisition includes the iterative process of designing, building, testing, identifying deficiencies, fixing, retesting, and repeating as needed to completion. DT&E is an important aspect of this process. DT&E is performed in the factory, in the laboratory, and on the proving ground. It is conducted by subcontractors as they are developing the components and subassembly; by the prime contractor as the components are assembled and integration of the system is ensured; and by the Government to verify and demonstrate how well the weapon system meets its technical requirements.

As defined in [Reference \(ah\)](#), DT&E is (1) Any testing used to assist in the development and maturation of products, product elements, or manufacturing or support processes. (2) Any engineering-type test used to verify status of technical progress, verify that design risks are minimized, substantiate achievement of contract technical performance, and certify readiness for initial OT. Development tests generally require instrumentation and measurements and are accomplished by engineers, technicians, or soldier operator-maintainer test personnel in a controlled environment to facilitate failure analysis.

DT&E is conducted to demonstrate that the engineering design and development process is complete. It is used by the contractor to reduce risk, validate and qualify the design, and ensure that the product is ready for Government acceptance. DT&E results are evaluated to ensure that design risks have been minimized and that the system will meet specifications. The results are also used to estimate the systems military utility when it is introduced into service. DT&E serves a critical purpose in reducing the risks of development by testing all components and subsystems, with emphasis on those with high risks. Finally, DT&E is the Government developing agency's tool used to verify that the system performs as technically specified and that the system is ready for OT. Using various illustrative systems, this chapter provides a general discussion of contractor and Government DT&E activities, stresses the need for an integrated test program, describes some special-purpose DTs, and discusses several factors that may influence the extent and scope of the DT&E program.

DT&E is conducted throughout the system life cycle from program initiation through system sustainment in order to reduce design and programmatic risks and to provide assessments. DT&E may be a mix of contractor testing and Government testing. A DT&E program:

- Verifies achievement of CTPs and KSAs, and assesses progress toward achievement of COIs.
- Verifies that the system satisfies the thresholds prescribed in the capabilities documents.
- Provides data to the PM to enable root cause determination and to identify corrective actions.
- Assesses system readiness for IOT&E.
- Characterizes system functionality.
- Provides information for cost, performance, and schedule trade-offs.
- Assesses system specification compliance.
- Reports on program progress to plan for reliability growth and characterizes reliability and maintainability for use during key reviews.

- Identifies system capabilities, limitations, and deficiencies.
- Assesses system safety.
- Assesses compatibility with legacy systems.
- Stresses the system within an intended mission environment.
- Supports information assurance certification and accreditation.
- Supports the joint interoperability certification processes.
- Documents achievement of contractual technical performance, and verify incremental improvements and system corrective actions.

The PM should develop a robust, integrated T&E strategy for DT&E, OT&E, and LFT&E to validate system performance and ensure that the product provides measurable improvement to operational capabilities. The integrated approach, however, should not compromise DT&E, OT&E, or LFT&E objectives.

## 6.2 DT&E and The System Acquisition Cycle

As illustrated in Figure 6-1, DT&E focuses on the technological and engineering aspects of a system or piece of hardware or software and is revisited as systems evolve or are upgraded. DT&E may begin before program initiation with the evaluation of evolving technology, and it continues after the system is in the field..

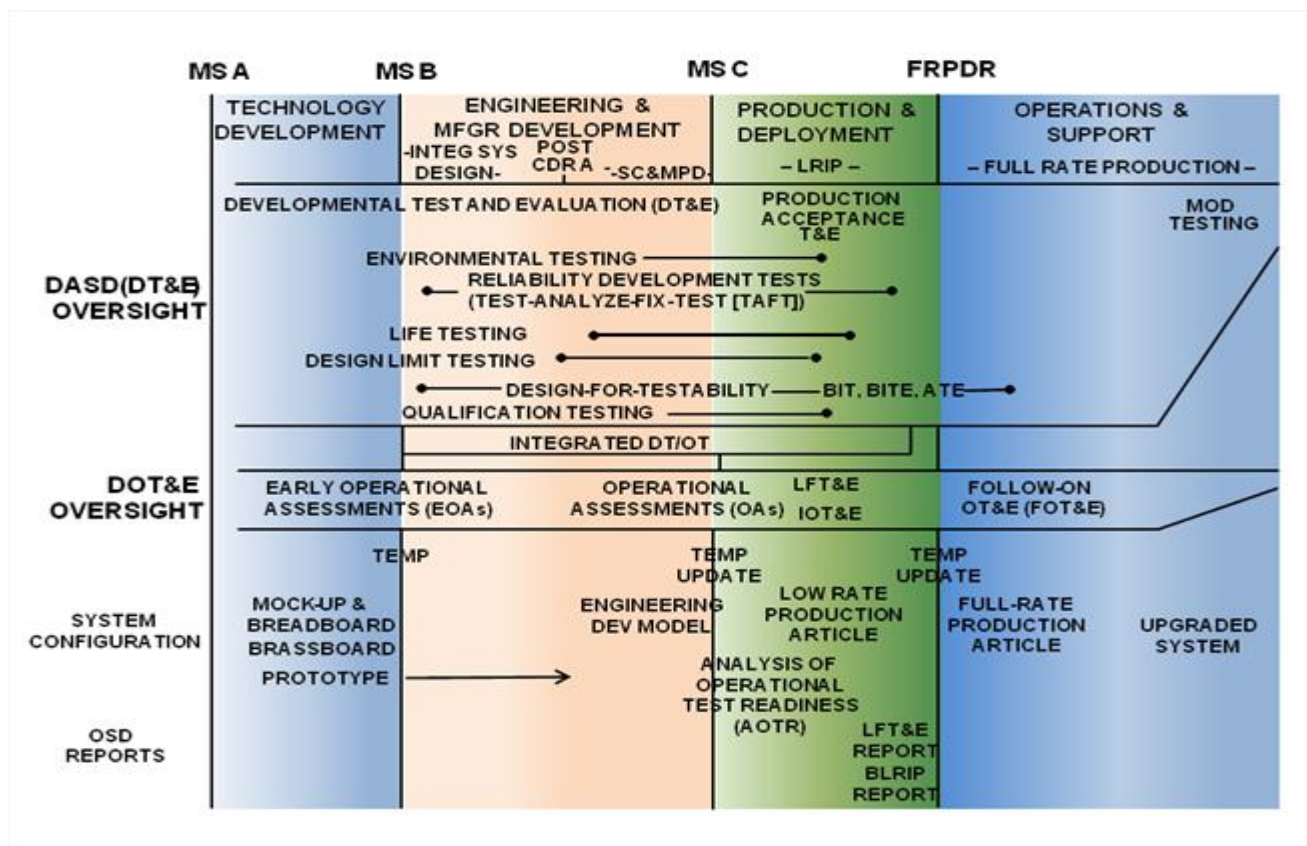


Figure 6-1 Example of Testing Activities throughout the Acquisition Lifecycle

### 6.2.1 DT&E Prior to MS A

Prior to program initiation, M&S, analytical studies, and technology feasibility testing may be conducted to confirm that the technologies being considered for the proposed system are appropriate, are technically feasible, and have potential for needed maturation.

### 6.2.2 DT&E During MSA and TD Phases

During these phases, the testing conducted depends on the state of technical maturity of the test articles design. DT&E that takes place is conducted by a contractor or the Government to:

- Assist in selecting the preferred alternative of system concepts, technologies, and designs.
- Influence subsystem and system design updates.
- Support updated AoA.
- Contribute to requirements updates.

Government testers participate in this testing because information obtained can be used to support technical reviews, early test planning in the TD phase, and development of the CDD and the RFP for MS B. The information obtained from these tests may also be used to support a program start decision by the Services or OSD. DT&E during the TD phase often supports a down-select decision when considering multiple competitors for the subsequent EMD phase. Multiple decision points in the TD phase are supported by DT&E such as Preliminary Design Review (PDR), AoA completion, down-select, and CDD completion.

### 6.2.3 DT&E During EMD Phase

DT is used to demonstrate that technical risk areas have been identified and can be reduced to acceptable levels; the best technical approach can be identified; and, from this point on, engineering efforts will be required rather than experimental efforts. It supports the decision review that considers transition from prototype design into advanced engineering and construction of the EDM. This DT&E includes contractor/Government integrated testing, engineering design testing, and advanced development verification testing.

DT during systems integration is most often conducted at the contractor's facility. It is conducted on components, subsystems, brassboard configurations, or advanced development prototypes to evaluate the potential application of technology and related design approaches before system demonstration. Component interface problems and equipment performance capabilities are evaluated. The use of validated M&S tools is encouraged, especially during the early phases to assess those areas that, for safety or testing capability limitations, cannot be observed directly through testing. M&S can provide early projections of systems performance, effectiveness, and suitability and can reduce testing costs. Testing may include initial environmental assessments.

RAM data needs to be collected throughout the test program. Examples of reliability development testing (RDT) processes include test, analyze, fix, and test (TAFT) and test, analyze, and fix (TAAF), which is shown in Figure 6-1. RAM data from early contractor testing provide key data points, including an

estimate of initial reliability, and become part of the systems RAM database to support planning, projections, and tracking. DT&E conducted during the SC&MPD effort of EMD provides the final technical data for determining a systems readiness to transition into LRIP. It is conducted using advanced EDMs and is characterized by engineering and scientific approaches under controlled conditions. During this same time, programs on OSD OT&E oversight are required to conduct an OA in support of an LRIP decision. The DT&E test lead should consider concurrent DT/OT during this period to maximize data collection and minimize test resources and time. The qualification testing provides quantitative and qualitative data for use in the systems evaluation. The evaluation results are used by the development community and are also provided to Service and OSD decision authorities. These tests measure technical performance including effectiveness, RAM, compatibility, interoperability, IA, safety, and supportability. They include tests of human engineering and technical aspects of the system. Demonstrations indicating that engineering is reasonably complete and that solutions to all significant design problems are in hand are also included. The PM should use [DoD 4245.7-M](#) (Reference (ai)) to check that all aspects of the program have been properly accomplished before any type of production begins.

#### **6.2.4 DT&E During P&D Phase**

##### **6.2.4.1 DT&E During LRIP**

Each Service has different and specific processes incorporated in the certification for IOT&E documentation. For example, the Navy conducts additional DT&E for certification called technical evaluation. This is a DT&E event controlled by the program office that is conducted in a more operationally realistic test environment. The Air Force, on the other hand, has developed a guide with a structured process using templates to assist the PM in assessing the programs readiness for IOT&E.

##### **6.2.4.2 DT&E After FRPDR**

DT may be necessary after the FRP decision is made. This testing is normally tailored to verify correction of identified design problems and demonstrate the system modifications readiness for production. This testing is conducted under controlled conditions and provides quantitative and qualitative data. It is conducted on production items delivered from either the pilot or initial production runs. To ensure that the items are produced according to contract specification, limited quantity production sampling processes are used. This testing determines whether the system has successfully transitioned from engineering development prototype to production, and whether it meets design specifications.

##### **6.2.4.3 Production Qualification Test (PQT)**

Qualification testing is a form of DT that verifies the design and manufacturing process. PQTs are formal contractual tests that confirm the integrity of the system design over the operational and environmental range in the specification. These tests usually use production hardware fabricated to the proposed production design specifications and drawings. Such tests typically include contractual reliability and maintainability (R&M) demonstration tests required before production release. PQT must be completed before FRP in accordance with [Reference \(d\)](#) .

DCMA typically conducts PQT at the direction of the program office. PQTs may be conducted on LRIP items to ensure the maturity of the manufacturing process, equipment, and procedures. These tests are conducted on each item or a sample lot taken at random from the first production lot and are repeated if the process or design is changed significantly or a second or alternative source is brought online. These tests are also conducted against contractual design and performance requirements.

### **6.2.5 DT&E During O&S Phase**

The DT&E that continues after IOC or initial deployment assesses the deployed systems operational readiness and supportability. It ensures that all deficiencies noted during previous testing have been corrected, evaluates proposed PIs and block upgrades, and ensures that ILS is complete. It also evaluates the resources on hand and determines whether the plans to ensure operational phase readiness and support objectives are sufficient to maintain the system for the remainder of its acquisition life cycle. For mature systems, DT&E is performed to assist in modifying the system to help meet new threats, add new technologies, aid in extending service life, or determine the effects of storage on system components. The individual in the PMO responsible for managing the package of support functions required to field and maintain the readiness and operational capability of major weapon systems, subsystems, and components is the product support manager (PSM). The PSM is responsible for all functions related to weapon system readiness in support of the PMs life cycle management responsibilities. The PSM should provide the DT&E community with the best insight into end-of-life issues.

Once a system approaches the end of its usefulness, the testing conducted is concerned with the monitoring of a systems current state of operational effectiveness, suitability, and readiness to determine whether major upgrades are necessary or deficiencies warrant consideration of a new system replacement. Tests are normally conducted by the OT community.

## **6.3 DT&E Responsibilities**

DT&E organizations continue to monitor and observe test progress, supporting test plan development and approval, and reporting as required. During the EMD phase, the OT&E and DT&E organizations must collaborate in conducting OAs and other forms of integrated testing. In some Services, there are also independent evaluation organizations that assist the testing organization in designing and evaluating DTs. As the figure shows, system DT is performed principally by contractors during the early development stages of the acquisition cycle and by Government test/evaluation organizations during the later phases.

### **6.3.1 Typical Contractor Testing Responsibilities**

Contractor testing plays a primary role in the total test program, and the results of contractor tests are useful to the Government evaluator in supporting Government test objectives. It is important that Government evaluators oversee contractor system tests and use test data from them to address Government testing issues. It is not uncommon for contractor testing to be conducted at Government test facilities because contractors often do not have the required specialized facilities (e.g., for testing



hazardous components or for missile flight tests). This arrangement enables Government evaluators to monitor the tests more readily, decreases total program costs, and increases Government confidence in the test results.

The PM and contracting officer must capture all T&E needs, directions, and requirements in the RFP using [Reference \(y\)](#). Normally, an RFP requires that the winning contractor submit an integrated test concept or TEMP within a short period after contract initiation for coordination with Government test agencies and approval. This test plan should include all tests required by the SOW, specifications, and testing expected as part of the contractor's overall engineering development and integration process.

If T&E requirements are not in the RFP, then chances are they will not be in the SOW or contractor's bid. If they are not in the SOW, then the Government will not get the required resources and/or higher costs will result. If the contractor has misinterpreted the RFP requirements or the Government has not adequately articulated needed testing as part of the RFP, then the iterative process of amending the contractor's test program begins. This iterative process must be accomplished within limited bounds so the contractor can meet the test objectives without significant effects on contract cost, schedule, or scope.

### 6.3.2 Typical Government Testing Responsibilities

Government testing builds on contractor testing and is performed to verify and demonstrate how well the system under development meets its technical compliance requirements, to provide data to assess developmental risk for decision making, and to ensure that the technical and support problems identified in previous testing have been corrected and that all critical issues to be resolved by testing have been adequately considered. All previous testing, from the contractor's bench testing through development agency testing of representative prototypes, is considered during Government evaluation.

PMs and the PMO must ensure that the DASD(DT&E), the DOT&E, and their designated representatives have full and immediate access to all records, all reports, and all data, including but not limited to data from all tests, system logs, execution logs, test director notes, user/operator assessments, etc. All data include but are not limited to classified, unclassified, and competition-sensitive or proprietary data when available. Data may be preliminary and must be identified as such.

Government materiel development organizations include major materiel acquisition commands and, in some cases, operational commands. The materiel acquisition commands have T&E organizations that conduct Government DT. In addition to monitoring and participating in contractor testing, these organizations conduct DT on selected high-concern areas to evaluate the adequacy of SE, design, development, and performance to specifications. The PMO must be involved in all stages of testing that these organizations perform.

In turn, the materiel development/T&E agencies conduct DT&E of the systems in the development stage to verify that they meet technical specifications and have the potential to meet operational requirements. These organizations operate Government proving grounds, test facilities, and labs. They

must be responsive to the needs of the PM by providing test facilities, personnel, and data acquisition services, as required.

#### 6.4 Test Program Integration

During the development of a weapon system, many tests are conducted by subcontractors, the prime contractor, and the Government. To ensure that these tests are properly timed and adequate resources are available and to minimize unnecessary testing, a coordinated test program must be developed and followed. The TEMP normally does not provide a sufficient level of detail concerning contractor or subcontractor tests. A contractor or PMO test plan must also be developed to describe these lower level tests in detail. The PM is responsible for coordinating the total T&E program. The PM and/or designated lead (typically the Chief Developmental Tester in many PMOs) performs this task with the assistance of a T&E WIPT whose members should be assembled from the development agency, user, technical and operational T&E, logistics, and training organizations. The PMO must remain active in all aspects of testing including planning, funding, resourcing, execution, and reporting. The PM plays an important role as the interface between the contractor and the Government testing community. Recent emphasis on early T&E highlights a need for early Government tester involvement in contractor testing and early assessments of system functions in the mission context of the operational environment in which the system will be used.

The PM shall identify each test phase or major event in the TEMP as a contractor or Government DT&E. All programs must plan for the conduct of DT&E or integrated test that includes or is led by Government personnel, so as to provide confidence that the system design solution is on track to execute the operational scenarios identified by the OTAs in accordance with [Reference \(d\)](#) .

Whenever feasible, DT&E and OT&E events should be combined, if doing so supports technical and operational test objectives, to gain the optimum amount of testing benefit for reasonable cost and time. The user community should be involved early in test planning to ensure that the statement of desired capabilities is interpreted correctly and tested realistically. Certain events can be organized to provide information useful to developmental and operational evaluators and lend themselves to the combined DT and OT approach. The concept is to conduct a single, combined test program that produces credible qualitative and quantitative information that can be used to address developmental and operational issues. See Chapter 8 of this Guide for additional information.

#### 6.5 Areas Of DT&E Focus

The products of DT&E are critical to the acquisition process. DT&E is focused on identifying acquisition risk; improving operational insight into the system; providing an independent risk assessment; providing characterization of system functionality; ensuring document specification and contract compliance; assessing system readiness for IOT&E; identifying system capabilities, limitations, and deficiencies; providing information for cost, performance, and schedule trade-offs; using integrated testing to produce credible qualitative and quantitative data; and enabling more rapid fielding..

### 6.5.1 System Life Cycle Testing

Life cycle testing is performed to assess the effects of long-term exposure to various portions of the anticipated environment. These tests are used to ensure that the system will not fail prematurely because of metal fatigue, component aging, corrosion, or other problems caused by long-term exposure to environmental effects. Requirements for life cycle testing must be identified early and integrated into system TEMPs and test plans, and testing must be started as soon as practical after stable prototypes are available. System life cycle tests can be time-consuming and costly; therefore, the testing requirements and life cycle characteristics must be carefully analyzed during the initial test design. Accelerated life cycle testing techniques are available and should be used whenever applicable. Collection and analysis of test data should occur throughout the testing cycle. If life cycle characteristics are ignored until the end of the testing phase, extensive redesign and project delays may result.

### 6.5.2 Design Evaluation and Verification Testing

Design evaluation and verification testing are conducted by the contractor and/or the development agency with the primary objective of influencing system design. Design evaluation is fully integrated into the DT cycle in order to:

Determine whether critical system technical characteristics are achievable.

Provide data for refining and making the hardware more rugged to comply with technical specification requirements.

Eliminate as many technical and design risks as possible or to determine the extent to which they are manageable.

Provide for evolution of design and verification of the adequacy of design changes.

Provide information in support of development efforts.

Ensure that components, subsystems, and systems are adequately developed before OTs.

### 6.5.3 Design Limit Testing (DLT)

DLTs are integrated into the test program to ensure that the system will provide adequate performance when operated at outer performance limits and when exposed to environmental conditions expected at the extremes of the operating envelope. The tests are based on mission profile data. Care must be taken to ensure that all systems and subsystems are exposed to the worst-case environments, with adjustments made because of stress amplification factors and cooling problems; for example, an aircraft component may have to be tested at temperature extremes from an arctic environment to a desert environment.

#### 6.5.4 Testing for Reliability

The RAM requirements are assessed during all contractor and Government testing. The reliability growth plan is an essential indicator of how RAM will be assessed and reported as DT&E progresses throughout the acquisition and testing cycles. Data are collected from each test event and placed in a RAM database, which is managed by the development agency. Contractor and Government DT and OT provide a measure of the systems common RAM performance against stated specifications in a controlled environment. RAM data collection during DT emphasizes reliability growth and comparison against a planned reliability growth curve (RGC) that should ultimately reach the specified requirement. Early projections of RAM are important to logistics support planners. The test data facilitate determination of spares quantities, maintenance procedures, and support equipment.

Testing for reliability is a planned process in which items are tested under actual or simulated mission-profile environments to disclose design deficiencies and to provide engineering information on failure modes and mechanisms. Testing for reliability provides a basis for early incorporation of corrective actions and verification of their effectiveness in improving the reliability of equipment. Testing is conducted under controlled conditions with simulated operational mission and environmental profiles to determine design and manufacturing process weaknesses. The reliability growth testing (RGT) process emphasizes reliability growth rather than a numerical measurement. Reliability growth during testing is the result of an iterative design process because as the failures occur, the problems are identified, solutions are proposed, the redesign is accomplished, and the testing for reliability continues. The TEMP requires discussion of RGT and its planned use on a program ( [Reference \(o\)](#) ).

#### 6.5.5 Readiness to Enter IOT&E

Throughout the EMD phase, DT&E activities should be pulling together assessments of technical performance with the operational context in which the system will be operated. Following MS C, the majority of the technical testing is complete and the DT to OT transition reports should be developed in preparation for IOT&E. Each Service is charged with developing and managing its own operational test readiness review (OTRR) process; in addition, all programs on DASD(DT&E) oversight are subject to an independent AOTR conducted by the DASD(DT&E). The goal of the AOTR is to provide the CAE with an independent assessment of the risk associated with the system's ability to meet operational suitability and effectiveness goals, identify system and subsystem maturity levels, assess programmatic and technical risk, and provide risk mitigation recommendations.

#### 6.6 System Design For Testing

Built-in test (BIT), built-in test equipment (BITE), and automated test equipment (ATE) are major areas that must be considered from the start of the design effort. During PDR/CDR, design for testability is evaluated as a condition for approval. Design for testability is an important consideration that addresses the need to:

Collect data during the development process concerning particular performance characteristics.

Enable efficient and economical production by providing ready access to and measurement of appropriate acceptance parameters.

Enable rapid and accurate assessment of the status of the product to the lowest repairable element when deployed.

Many hardware systems have testing circuits designed and built in. This early planning by design engineers allows easy testing for fault isolation of circuits, both in system development phases and during OT. This type of circuit design requires early planning by the PM to ensure that the RFP includes the requirement for designed/BIT capability. Evaluation of these BIT/BITE/ATE systems must be included in the test program.

### **6.7 DT&E Of Limited Procurement Quantity Programs**

Programs that involve the procurement of relatively few items, such as satellites, some large missiles, ships, and unique intelligence equipment, typically over an extended period, are normally subjected to modified DT&E. Occasionally, a unique test approach that deviates from the standard timing and reporting schedule will be used. The DT&E principle of iterative testing starting with components, subsystems, prototypes, and first-production models of the system is normally applied to limited procurements. It is important that DT&E and OT&E organizations work together to ensure that integrated T&E plans are adapted/tailored to the overall acquisition strategy.

### **6.8 Summary**

DT&E is a critical part of an iterative material acquisition process of designing, building, testing, identifying deficiencies, fixing, retesting, and repeating. It is performed in the factory, in the laboratory, and on the proving ground by contractors and the Government. Contractor and Government testing is combined into one integrated test program and conducted to determine whether the performance requirements have been met and to provide data to the decision authority.

## Test & Evaluation Management Guide

### Chapter 7 - DT&E Support of Technical Reviews and Milestone Decision

#### 7.1 Introduction

Throughout the acquisition process, DT&E is oriented around the demonstration of technical compliance to specifications showing the completeness and adequacy of SE, design, development, and performance. DT&E is a tool that shows that the system performs as specified, or having identified deficiencies, shows that those deficiencies have been corrected and the system is ready for OT. DT&E process results are used throughout SE efforts to provide valuable data in support of formal technical reviews. DT&E inherently supports AoA updates, design reviews, requirements updates, and readiness for OT and use by operational units, as outlined in descriptions of the technical reviews detailed within this chapter.

A pictorial roadmap of key activities in the systems acquisition processes-the Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System chart-is available at <https://ilc.dau.mil> . The chart is a training aid for DAU courses and illustrates the interaction of the three key processes that must work in concert to deliver the capabilities required by the Warfighters: the requirements process (JCIDS process); the acquisition process (Defense Acquisition System process); and the program and budget development process (PPBE process).

This chapter describes DT&Es support to the technical reviews essential to the SE effort. As depicted in Figure 7-1, all phases of the acquisition life cycle employ DT&E to facilitate various developmental evaluation requirements. The evaluations span from early prototype and system alternative assessments through product development and verification of system specifications and PQTs.

#### 7.2 DT&E and The Review Process

##### 7.2.1 Technical Reviews

Technical reviews and audits are conducted as part of the overall SE process to ensure that the design meets the system, subsystem, and software specifications and to gain insight into development progress and risks. Each review or audit is unique in its timing, orientation, and exit/entrance criteria.

The ICD is very important in this process. It is the top-level document used as a benchmark to compare contractor progress in designing and developing the desired product. Criteria and timing for these formal technical reviews and audits can be found in Chapter 4 (Systems Engineering) of [Reference \(j\)](#). Detailed official checklists for all DoD technical reviews and audits can be found at the SE CoP, available via the DAU Acquisition Community Connection at <https://acc.dau.mil/CommunityBrowser.aspx> .

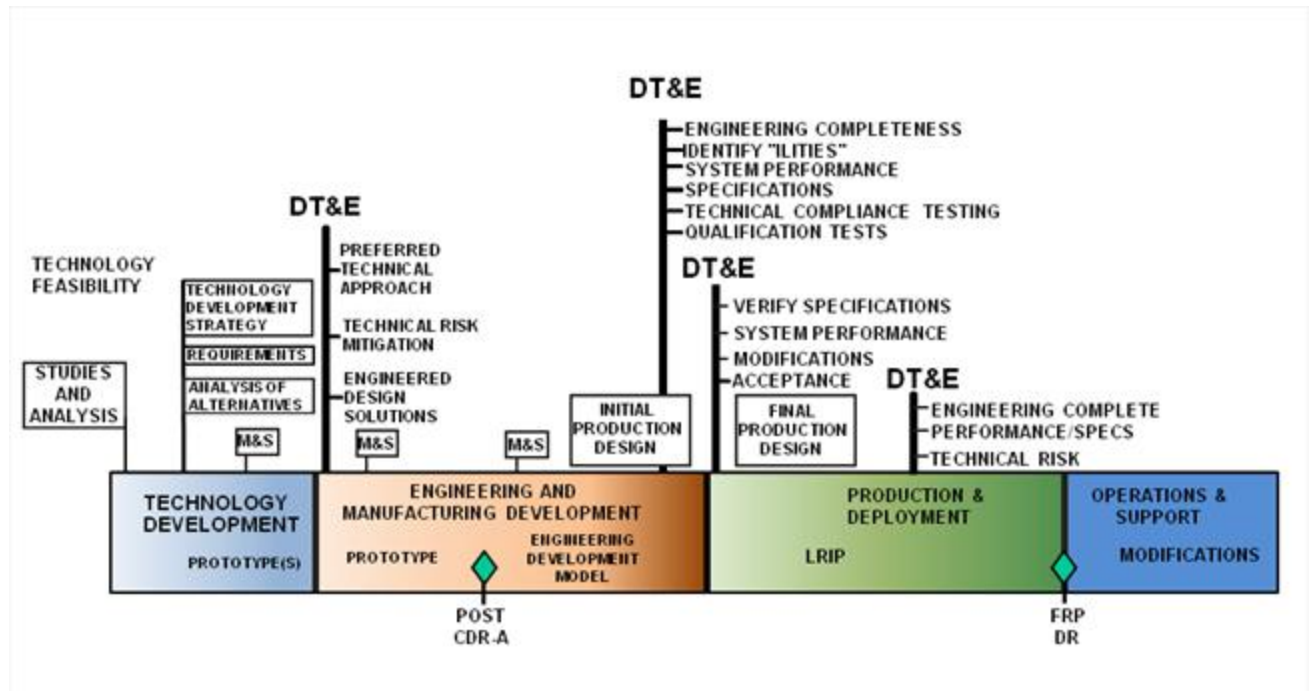
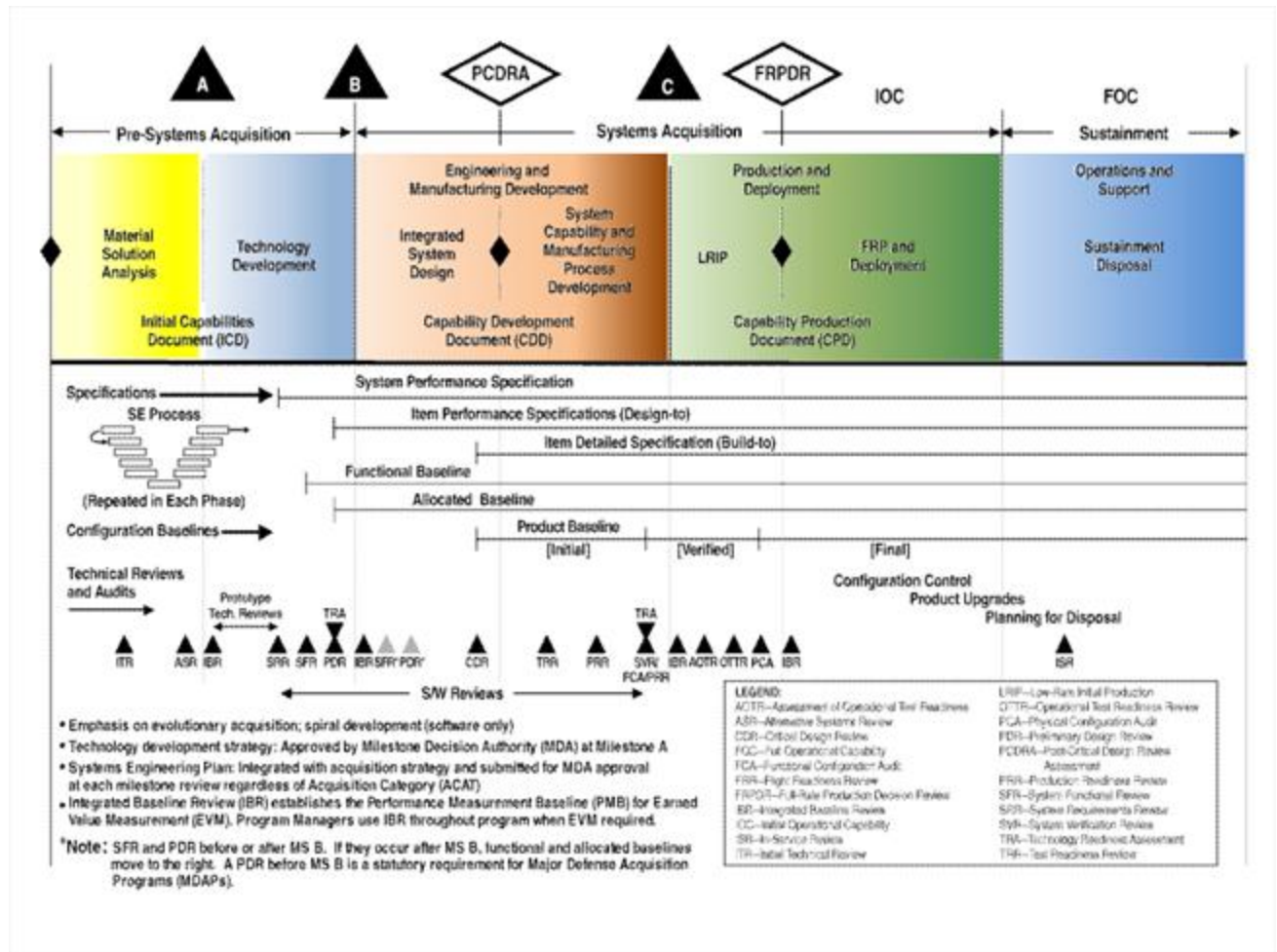


Figure 7-1 Example DT&E Activities Across Phases of the Acquisition Life Cycle

### 7.2.2 Testing in Support of Technical Reviews

The testing community must be continually involved in supporting technical reviews at the subsystem and system levels. The timing of these events, illustrated in Figure 7-2, will vary somewhat from program to program. Lower level design reviews (typically at subsystem level) will lead to system-level reviews. Decisions made at these reviews have major impacts on the system test design and the resources required to test and may impact the TEMP and other documentation. Technical reviews and their proposed timing on a given program are typically discussed in the programs SEP. Figure 7-3 illustrates the program specifications, which are key aspects of the technical review process, and how they are developed and matured across the system life cycle.

DT&E is a process to support the developmental evaluation of a system and evaluate the maturation of KPPs, KSAs, TPMs and CTPs, and parameters. In addition, technical performance measures provide a technique for predicting the future value of a key technical performance parameter of the higher level product under development, based on current assessments of products lower in the system structure. During the technical review process, these parameters and measures assist in the evaluation of system development.





system LCC have been quantified to the maximum extent and that the range of uncertainty in these parameters has been captured and reflected in the program cost estimates.

Specification	When Initially Prepared	Preparing Agent	Approving Agent	Content	Baseline
System Performance (Old Type A)	Mid TD	Developer/PM Industry	Developer/PM User	Defines Mission and Technical Requirement; Allocates Requirements to Functional Areas; Documents Design Constraints; Defines Interfaces	Functional
Item Performance (Old Type B)	Late TD	Industry	Developer/PM	Details Design Requirements; States and Describes Performance Characteristics of each CI; Differentiates Requirements according to Complexity and Discipline Sets	Allocated "Design To"
Item Detail (Old Type C)	Late ISD	Industry	Developer/PM	Defines Form, Fit, Function, Performance and Test Requirements for Acceptance	P R O D U C T
Process (Old Type D)	Late EMD	Industry	Developer/PM	Defines Process Performed During Fabrication	
Material (Old Type E)	Late EMD	Industry	Developer/PM	Defines Production of Raw or Semi Fabricated Material used in Fabrication	
					"Build To"

**Figure 7-3 Specifications Summary**

**Alternative Systems Review (ASR):** The ASR is a multi-disciplined technical review to ensure that the technical baseline agrees with the customer's needs and expectations and that the system under review can proceed into the TD phase. The ASR should be completed prior to and provide information for MS A. Generally, the ASR assesses the preliminary materiel solutions that have been evaluated during the MSA phase and ensures that the one or more proposed materiel solutions have the best potential to be cost-effective, affordable, operationally effective, and suitable and can be developed to provide a timely solution to a need at an acceptable level of risk. Of critical importance to this review is the understanding of available system concepts to meet the capabilities described in the ICD and to meet the affordability, operational effectiveness, technology risk, and suitability goals inherent in each alternative concept.

Acquisition policy requires prototyping in the TD phase; therefore, the ASR should identify key system elements that two or more competing teams will prototype prior to MS B.

### 7.2.3.2 Summary of TD Phase Reviews

**Integrated Baseline Review (IBR):** Baselines formally document a product at some given level of design definition. They are references for the subsequent development to follow. Most DoD systems are developed using the three classic baselines: functional, allocated, and product. Though the program-unique specifications are the dominant baseline documentation, they alone do not constitute a baseline. Additional documents include both end and enabling product descriptions. End-product baseline documents normally include those describing system requirements, functional architecture, physical architecture, technical drawing package, and requirements traceability. APBs are high-level assessments of program maturity and viability. Configuration baselines are system descriptions. The IBR establishes the Performance Measurement Baseline (PMB) for Earned Value Management (EVM). PMs may use the IBR throughout the program when EVM is required.

**Prototype Reviews:** The definition, development, and demonstration of prototypes of system, subsystem, assembly, and component may require the application of SE technical management processes and technical processes and appropriate prototype technical reviews. Technical reviews in support of competitive prototyping and SE technical reviews such as prototype functional review, prototype PDR, or prototype CDR can be beneficial to support the technical approach and program plans. Application, use, and timing of prototype reviews are at the discretion of the program office and prototype developer and are outlined in the programs SEP.

**System Requirements Review (SRR):** The SRR is a multi-disciplined technical review to ensure that the system under review can proceed into initial systems development and that all system requirements and performance requirements derived from the ICD or draft CDD are defined and testable and are consistent with cost, schedule, risk, technology readiness, and other system constraints. Generally, this review assesses the system requirements as captured in the system specification and ensures that the system requirements are consistent with the approved materiel solution (including its support concept) as well as available technologies resulting from the prototyping effort.

The SRR is conducted to ascertain progress in defining system technical requirements. The results of integrated test planning are also reviewed to ensure the adequacy of planning to assess the design and to identify risks. Issues of testability of requirements should be discussed. The SRR is intended to confirm that the user's operational requirements are sufficiently well understood and have been translated into system-specific technical requirements to permit the developer (contractor) to establish an initial system-level requirements baseline. The SRR determines the direction and progress of the SE effort and the degree of convergence upon a balanced and complete configuration baseline. It is normally held during the TD phase, but it may be repeated after the start of EMD phase to clarify the contractor's understanding of redefined or new user requirements.

**System Functional Review (SFR):** The SFR is a multi-disciplined technical review to ensure that the systems functional baseline is established and has a reasonable expectation of satisfying the requirements of the ICD or draft CDD within the currently allocated budget and schedule. It completes the process of defining the items or elements below system level. This review assesses the

decomposition of the system specification to system functional specifications, ideally derived from use-case analysis. A critical component of this review is the development of representative operational use cases for the system. System performance and the anticipated functional requirements for operations maintenance and sustainment are assigned to subsystems, hardware, software, or support after detailed analysis of the architecture and the environment in which it will be employed. The SFR determines whether the systems functional definition is fully decomposed to its lower level and whether IPTs are prepared to start preliminary design.

As part of the SFR, the systems lower level performance requirements are evaluated to determine whether they are fully defined and consistent with the system concept, and whether traceability of lower level systems requirements to top-level system performance and the CDD is maintained. The SFR results in two major products: the final version of the system performance specification and draft version of the performance specifications, which describe the items below system level (item performance specifications). The SFR is the first review that begins to allocate requirements to separated subsystems. As such, it is also the first review in which the need for ICDs becomes necessary to define areas of responsibility and constraints requiring coordination. A successful review is predicated on the IPTs determination that the system performance requirements, lower level performance requirements, and plans for design and development form a satisfactory basis for proceeding into preliminary design.

**Software Specification Review (SSR):** The SSR is a critical subsystem review, unique to software-intensive systems and held prior to the subsystem PDR. The SSR is a formal review of the computer software configuration item (CSCI) requirements, normally held after an SFR but before the start of a CSCI preliminary design. Its purpose is to validate the allocated baseline for preliminary CSCI design, ensure traceability of software requirements to higher level requirements, and establish software test criteria. See also Chapter 16 of this Guide.

**Preliminary Design Review (PDR):** The PDR is a technical assessment establishing the systems allocated baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable. This review assesses the allocated design documented in subsystem product specifications for each CI in the system and ensures that each function in the functional baseline has been allocated to one or more system CIs. The PDR establishes the system-level allocated baseline (hardware, software, human/support systems) and underlying architectures to ensure that the system under review has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule.

For complex systems, a PDR may be conducted incrementally at the subsystem level for each CI. These incremental reviews lead to an overall system-level PDR. The PDR evaluates the set of subsystem requirements to determine whether they correctly and completely implement all system requirements allocated to the subsystem. The PDR also determines whether subsystem requirements trace with the system design. A successful PDR is predicated on the determination that the subsystem requirements, subsystem preliminary design, results of peer reviews, and plans for development, testing, and

evaluation form a satisfactory basis for proceeding into detailed design and test procedure development.

### 7.2.3.3 Summary of EMD Phase Reviews

**Critical Design Review (CDR):** The CDR is a key point within the EMD phase. The CDR is a multi-disciplined technical review establishing the initial product baseline to ensure that the system under review has a reasonable expectation of satisfying the requirements of the CDD within the currently allocated budget and schedule. Incremental CDRs are held for each CI culminating with a system-level CDR. This review assesses the final design as captured in product specifications for each CI in the system and ensures that each product specification has been captured in detailed design documentation. CIs may consist of hardware and software elements and include items such as airframe/hull, avionics, weapons, crew systems, engines, trainers/training, support equipment, etc. Product specifications for hardware enable the fabrication of CIs and include production drawings. Product specifications for software enable coding of the CSCI. The CDR evaluates the proposed baseline (Build To documentation) to determine whether the system design documentation (initial product baseline, including item detail specifications, material specifications, process specifications) is satisfactory to start initial manufacturing.

The CDR brings closure to technical risk mitigation and alternate design paths in detailed system design. Once the product baseline is established, opportunities to improve performance or reduce LCCs are severely limited. Changes to support equipment, training requirements, logistics and supply elements, interoperability, and performance can only be accomplished through a formal engineering change proposal. All technical risk should be reduced to acceptable levels, and remaining program execution risk resulting from resource or schedule shortfalls should be addressed quickly or it will jeopardize program success.

For complex systems, a CDR may be conducted for each subsystem and logistics element. These incremental reviews lead to an overall system CDR. Incremental design reviews are usually defined at ICD boundaries. When incremental reviews have been conducted, additional risk is introduced until the overall system CDR establishes the complete system product baseline. Each incremental CDR closes a functional or physical area of design to modification regardless of when it is held. This completed area of design may need to be reopened if open areas cannot achieve desired performance in isolation. If the schedule is being preserved through parallel design and build decisions, any system deficiencies that lead to reopening design will result in rework and possible material scrap.

At CDR, the EMD process results in a detailed product baseline for the system, hardware, software, support equipment, training systems, system integration laboratory, and technical data. The subsystem detailed designs and logistics elements are evaluated to determine whether they correctly and completely implement all allocated system requirements and whether the CDD traceability to final system detail design is maintained. The overall system-level CDR is not only approval of the system product baseline but also approval of the product baselines for maintainability, supportability, and logistics elements. A successful review is predicated on the review chairperson's determination that the

subsystem requirements, subsystem detail design, results of peer reviews, and plans for T&E form a satisfactory basis for proceeding into system fabrication, demonstration, and test.

**Test Readiness Review (TRR):** The TRR is a multi-disciplined technical review designed to ensure that the subsystem or system under review is ready to proceed into formal test. The TRR assesses test objectives, test methods and procedures, scope of tests, and safety and confirms that required test resources have been properly identified and coordinated to support planned tests. The TRR verifies the traceability of planned tests to program requirements and user needs. It determines the completeness of test procedures and their compliance with test plans and descriptions. The TRR also assesses the system under review for development maturity, cost/ schedule effectiveness, and risk to determine readiness to proceed to formal testing.

The TRR as a tool can be used to support all tests in all phases of an acquisition program, including testing within a system-of-systems context. The PMs and the T&E WIPT should tailor any TRR to the specific acquisition phase, the specific planned tests, and the identified level of risk within the program. The scope of the review is directly related to the risk level associated with performing the planned tests and the importance of the test evaluation results to overall program success. The scope of a planned TRR should align with the requirements verification matrix in the programs SEP.

Readiness to convene a TRR is predicated on the PMs and T&E WIPTs determination that preliminary, functional, and pre-qualification test evaluation results form a satisfactory basis for proceeding with a TRR and subsequent initiation of formal, system-level test. The TRR should answer the following questions:

- Why are we testing? What is the purpose of the planned test? Does the planned test verify a requirement that is directly traceable back to a system specification or other program requirement?
- What are we testing (subsystem, system, system of systems, other)? Is the configuration of the system under test sufficiently mature, defined, and representative to accomplish planned test objectives and/or support defined program objectives?
- Are we ready to begin testing? Have all planned preliminary, informal, functional, unit-level, subsystem, system, and qualification tests been conducted, and are the results satisfactory?
- What is the expected result and how can/do the test evaluation results affect the program?
- Is the planned test properly resourced (people, test article or articles, facilities, data systems, support equipment, logistics, etc.)?
- What are the risks associated with the tests and how are they being mitigated?
- What are the hazards and ESOH risks associated with the specific testing?
- Have the necessary Safety Releases from the PM been provided to developmental and operational testers prior to any test using personnel?
- What is the fall-back plan should a technical issue or potential showstopper arise during testing?

**Flight Readiness Review (FRR):** The FRR is a type of Test Readiness Review, and is applicable only to aviation programs. It assesses the readiness to initiate and conduct flight tests or flight operations. Typically, FRR approval requires the aviation system to be under configuration management, a flight

clearance to be issued by the technical authority, the flight test plan(s) to be approved, and discrepancy tracking and risk assessment processes to be in place.

**System Verification Review (SVR):** The SVR is a multi-disciplined product and process assessment to ensure that the system under review can proceed into LRIP and FRP within cost (program budget), schedule (program schedule), risk, and other system constraints. Generally, this review is an audit trail from the SFR. It assesses the system functionality and determines whether the system meets the functional requirements documented in the functional baseline. The SVR establishes and verifies final product performance. The SVR is often conducted concurrently with the production readiness review (PRR). The FCA may also be conducted concurrently with the SVR.

**Functional Configuration Audit (FCA):** The FCA is the formal examination of the as tested characteristics of a CI (hardware and software) with the objective of verifying that actual performance complies with design and interface requirements in the functional baseline. It is essentially a review of the CIs test/analysis data, including software unit test results, to validate that the intended function or performance stated in its specification is met. For the overall system, this would be the system performance specification. For large systems, FCAs may be conducted on lower level CIs for specific functional areas and address non-adjudicated discrepancies as part of the system-level FCA. A successful FCA typically demonstrates that the EMD product is sufficiently mature for entrance into LRIP.

During the FCA, all relevant test data are reviewed to verify that the item has performed as required by its functional and/or allocated configuration identification. The audit is conducted on the item representative (prototype or production) of the configuration to be released for production. The audit consists of a review of the contractors test procedures and results. The information provided will be used during the FCA to determine the status of planned tests.

The SVR is a system-level configuration audit that may be conducted after system testing is completed. The objective is to verify that the actual performance of the CI (the production configuration), as determined through testing, complies with its item specifications (performance) and to document the results of the qualification tests. The SVR and FCA are often performed at the same time; however, if sufficient test results are not available at the FCA to ensure that the CI will perform in its operational environment, the SVR can be scheduled for a later time.

**Production Readiness Review (PRR):** The PRR examines a program to determine whether the design is ready for production and whether the prime contractor and major subcontractors have accomplished adequate production planning without incurring unacceptable risks that will breach thresholds of schedule, performance, cost, or other established criteria. The review examines risk; it determines whether production or production preparations identify unacceptable risks that might breach thresholds of schedule, performance, cost, or other established criteria. The review evaluates the full, production-configured system to determine whether it correctly and completely implements all system requirements. The review determines whether the traceability of final system requirements to the final production system is maintained.

The PRR examines the readiness of the manufacturing processes, the quality management system, and the production planning (i.e., facilities, tooling and test equipment capacity, personnel development and certification, process documentation, inventory management, supplier management). A successful review is predicated on the plans for design and development addressing the system performance requirements and lower level performance requirements, and forms a satisfactory basis for proceeding into preliminary design. For additional information see Chapter 9 of this Guide.

#### 7.2.3.4 Summary of P&D Phase Reviews

**Physical Configuration Audit (PCA):** The PCA examines the actual configuration of an item being produced. It verifies that the related design documentation matches the item as specified in the contract and as built. In addition to the standard practice of ensuring product verification, the PCA confirms that the manufacturing processes, quality control system, measurement and test equipment, and training are adequately planned, tracked, and controlled. The PCA validates many of the supporting processes used by the contractor in the production of the item and verifies other elements of the item that may have been impacted/redesigned after completion of the SVR.

A PCA is normally conducted when the Government plans to control the detail design of the item it is acquiring via the technical data package. When the Government does not plan to exercise such control or purchase the items technical data package (e.g., performance based procurement), the contractor should conduct an internal PCA to define the starting point for controlling the detail design of the item and establishing a product baseline. The PCA is complete when the design and manufacturing documentation matches the item as specified in the contract and as built.

**Assessment of Operational Test Readiness (AOTR):** Prior to CAE determination of readiness for IOT&E, the DASD(DT&E) conducts an independent AOTR for all ACAT I and IA programs as well as special interest programs designated by the DASD(DT&E). The AOTR focuses on the technical and materiel readiness of the program to proceed into IOT&E. Assessment results are based on capabilities demonstrated in DT&E and earlier OAs. A DT&E report of results and the progress assessment must be provided to the DASD(DT&E) and DOT&E prior to the AOTR. That report can be a written document or a briefing to DASD(DT&E) and DOT&E representatives and should include the following: an analysis of the systems progress in achieving CTPs; satisfaction of approved IOT&E entrance criteria; a technical risk assessment; level of software maturity and status of software trouble reports; and predicted IOT&E results, including the impacts of any shortcomings on the systems expected performance during IOT&E. The report will be provided prior to the CAEs determination of system readiness. This will allow OSD time to formulate and provide its recommendation to the CAE. All appropriate developmental and operational T&E organizations should be invited to the IOT&E readiness review.

The goal of the AOTR is to assess the risk associated with the system's ability to meet operational suitability and effectiveness goals, identify system and subsystem maturity levels, assess programmatic and technical risk, and provide risk mitigation recommendations. The results of the AOTR are provided to the USD(AT&L), DOT&E, and CAE. The CAE must consider the results of the AOTR before making a determination of materiel readiness for IOT&E.

**Operational Test Readiness Review (OTRR):** The OTRR is a multi-disciplined product and process assessment to ensure that the system can proceed into IOT&E with a high probability of success and that the system is effective and suitable for service introduction. The FRP decision may hinge on this successful determination. The understanding of available system performance in the operational environment to meet the CPD is important to the OTRR. Consequently, it is important that the test addresses and verifies system reliability, maintainability, and supportability performance and determines whether the hazards and ESOH residual risks are manageable within the planned testing operations. The OTRR is complete when the SAE evaluates and determines materiel system readiness for IOT&E. The OTRR risk assessment checklist is designed as a technical review preparation tool and should be used as the primary guide for assessing risk during the review. This checklist is available on the SE CoP via the DAU Acquisition Community Connection at <https://acc.dau.mil/CommunityBrowser.aspx>.

#### 7.2.3.5 Summary of (O&S) Phase Reviews

**In-Service Review (ISR):** The ISR is a multi-disciplined product and process assessment to ensure that the system under review is operationally employed with well-understood and managed risk. This review is intended to characterize the in-service health of the deployed system. It provides an assessment of risk, readiness, technical status, and trends in a measurable form. These assessments substantiate in-service support budget priorities. The consistent application of sound programmatic, SE, and logistics management plans, processes, and sub-tier in-service stakeholder reviews will help achieve ISR objectives. Example support groups include the System Safety Working Group and the Integrated Logistics Management Team. A good supporting method is the effective use of available Government and commercial data sources. In-service safety and readiness issues are grouped by priority to form an integrated picture of in-service health, operational system risk, system readiness, and future in-service support requirements.

### 7.3 Tailoring Reviews to Specific Needs

The reviews described in this chapter are based on a complex system development project requiring significant technical evaluation. There are also cases in which system technical maturity is more advanced than normal for the phase; for example, a situation in which a previous program or an Advanced Concept Technology Demonstration (ACTD) has provided a significant level of technical development applicable to the current program. In some cases, tailoring precipitates the merging or even elimination of acquisition phases. Tailoring does not justify the elimination of technical management activities or relieve the Government PM of the responsibilities to see that proper SE disciplines are enforced. It does, however, highlight the need for flexibility and tailoring to the specific needs of the program under development.

In tailoring efforts, be extremely careful determining the level of system complexity. The system integration effort, the development of a single advanced technology or complex subcomponent, or the need for intensive software development may be sufficient to establish the total system as a complex project, even though it appears simple because most subsystems are simple or off-the-shelf.



#### **7.4 Summary**

Technical design reviews and audits are an integral and essential part of the SE process. The meetings range from very formal reviews by Government and contractor PMs to informal technical reviews concerned with product or task elements of the WBS. Reviews may be conducted in increments over time. All reviews share the common objective of determining the technical adequacy of the existing design to meet technical requirements. Reviews and audits may be tailored by the PM to support the programs requirements and objectives. The DT/OT assessments and test results are made available to the reviews, and it is important that the test community be active participants in a programs technical review activities.

## Test & Evaluation Management Guide

### Chapter 8 - Integrated Testing

#### 8.1 Introduction

As defined in the DOT&E and [Deputy Under Secretary of Defense for Acquisition and Technology Memorandum](#) (Reference (aj)), integrated testing is the collaborative planning and collaborative execution of test phases and events to provide shared data in support of independent analysis, evaluation, and reporting by all stakeholders, particularly the developmental (both contractor and Government) and operational T&E communities.

This chapter discusses the use of integrated testing and highlights some of its advantages and disadvantages.

#### 8.2 Integrated Testing

The goal of integrated testing is to conduct a seamless test program that produces credible qualitative and quantitative data useful to all evaluators and to address developmental, sustainment, and operational issues early in the acquisition process to the decision maker. Even with the best integrated effort, some DT must inherently be sequential as it is inappropriate or unsafe to begin OT before certain developmental steps and capabilities are reached.

Integrated testing allows for the sharing of test events, in which a single test point or mission can provide data to satisfy multiple objectives, without compromising the test objectives and responsibilities of participating test organizations. Test points in this context means test conditions denoted by time, three-dimensional location and energy state, and system operating configuration, in which preplanned test techniques are applied to the system under test and the response(s) are observed and recorded. Integrated testing is not just concurrent or combined DT and OT, in which both DT and OT test points are interleaved on the same mission or schedule. Integrated testing focuses the entire test program (contractor test, Government DT, LFT, IA, and OT) on designing, developing, and producing a comprehensive plan that coordinates all test activities to support evaluation results for decision makers at required decision reviews.

Although these ideas of integrated testing are well understood in theory, their actual implementation has been far more difficult. The following basic principles should help focus the efforts of the T&E and acquisition communities:

Collaboration and trust are required on two levels: between the acquisition and T&E communities, and among all test organizations (to include the contractors) who work on the program. Without collaboration and trust, T&E will remain fragmented and suboptimized.

Early tester involvement and influence must help shape the emerging requirements and acquisition strategies, processes, and outputs. The earlier integrated testing concepts are considered, the more they will benefit the program.

Integrated testing principles and methods must be intentionally designed into the program, preferably before MS A, well before any T&E plans are written. They cannot be an afterthought.

Common T&E parameters, methodologies, and terminology must be agreed upon before any data are collected to ensure widest possible use with minimum duplication.

A common T&E database must capture the data in ways that ensure data pedigree and integrity, validity, security, and access to all testers as much as possible.

Integrated test planning should use STAT, such as DOE or similar tools, to make each test event serve multiple goals and organizations. Each test event must squeeze out as much value and data as possible.

The goals of each test organization must not be compromised; each organization must retain its ability to report results to decision makers.

The amount of T&E data must be right sized to the needs of decision makers and Warfighters at each program waypoint. Too little information results in poor execution, and too much produces waste.

It is just as important to define what integrated testing is not. Integrated testing is not an event or separate test phase, and it is not a new type of test. It does not require a single integrated test plan but is a group of test plans that are integrated. Integrated testing does not include the earliest engineering testing of components and subsystems. It does not have to result in an integrated test report but may have several reports using the same common T&E database.

Integrated testing must go hand in glove with early tester involvement or influence-you cannot have one without the other. Early influence means that anyone who writes or reviews early documents (i.e., requirements documents, acquisition strategies, the TES, AoAs, test scenarios, CONOPS, RFPs, SOWs) must use integrated testing principles and goals to shape these forthcoming program documents. The acquisition strategy and first formative milestone decision(s) must be guided by these goals and principles; otherwise, the insertion of integrated testing into program strategies will quickly become more difficult over time.

Both developmental and operational testers must collaborate during the requirements development process to ensure that requirements documents are formulated so all testers can use and understand them. These requirements must be translatable into contractual language for contractor testing; CTPs for DT; and COIs, MOEs, and MOSs for operational testers. Acquisition and requirements officials must be realistic about what is achievable within predetermined technical, time, and budget constraints and include trade space for delivery of capabilities in increments if necessary. For the T&E community, requirements must be clear, unambiguous, testable, and operationally relevant/realistic.

### **8.3 Early Involvement**

Early information about achievement of performance specifications is useful to the decision maker when the evaluation and information are provided with sufficient time to react and affect changes in design. The key point is that saving the evaluation of DT data for independent evaluation later in the

developmental cycle when the OT occurs negates the point of the early information. As stated in the [MCOTEA Manual](#) (Reference (ak)), information's usefulness diminishes as time passes.

As soon as a new program is identified, the PM should form a T&E WIPT to ensure that rigorous T&E design considerations support the TES, the acquisition strategy, the TEMP, the first milestone decision, and any other early T&E-related activity. The T&E WIPT may have an initial cadre of T&E members who give sound advice in their areas of expertise using any available early information about the proposed new system (e.g., technical papers, past experience, test scenarios, or emerging concepts of employment). The PM and the operational tester should co-chair the T&E WIPT, which ensures T&E coverage of the entire program from the earliest to the latest acquisition phases. Integrated testing concepts must be embedded in the TES and TEMP.

According to an article by Edward R. Greer in the ITEA Journal, integrated testing requires careful planning to be successful and has multifaceted meanings. Some of these meanings include the following:

Integrated testing must be an integral part of development and acquisition, providing clear and unambiguous data. All stakeholder needs should be considered and met. Stakeholders include the PM, contractors, the program management team, the entire development team, and the end user.

Contractor and Government DT&E must be planned and conducted in a manner such that there is no duplication of effort, facilities, personnel, or other resources. The open sharing of test data across the test spectrum, from contractor to Government testing, in order to achieve efficiencies is essential.

The continuance of a smooth and integrated flow from DT&E with and into OT&E must be established. Figure 8-1 illustrates an integrated testing continuum that allows for efficiency across contractor DT&E, Government DT&E, and Government OT&E.

A properly developed integrated test approach can generate significant time and cost savings. However, the integrated approach must not compromise either DT or OT objectives. For integrated testing to be most effective, planning efforts must be carefully coordinated early in the program to ensure that data are obtained to satisfy the separate needs of both the developing agency and the independent operational tester. Care must also be exercised to ensure that an integrated test program contains sufficient OT events to quantify and mitigate risk for the decision maker and satisfy the requirement for an independent evaluation. In all integrated test programs, provisions for separate independent developmental and operational evaluations of test results should be provided.

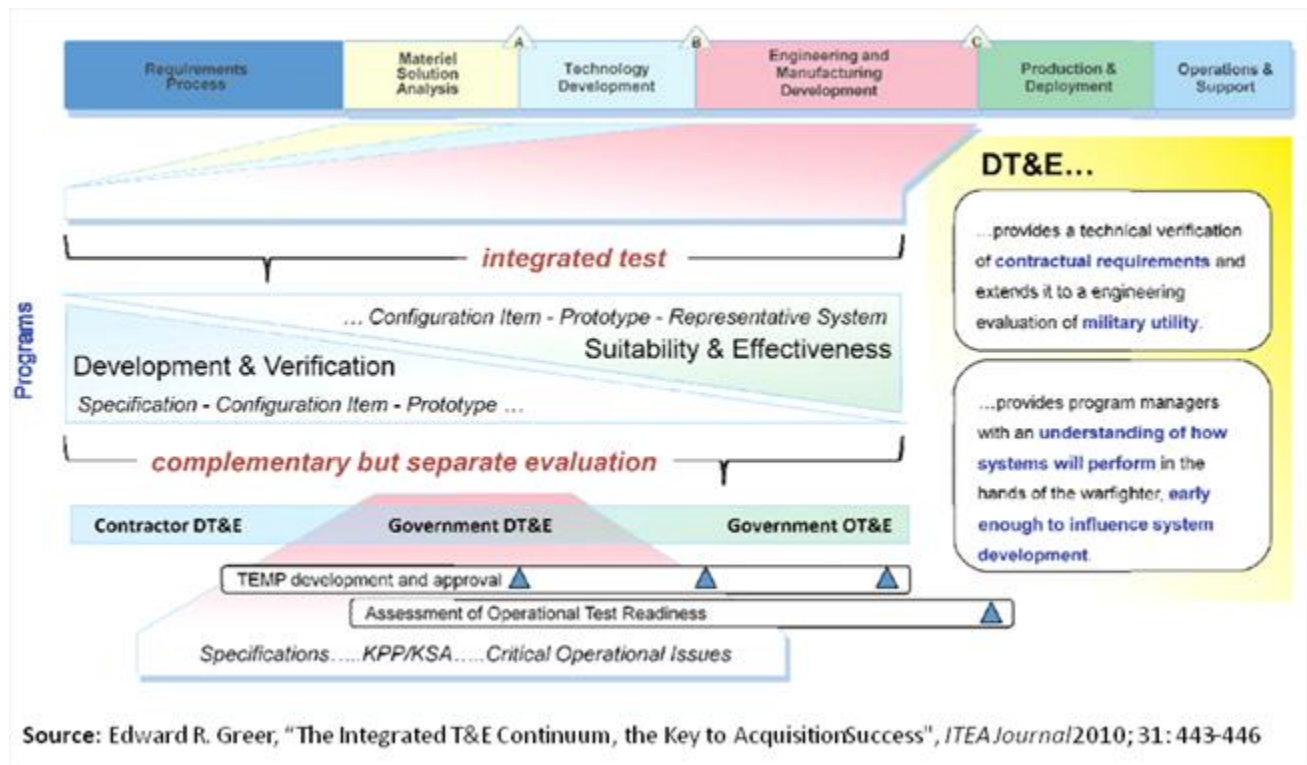
The T&E continuum illustrated in Figure 8-1 can normally be divided into several segments.

In the initial segment, contractor DT events usually assume priority because critical technical and engineering tests must be accomplished to continue the engineering and development process. During this early period, OT personnel participate to gain familiarity with the system and to gain access to any test data that can support OT and demonstrate reliability growth. More importantly, OT personnel also

provide operational inputs that influence system design early, while it is still inexpensive and easy to make changes.

Next, the integrated portion of the testing frequently includes shared DT and OT objectives or joint data requirements. Again, OT involvement continues to influencing system design.

A last segment may contain some dedicated and/or separate OT events to be conducted primarily by the OTA. The OTA and implementing command must ensure that the integrated test is planned and executed in conjunction with the top-level evaluation framework matrix in the TEMP to provide the necessary OT information. The OTA provides an independent evaluation of the system and is ultimately responsible for achieving OT&E objectives.



**Figure 8-1 Integrated Testing as Part of an Overall T&E Continuum**

Certain test events can be organized to provide information useful to both developmental and operational testers through implementation of a coordinated test design process. One or more STAT processes could be used to develop an integrated developmental and operational test program that provides confidence that the performance of a system is understood. (DOE is one such methodology.) For example, prototype free-fall munitions could be released from a fighter aircraft under operational employment conditions instead of from a static stand in such a way as to satisfy DT and OT objectives. Such instances need to be identified as part of the T&E planning process to prevent duplication of effort. An integrated testing approach is also appropriate for certain specialized tests. For example, in the case of nuclear hardness and survivability (NH&S) testing, systems cannot be tested in a totally realistic operational environment; therefore, a single NH&S test may be used to meet both DT and OT objectives.

## 8.4 Evaluation Framework

A T&E program strategy should be structured to provide knowledge to reduce risk in acquisition and operational decisions. That knowledge is developed through the evaluations of all available and relevant data and information from contractor and Government sources. The evaluation framework matrix describes the links between key program and user parameters and the operational and developmental areas that must be evaluated for those parameters. It correlates the knowledge required concerning KPPs/KSAs, CTPs, and key test measures (i.e., MOEs and MOSs) and the planned test methods, key test resources, and facility or infrastructure needs. The discussion of the evaluation framework matrix should also identify major risks or limitations to completing the evaluations. The TEMP reader should be left with a clear understanding of what key questions the evaluations will answer for the program and user and at what key decision points. This layout and discussion will also provide the rationale for the major test objectives and the resulting major resource requirements provided in the Part IV of the TEMP.

The discussion in the evaluation framework matrix should describe the intended maturation of key technologies and the overall system, the evaluation of capabilities in a mission context, and evaluations needed to support required certifications or to comply with statute. The details of how the evaluations will be performed should be left to separate evaluation plans (e.g., system evaluation plan (Army), OT&E plan, LFT&E plan).

The evaluation of the maturation of a system or capability is described in the DT&E section of the evaluation framework and should address the overall approach to evaluate development of system capabilities. The approach should cover CTPs, key system risks, and any certifications required (weapon safety, interoperability). The evaluation of technology maturity should support the TDS. The evaluation of system maturity should support the acquisition strategy. The extent of this discussion will be driven by the amount of development in the acquisition strategy. For example, if the system is an NDI (i.e., COTS or Government off-the-shelf (GOTS)), then there may not be much, if any, maturation of the system required. If the system is a new technologies effort, pushing the state of the art or providing capabilities significantly improved over what is currently being achieved in the operational environment, then there may be a significant amount of effort in maturing or developing the system or its support system and, therefore, more decisions requiring knowledge from evaluations. In assessing the level of evaluations necessary, equal consideration should be given to the maturity of the technologies used, the degree to which system design (hardware and software) has stabilized, as well as the operational environment for the employment of the system. A lesson learned from prior programs is that using a COTS item in a new environment can result in significant capability shortfalls and, therefore, may require unplanned RDT&E efforts to reach required maturity levels.

The system maturation discussions should also cover evaluations for production qualification, production acceptance, and sustainment of the system. The production evaluations may be covered by DCMA representatives and procedures at the contractor's manufacturing plant, or they may require T&E effort to establish and mature the processes. Therefore, the appropriate level of evaluation could range from none, for normal DCMA practices, to minimal for first article qualification checks, to more extensive evaluations based upon results for new or unique manufacturing techniques, especially with

new technologies. The sustainment evaluation discussions should address the key risks or issues in sustaining or assessing the system capability in operational use. The sustainment evaluation discussion should address the overall logistics T&E effort, maintenance (both corrective and preventative), servicing, calibration, and support aspects.

The discussion of mission context evaluations addresses the approach to evaluate operational effectiveness and operational suitability of the system for use by typical users in the intended mission environments. This should also include joint operations issues. These evaluations provide a prediction of how well the system will perform in field use and in IOT&E and may be used to reduce the scope of IOT&E, but these evaluations do not replace or eliminate the need for IOT&E.

The discussion should include COIs. COIs are the operational effectiveness and operational suitability issues (not parameters, objectives, or thresholds) that must be examined to evaluate/assess the systems capability to perform its mission. Not all operational issues are critical-COIs must be relevant to the required capabilities, be of key importance to the system being operationally effective and suitable, and represent a significant risk if not satisfactorily resolved.

The evaluation strategy must include those evaluations required by statute, specifically IOT&E, survivability, and lethality. The IOT&E discussion should describe the approach to conduct the independent evaluation of the system, including official resolution of the COIs. The discussion of the approach to evaluate the survivability/lethality of the system should show how the evaluation will influence the development and maturation of the system design. The discussion should include a description of the overall live-fire evaluation strategy for the system (as defined in [section 2366](#) of Reference (b)); critical live-fire evaluation issues; and any major evaluation limitations.

The discussions supporting the evaluation framework matrix should concisely articulate links between key decisions in the system life cycle, the areas that need to be evaluated to support those decisions, and an outline of the test methodologies needed to obtain the data for the evaluations. The discussions should be summarized in a matrix such as the one depicted in Figure 8-2, which shows one way that an evaluation framework matrix can be organized. Equivalent Service-specific formats that identify the same relationships and information are appropriate. The matrix in the TEMP is an executive-level view that should provide building blocks for more detailed matrixes and links within supporting test plans.

Key Requirements and T&E Measures				Test Methodologies/ Key Resources (M&S, SIL, MF, ISTF, HITL, OAR)	Decision Supported
Key Reqs	COIs	Key MOEs/MOSs	CTPs & Threshold		
KPP #1:	COI #1. Is the XXX effective for...	MOE 1.1.	Engine Thrust	Charger measurement Observation of performance profiles OAR	PDR CDR
	COI #2. Is the XXX suitable for...		Data upload time	Component level replication Stress and Spike testing in SIL	PDR CDR
	COI #3. Can the XXX be...	MOS 2.1.			MS-C FRP
		MOE 1.3.			Post-CDR FRP
		MOE 1.4.	Reliability based on growth curve	Component level stress testing Sample performance on growth curve Samplpe performance with M&S augmentation	PDR CDR MS-C
KPP #2		MOS 2.4.	Data link		MS-C SR
KSA #3	COI #4 Is training...	MOE 1.2.		Observation and survey	MS-C FRP
KSA #3.a	COI #5 Documentation	MOS 2.5			MS-C FRP

**Figure 8-2 Top-Level Evaluation Framework Matrix**

The evaluation framework matrix is divided into three sections: Key Requirements and T&E Measures; Test Methodologies/Key Resources; and Decisions Supported

**Key Requirements and T&E Measures** . These are the KPPs and KSAs and the top-level T&E issues and measures for evaluation. The top-level T&E issues would typically include COIs and COIC, CTPs, and key MOEs/MOSs. System-of-systems COIs should also be included. Each measure should be associated with one or more key requirements. However, there could be T&E measures without an associated key requirement or COI/COIC. Hence, some cells in the evaluation framework matrix may be empty. A simple test to determine whether this section of the matrix is minimally adequate is to confirm that each decision supported has at least one T&E measure associated with it, and that each key requirement also has at least one T&E measure associated with it. Outside of that, only include the T&E issues and measures that drive size or scope of the T&E program.

**Overview of Test Methodologies and Key Resources** . These identify test methodologies or key resources necessary to generate data for evaluations to support decisions. The content of this column should indicate the key methodologies or significant resources that will be required. Test methodology refers to high-level descriptions of methods used to obtain the data. For example, M&S, system integration lab, or open-air range each represent a different methodology for obtaining test data. For situations in which multiple methodologies are acceptable, show the preferred methodology that will be



used. Short notes or acronyms should be used to identify the methodology. Models or simulations should be identified with the specific name or acronym.

**Decisions Supported** . These are the major design, developmental, manufacturing, programmatic, acquisition, or employment decisions driving the need for knowledge to be obtained through T&E. These decisions include acquisition milestones/key decision points, design reviews, certifications, safety releases, production acceptance, and operational employment/deployment. The operational employment/deployment decisions include those made by operators and maintainers that drive the need for validated operating and maintenance manuals. This column would not contain each decision that an operator or maintainer would make but just the overall level of knowledge needed for operating or maintenance data or instructions, or that steer significant or top-level decisions. The key determinant for what to include in this section is whether the decision supported (or knowledge requirement) drives trade space for performance, cost or schedule, or the size or scope of the T&E program. Only those decisions that facilitate program decisions or the size or scope of the T&E program should be included.

## 8.5 Test Data

It is important to establish common T&E tools, methodologies, standards, formulas, etc., that enable the widest possible utilization of all data. Commonality cannot be an afterthought but must be as carefully planned as the T&E event matrixes. Data annotated in furlongs per fortnight would be difficult to merge together with data annotated in miles per hour. Agreement on a common T&E database that has commonly established parameters for all data will enhance the ease and usefulness of integrated testing.

Careful records of system configuration are needed to help all stakeholders decide whether they can use all or part of the available data. Configurations are expected to change during DT&E, and not all DT&E data may be usable for OT&E purposes because OT&E requires data from production-representative test articles. However, some earlier data such as the reliability assessments of components and subsystems that have not been changed may still be usable for OT&E.

## 8.6 Summary

An integrated testing approach may offer an effective means of shortening the time required for testing and achieving cost savings. Integrated testing is the DoDs preferred approach to structure a test program. To be effective, extensive collaboration is required to ensure that the developmental and operational test requirements are addressed. Key to a successful T&E program is the establishment of the T&E WIPT. It is possible to have combined test teams, consisting of DT, OT, and contractor personnel involved throughout the testing process. The teams can provide mutual support and share mutually beneficial data as long as the test program is carefully planned and executed and reporting activities are conducted separately.

## Test & Evaluation Management Guide

### Chapter 9 - Production - Related Testing Activities

#### 9.1 Introduction

Most of the T&E activities discussed in this guide concern the testing of the actual weapon or system being developed. However, a key part of the transition to production involves an evaluation of production-related test activities and the production process that manufactures the actual system. This chapter describes production management and the production process testing that can be performed to assess the effectiveness of the manufacturing process and the producibility of the systems design.

Normally, the DT and OT organizations are not involved directly in this process. Usually, the manufacturing and quality assurance (QA) sections of the program office and a representative of the DCMA oversee/perform many of these functions and can assist in these efforts. DCMA is the DoD Component that works directly with defense suppliers to help ensure that DoD, Federal, and allied Government supplies and services are delivered on time and at projected cost and meet all performance requirements. Before contract award, DCMA provides advice and services to help construct effective solicitations, identify potential risks, select the most capable contractors, and write contracts that meet customer needs. After contract award, DCMA monitors contractor's performance and management systems to ensure that cost, product performance, and delivery schedules are in compliance with the terms and conditions of the contracts.

#### 9.2 Quality In Design

Design engineering efforts should lead to a producible and testable product. The objectives of these design efforts are to achieve effective and efficient manufacturing processes with the necessary process controls to satisfy requirements and minimize manufacturing costs. The design of the system should facilitate, throughout the supply chain, the timely and affordable manufacture, assembly, and delivery of a quality product to the customer.

QA is the part of quality management focused on providing confidence that quality requirements will be fulfilled. Effective quality management activities are important for reducing process-related risks to programs. Further information about quality management is in [Reference \(j\)](#).

#### 9.3 Production Management

Production (or manufacturing) management is the effective use of resources to produce, on schedule, the required number of end items that meet specified quality, performance, and cost. Production management includes but is not limited to industrial resource analysis, producibility assessment, producibility engineering and planning, production engineering, industrial preparedness planning, postproduction planning, and productivity enhancement. Production management begins early in the acquisition process, as early as the concept assessments, and is specifically addressed at each program milestone decision point.

As development proceeds, the manufacturing strategy is developed, and detailed plans are made for production. Independent producibility assessments, conducted in preparation for the transition from development to production, are reviewed before entering LRIP. Once production starts, the producibility of the system design concept is evaluated to verify that the system can be manufactured in compliance with the production-cost and the industrial-base goals and thresholds.

The LRIP decision is supported by an assessment of the readiness of the system to enter production. The system cannot enter production until it is determined that the principal contractors have the necessary resources (i.e., physical, financial, and managerial capacity) to achieve the cost and schedule commitments and to meet peacetime and mobilization requirements for production of the system. The method of formally assessing production readiness is the PRR (See Chapter 7), which is conducted prior to MS C.

#### 9.4 Role Of The PRR

The PRR is intended to determine the status of completion of the specific actions that must be satisfactorily accomplished before executing a production go-ahead decision. The review is typically accomplished in an incremental fashion before commencing production. Usually several incremental reviews and one final review are conducted to assess the risk in exercising the production go-ahead decision. In its earlier stages, the PRR concerns itself with gross-level manufacturing concerns such as the need for identifying high-risk/low-yield manufacturing processes or materials, or the requirement for manufacturing development effort to satisfy design requirements. According to DAU Technical [Guide to Production Readiness Reviews and Manufacturing Risk Assessment](#), timing of the incremental PRRs is event-driven and a function of program posture and is not specifically locked into other reviews.

Figure 9-1 provides a list of typical criteria evaluated as part of a PRR. A PRR is typically conducted by an IPT, which may include DCMA support. The IPT lead assembles a team composed of individuals in the disciplines of design, industry, manufacturing, procurement, inventory control, contracts, engineering, and quality training. The PRR director organizes and manages the team effort and supervises preparation of the findings. PRR decision authority lies with the Government, typically the PM. Examples of a detailed PRR checklist are available from DAU at <https://acc.dau.mil/CommunityBrowser.aspx?id=23248>. The checklist may be scaled down based on ACAT level or program risk.

#### 9.5 Production Qualification Testing

Qualification testing is performed to verify the design and manufacturing process, and it provides a baseline for subsequent acceptance tests. Production qualification testing is conducted at the unit, subsystem, and system level on production items and is completed before the production decision. The results of these tests are a critical factor in assessing the systems readiness for production. Down line PQTs are performed to verify process control and may be performed on selected parameters rather than at the levels originally selected for qualification.

<p><b>Product Design</b></p> <ul style="list-style-type: none"> <li>Producible at Low Risk</li> <li>Stabilized at Low Rate of Change</li> <li>Validated Design</li> <li>Reliability, Maintainability, and Performance Demonstrated</li> </ul> <p><b>Industrial Resources</b></p> <ul style="list-style-type: none"> <li>Adequate Plant Capacity (Peacetime and Wartime Demands)</li> <li>Facilities, Special Production and Test Equipment, and Tooling Identified</li> <li>Needed Plant Modernization (CAD/CAM, Other Automation) Accomplished</li> <li>Associated Computer Software Developed</li> <li>Skilled Personnel and Training Programs Available</li> </ul> <p><b>Production Engineering and Planning</b></p> <ul style="list-style-type: none"> <li>Production Plan Developed</li> <li>Production Schedules Compatible with Delivery Requirements</li> <li>Manufacturing Methods and Processes Integrated with Facilities, Equipment, Tooling and Plant Layout</li> <li>Value Engineering Applied</li> <li>Alternate Production Approaches Available</li> <li>Drawings, Standards and Shop Instructions are explicit</li> <li>Configuration Management Adequate</li> <li>Production Policies and Procedures Documented</li> <li>Management Information System Adequate</li> <li>Contractor's Management Structure is Acceptable to the PMO</li> </ul> <p><b>Materials</b></p> <ul style="list-style-type: none"> <li>All Selected Materials Approved By Contractor's Material Engineers</li> <li>Bill of Materials Prepared</li> <li>Make-or-Buy Decisions Complete</li> <li>Procurement of Long Lead-Time Items Identified</li> <li>Sole-Source and Government-Furnished Items Identified</li> <li>Contractor's Inventory-Control System Adequate</li> <li>Contractor's Material Cost Procurement Plan Complete</li> </ul> <p><b>Quality Assurance (QA)</b></p> <ul style="list-style-type: none"> <li>Quality Plan in Accordance with Contract Requirements</li> <li>Quality Control Procedures and Acceptance Criteria Established</li> <li>QA Organization Participates in Production Planning Effort</li> </ul> <p><b>Logistics</b></p> <ul style="list-style-type: none"> <li>Operational Support, Test and Diagnostic Equipment Available at System Deployment</li> <li>Training Aids, Simulators, and Other Devices Ready at System Deployment</li> <li>Spares Integrated into Production Lot Flow</li> </ul>
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**Figure 9-1 Typical Criteria Evaluated as Part of a PRR**

### 9.5.1 PQTs

PQTs are a series of formal contractual tests conducted to ensure design integrity over the specified operational and environmental range. The tests are conducted on pre-FRP items fabricated to the proposed production design drawings and specifications. The PQTs include all contractual R&M demonstration tests required before production release. For volume acquisitions, these tests are a constraint to production release.

### 9.5.2 First Article Tests (FATs)

FATs consist of a series of formal contractual tests conducted to ensure the effectiveness of the manufacturing process, equipment, and procedures. These tests are conducted on a random sample from the first production lot. According to Subpart 9.3 of the [Federal Acquisition Regulation](#) (Reference (a)), these series of tests are repeated if the manufacturing process, equipment, or procedure is changed significantly and when a second or alternative source of manufacturing is brought online.

## 9.6 Transition To Production

In an acquisition process, often the first indication that a system will experience problems is during the transition from engineering design to LRIP. This transition may continue over an extended period, and during this period, the system is undergoing stringent contractor and Government testing. There may be unexpected failures requiring significant design changes, which impact quality, producibility, and supportability and may require program schedule slippage. Long periods of transition usually indicate that insufficient attention to design or producibility was given early in the programs acquisition process.

### 9.6.1 Transition Planning

Producibility engineering and planning is the common thread that guides a system from early concept to production. Planning is a management tool used to ensure that adequate risk-handling measures have been taken to transition from development to production. One product from the planning process is a checklist for use during the readiness reviews. Planning should tie together the applications of designing, testing, and manufacturing activities to reduce data requirements, duplication of effort, costs, and scheduling and to ensure early success of the LRIP first production article.

### 9.6.2 Testing During the Transition

Testing accomplished during the transition from development to production will include acceptance testing, manufacturing screening, and final testing. These technical tests are performed by the contractor to ensure that the system will transition smoothly and that test design and manufacturing issues affecting design are addressed. During this same period, the Government will be using the latest available CIs to conduct the IOT&E. The impact of these tests may overwhelm the configuration management of the system unless careful planning is accomplished to handle these changes.

## 9.7 LRIP

LRIP is the production of a system in limited quantity to provide articles for IOT&E and to demonstrate production capability. Also, LRIP permits an orderly increase in the production rate sufficient to lead to FRP upon successful completion of OT. The decision to have an LRIP is made at the MS C approval of the program acquisition strategy. At that time, the PM must identify the quantity to be produced during LRIP and validate the quantity of LRIP articles to be used for IOT&E (ACAT I approved by the DOT&E; ACAT II and III approved by the Service OTA) in accordance with [Enclosure 2](#) of Reference (d).

Consistent with [section 2400](#) of Reference (b), [Reference \(d\)](#), and [Reference \(h\)](#), production-representative articles should be used for T&E. Wherever practical, T&E will be conducted using LRIP systems assembled using the parts, tools, and manufacturing processes intended for use in FRP. The system will also utilize the intended production versions of software. In addition, the logistics system and maintenance manuals intended for use on the fielded system should be in place.

When the use of LRIP articles is impractical, the system used in T&E should, at a minimum, incorporate the same parts and software to be used in LRIP articles. In particular, the hardware and software should be as defined by the system-level CDR, FCA, and SVR, including correction of appropriate major deficiencies identified during DT. (See Chapter 7 of this Guide for a discussion of the technical reviews.) Manufacturing processes to be used in FRP should also be adhered to as closely as possible. DOT&E must be provided with detailed information describing any process differences in order to independently evaluate whether the differences are acceptable.

DOT&E will assess adherence to the above guidelines as part of its responsibility for reviewing and approving TEMPs and test plans. Proposals to use articles not from LRIP to conduct IOT&E will be considered for approval by DOT&E using the criteria stated above as part of those reviews.

When the decision authority thinks the systems will not perform to expectation, the PM may direct that the system not proceed into LRIP until there is a program review. The DOT&E submits a BLRIP report on all oversight systems to congressional committees before the FRP decision, which approves the system to proceed beyond LRIP, is made.

## 9.8 PAT&E

The PAT&E ensures that production items demonstrate the fulfillment of the requirements and specifications of the procuring contract or agreements. The testing also ensures that the system being produced demonstrates the same performance as the pre-FRP models. The procured items or system must operate in accordance with system and item specifications. The PAT&E is usually conducted by the program office QA section at the contractor's plant or by DCMA support staff and may involve operational users. Acceptance may be either at the source (contractor's plant) or the destination (Government-identified site) based on the need for test or inspection resources that may not be readily available at the contractor's facilities. At a high level, PAT&E prescribes the policies and procedures to ensure that supplies and services conform to contract requirements in [Subpart 46.401](#) of Reference (a).

The effectiveness of a PAT&E program is directly tied to inclusion of contract language that clearly defines the acceptance requirements and outcomes of compliance. Appropriate contractual acceptance criteria are developed by understanding program reliability and performance requirements and identifying the methods and thresholds by which the compliance to requirements will be evaluated. In accordance with the acquisition regulation, incentives must be used to the maximum extent practical and may be positive, negative, or a combination of both. Government surveillance (PAT&E) is usually formalized in a quality assurance surveillance plan (QASP) (See [Subpart 46.401](#) of Reference (a)). The QASP is incorporated into the contract.

For the PAT&E of an Air Force bomber, for example, the contractor and Government QA inspectors reviewed all manufacturing and ground testing results for each aircraft. In addition, a flight test team, composed of contractor and Air Force test pilots, flew each aircraft a minimum of 10 hours, demonstrating all onboard aircraft systems while in flight. Any discrepancies in flight were noted, corrected, and tested on the ground; they were then retested on subsequent checkouts and acceptance flights. Once each aircraft had passed all tests and all systems were fully operational, Air Force authorities accepted the aircraft. The test documentation also became part of the delivered package. During this test period, the program office monitored each aircrafts daily progress.

## 9.9 Summary

A primary purpose of production-related testing is to lower the production risk. The PM must ensure that the contractors and subcontractor's manufacturing strategy and capabilities will result in the desired product within acceptable cost. The LRIP and PAT&E also play major roles in ensuring that the production unit is identical to the design drawings and conforms to the specifications of the contract, the IOT&E is conducted with representative system configurations, and the system fielded will meet the user's needs.



## Test & Evaluation Management Guide

### Chapter 10 - Introduction to Operational Test and Evaluation

#### 10.1 Introduction

This chapter provides an introduction to the concept of OT&E. It outlines the purpose of OT&E, defines OT&E, discusses the primary participants in the OT&E process, describes several types of OT&E, and includes some general guidelines for the successful planning, execution, and reporting of OT&E programs.

#### 10.2 Purpose and Scope of OT&E

OT&E is conducted for major programs by an organization that is independent of the developing, procuring, and using commands. Some form of OA or OT is normally conducted in each acquisition phase. Each should be keyed to a decision review in the materiel acquisition process. OT&E should be focused on mission accomplishment rather than meeting specifications, requirements, MOEs, and MOPs. The OT&E provides the decision authority with an estimate of the following:

- The degree of satisfaction of the user's requirements expressed as operational effectiveness and operational suitability of the new system.
- The systems current capabilities, considering equipment already available and operational benefits or burdens associated with the new system.
- The need for further development of the new system to correct performance deficiencies.
- The adequacy of doctrine, organizations, operating techniques, tactics, and training for employment of the system; of maintenance support for the system; and of the systems performance in the countermeasures environment.

OT&E is legally defined in [section 2399](#) of Reference (b) as the field test, under realistic combat conditions, of any item of (or key component of) weapons, equipment, or munitions for the purposes of determining the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users; and the evaluation of the results of such test. This term does not include an operational assessment based exclusively on computer modeling; simulation; or an analysis of system requirements, engineering proposals, design specifications, or any other information contained in program documents.

Key aspects of this legal definition of OT&E are the terms operational effectiveness and operational suitability, which can be defined as follows:

- **Operational Effectiveness** . The degree to which the system accomplishes its missions when employed by operational personnel in a realistic scenario (natural, electronic, threat) with the appropriate organization, doctrine, supportability, survivability, vulnerability, and threat (including countermeasures, nuclear threats, nuclear effects, and NBC threats) environment, and using tactics and techniques developed during earlier FOT&E.



- **Operational Suitability** . The degree to which the system can be placed in operational field use, with specific evaluations of availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, natural environmental effects and impacts, logistics supportability, and documentation and training requirements.

Operational effectiveness and suitability must be evaluated and reported on the basis of whether a system can be used by Soldiers, Sailors, Airmen, and Marines to accomplish a combat mission. The appropriate environment for that evaluation includes the system under test and all interrelated systems (i.e., its planned or expected environment in terms of weapons, sensors, C2, and platforms, as appropriate) needed to accomplish an end-to-end mission in combat. The data used for evaluation are appropriately called MOEs because they measure the military effect (mission accomplishment) that comes from the use of the system in its expected environment. Figure 10-1 depicts the scope of OT&E.

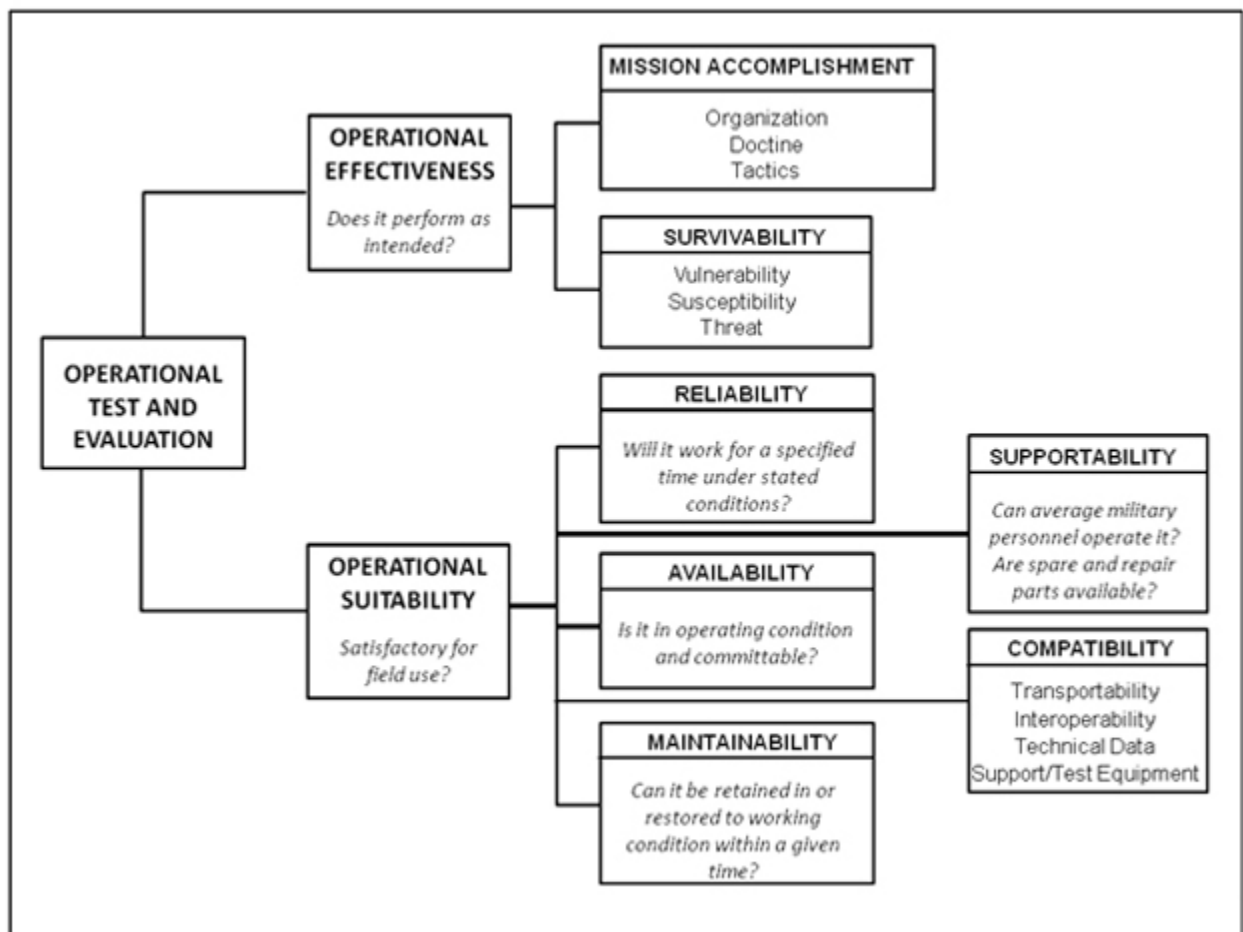


Figure 10-1 Scope of the OT&E Effort

### 10.3 Test Participants

OT&E is managed by an independent OTA, which each Service is required to maintain. Personnel who operate, maintain, and support the system during OT&E are trained to a level commensurate with that of typical personnel who will perform these functions under peacetime and wartime conditions. Also, PMO personnel, the IPTs, and test coordinating groups play important parts in the overall OT&E planning and execution process.

#### 10.3.1 Service OTAs

The OT&E agencies should become involved early in the systems life cycle, usually during the programs evaluation of concepts. At that time, they can begin to develop strategies for conducting OT&E. As test planning continues, a more detailed TEMP (which includes OTs, among other tests) is developed, and the test resources are identified and scheduled. During the early stages, the OTAs structure an OT&E program consistent with the approved acquisition strategy for the system, identify critical OT issues, and assess the adequacy of candidate systems. As the program moves into advanced planning, OT&E efforts are directed toward becoming familiar with the system, encouraging interface between the user and developer, and further refining the COIs. The OTA test directors, analysts, and evaluators design the OT&E so that the data collected will support answering the COIs.

Each Service has an independent organization dedicated to planning, executing, and reporting the results of that Service's OT&E activities. These organizations are ATEC, Navy OPTEVFOR, AFOTEC, and MCOTEA. Although policy requires an OTA only within the Services, DISA has designated JITC as the OTA for its DoD information systems and a special operations command element conducts many of its own IOT&Es.

#### 10.3.2 Test Personnel

OT is conducted on materiel systems with typical user organizational units in a realistic operational environment. It uses personnel with the same specialties (i.e., military occupational specialties, Air Force specialty codes) as those who will operate, maintain, and support the system when fielded. Participants are trained in the systems operation based on the Services operational mission profiles. Because some OT&E consists of force-on-force tests, the forces opposing the tested system must also be trained in the use of threat equipment, tactics, and doctrine. For OT conducted before IOT&E, most system training is conducted by the systems contractor. For IOT&E, the contractor trains the Service school cadre, who then train the participating organizational units. Once the system has entered FRP, the Service will normally assume training responsibilities, unless the contractor will continue to train once the system is fielded. OT often requires a large support staff of data collectors and scenario controllers operating in the field with the user test forces and opposing forces.

## 10.4 OT&E as it Relates to DT&E

As shown in Figure 10-2, DT is focused on verifying that the system under test meets its technical requirements, and OT focuses on validating the functioning of the equipment in a realistic combat environment. Although DT&E and OT&E are separate activities and are conducted by different test communities, the communities frequently interact and complement each other. Well-constructed test programs can and should be integrated in many respects. DT&E provides a view (verification) of the technical objectives, and OT&E provides an assessment (validation) of the systems potential to satisfy user requirements.

DT	IOT&E
<ul style="list-style-type: none"> <li>• Controlled by program office</li> <li>• One-on-one tests</li> <li>• Controlled environment</li> <li>• Contractor involvement</li> <li>• Trained, experienced operators</li> <li>• Precise Performance Objectives and Threshold Measurement</li> <li>• Test to Technical Specification</li> <li>• Development Test Article</li> </ul>	<ul style="list-style-type: none"> <li>• Controlled by independent agency</li> <li>• Many-on-many tests</li> <li>• Realistic environment with operational scenario</li> <li>• Restricted contractor involvement</li> <li>• User troops recently trained</li> <li>• Performance Measurement of Operational Effectiveness &amp; Suitability</li> <li>• Test to operational requirements</li> <li>• Production representative test article</li> </ul>

**Figure 10-2 Comparison of DT and IOT&E Differences Highlighted**

## 10.5 Types of OT&E

OT&E efforts can be divided into two phases: (1) OT performed before FRP and (2) OT performed after the FRP decision. The pre-FRP OT&E includes EOAs, OAs, and IOT&E. OAs begin early in the program, frequently before program start, and continue until the system is certified as ready for IOT&E. The IOT&E is conducted late during low-rate production, when test assets are available, in support of the FRPDR. The Navy uses the term OPEVAL (operational evaluation) to define IOT&E. After transition to FRP, all subsequent OT is usually referred to as FOT&E.

Evolutionary acquisition is the DoDs preferred acquisition approach for many defense systems. An evolutionary approach delivers capability in increments, recognizing upfront the need for future capability improvements. Each increment is a militarily useful and supportable operational capability that can be developed, produced, deployed, and sustained. Block upgrades, P3Is, and similar efforts that provide a significant increase in operational capability and meet an acquisition category threshold as specified by [Reference \(d\)](#) are managed as separate increments. Early involvement of all test agencies is essential in the first and subsequent evolutionary increment. Test content and reporting should be tailored against earlier test results, evaluating at a minimum the increment of mission accomplishment and survivability required of the new increment, plus whether performance previously demonstrated by the previous increment has been degraded in accordance with [Enclosure 6](#) of Reference (d).

### 10.5.1 EOAs

EOAs are conducted primarily to forecast and evaluate the potential operational effectiveness and suitability of the weapon system during development. EOAs started during the MSA and/or TD acquisition phases may continue into system integration and are conducted on prototypes of the developing design.

### 10.5.2 OAs

An OA is an evaluation of operational effectiveness and operational suitability made by an independent OT activity, with user support as required, on other than production systems. The focus of an OA is on significant trends noted in development efforts, programmatic voids, risk areas, adequacy of requirements, and the ability of the program to support adequate OT. An OA may be conducted at any time using technology demonstrators, prototypes, mock-ups, EDMs, or simulators but will not substitute for the IOT&E necessary to support FRP decisions. An OA is normally conducted prior to MS C.

The OA normally takes place during each phase of the acquisition process prior to IOT&E. It is used to provide an early assessment of potential operational effectiveness and suitability for decision makers at decision points. These assessments attempt to project the systems potential to meet the user's requirements. Assessments conducted early in the program development process may be called EOAs.

The OA begins when the OTAs start their evaluations of system-level performance. The OTA uses any testing results, M&S, and data from other sources during an assessment. These data are evaluated by the OTA from an operational point of view. As the program matures, these OAs of performance requirements are conducted on EDMs or pre-production articles until the system performance is considered mature. The mature system can then be certified ready for its IOT&E (OPEVAL in the Navy). When using an evolutionary acquisition strategy, subsequent increments will at least have an OA before the new increment is issued to the user.

### 10.5.3 IOT&E (Navy OPEVAL)

Prior to entering IOT&E, an OTRR is conducted. An OTRR is a multi-disciplined product and process assessment to ensure that the system can proceed into IOT&E with a high probability of success and that the system is effective and suitable for service introduction. The FRP decision may hinge on this successful determination. The understanding of system performance in the operational environment to meet the CPD is important to the OTRR. Consequently, it is important that the test addresses and verifies system reliability, maintainability, and supportability performance and determines whether the hazards and ESOH residual risks are manageable within the planned testing operations. The OTRR is complete when the SAE, or the appointed MDA, evaluates and determines materiel system readiness for IOT&E.

The OT&E performed in support of the FRP decision is generally known as IOT&E. The Navy calls this event OPEVAL. The IOT&E occurs during LRIP and must be completed before the FRPDR. More than one IOT&E may be conducted on the system if there are system performance problems requiring retest, the

system is decertified, or a need exists to test in additional environments. The IOT&E is conducted on a production or production-representative system using typical operational personnel in a realistic combat scenario.

The IOT&E is the final dedicated phase of OT&E preceding an FRP decision. The Services OTRR precedes the beginning of testing considers the results of DT&E, manufacturing processes, safety, and other Service specific exit/success criteria. For OSD T&E oversight programs, the DASD(DT&E) submits an AOTR for use in the certification of readiness for OT&E decision. The IOT&E is conducted by an OT&E agency independent of the contractor, PMO, or developing agency. IOT&E has been described as follows:

- All OT&E conducted on production or production-representative articles to support the decision to proceed beyond LRIP. It is conducted to provide a valid estimate of expected system operational effectiveness and operational suitability. The definition of OT&E as spelled out in [section 139](#) of Reference (b) is generally considered applicable only to IOT&E.
- The results from IOT&E are evaluated and presented to the MDA to support the FRP decision, and for MDAPs and selected OSD oversight programs, the results are documented in DOT&Es BLRIP report. This phase of OT&E addresses the KPPs identified in the CPD and the COIs identified in the TEMP. IOT&E plans for ACAT I and IA and other designated programs must be approved by the DOT&E. DOT&E considers the Service reports, but the foundation of the BLRIP report is DOT&Es own independent analysis and evaluation.

#### **10.5.4 FOT&E**

FOT&E is the OT&E that may be necessary after the FRPDR to refine the estimates made during IOT&E, to evaluate changes, and to reevaluate the system to ensure that it continues to meet operational needs and retains its effectiveness in a new environment or against a new threat. FOT&E is conducted during fielding/deployment and operational support and sometimes may be divided into two separate activities. Preliminary FOT&E is normally conducted after IOC is attained to assess full system capability. It is conducted by the OTA or designated organization to verify the correction of deficiencies, if required, and to assess system training and logistics status not evaluated during IOT&E. Subsequent FOT&E is conducted on production items throughout the life of a system. The results are used to refine estimates of operational effectiveness and suitability; to update training, tactics, techniques, and doctrine; and to identify operational deficiencies and evaluate modifications. This later FOT&E often is conducted by the operating command.

FOT&E is conducted in a realistic tactical environment similar to that used in IOT&E, but fewer test items may be used. Normally, FOT&E is conducted using fielded production systems. Specific objectives of FOT&E include testing modifications that are to be incorporated into production systems, completing any deferred or incomplete IOT&E, evaluating correction of deficiencies found during IOT&E, and assessing reliability including spares support on deployed systems. The tests are also used to evaluate the system in a different platform application for new tactical applications or against new threats .

### 10.5.5 Qualification Operational Test and Evaluation (QOT&E)

QOT&E may be performed by the major command, user, or OTA and is conducted on minor modifications or new applications of existing equipment when no R&D funding is required. An example of a program in which QOT&E was performed by the Air Force is the A-10 Air-to-Air Self-Defense Program. In this program, the mission of the A-10 was expanded from strictly ground support to include an air-to-air defense role. To accomplish this expansion, the A-10 aircraft was modified with off-the-shelf AIM-9 and air-to-air missiles; QOT&E was performed on the system to evaluate its operational effectiveness and suitability.

### 10.6 Test Planning

OT planning is one of the most important parts of the OT&E process. Proper planning facilitates the acquisition of data to support the determination of the weapon systems operational effectiveness and suitability. Planning must be pursued in a deliberate, comprehensive, and structured manner. Careful and complete planning may not guarantee a successful test program, but inadequate planning can result in significant test problems, poor system performance, and cost overruns. OT planning is conducted by the OTA before program start, and more detailed planning usually starts about 2 years before each OT event.

Operational planning can be divided into three phases: early planning, advanced planning, and detailed planning. Early planning entails developing COIs, formulating a plan for evaluations, determining the CONOPS, envisioning the operational environment, and developing mission scenarios and resource requirements. Advanced planning determines the purpose and scope of testing and identifies MOEs and other measures for critical issues. It includes developing test objectives, establishing a test approach, and estimating test resource requirements. Detailed planning involves developing step-by-step procedures to be followed as well as the final coordination of resource requirements.

#### 10.6.1 Testing COIs

As defined in [Reference \(ah\)](#), a COI is a key operational effectiveness and/or operational suitability issue (not a parameter, objective, or threshold) that must be examined in OT&E to determine the systems capability to perform its mission. A COI is normally phrased as a question that must be answered in order to properly evaluate operational effectiveness (e.g., Will the system detect the threat in a combat environment at adequate range to allow successful engagement?) or operational suitability (e.g., Will the system be safe to operate in a combat environment?). A COI may be broken down into a set of MOEs and MOSs. The latter two measures in turn are further decomposed into supporting MOPs. See also Figure 5-3.

One purpose of OT&E is to resolve COIs about the system. The first step in an OT&E program is to identify these critical issues, some of which may be explicit in the CDD. Examples can be found in questions such as the following: How well does the system perform a particular aspect of its mission? Can the system be supported logistically in the field? Other issues arise from questions asked about system performance or how the system will affect other systems with which it must operate. Critical

issues provide focus and direction for the OT. Identifying the issues is analogous to the first step in the SE process that is, defining the problem.

When COIs are properly addressed, deficiencies in the system can be uncovered. COIs form the basis for a structured technique of analysis by which detailed sub-objectives or MOEs can be established. During the OT, each sub-objective is addressed by an actual test measurement (MOP). After these issues are identified, the evaluation plans and test design are developed for test execution.

### 10.6.2 Test Realism

Test realism for OT&E will vary directly with the degree of system maturity. Efforts early in the acquisition program should focus on active involvement of users and operationally oriented environments. Fidelity of the combat environment should peak during the IOT&E when force-on-force testing of the production-representative system is conducted. The degree of success in replicating a realistic operational environment has a direct impact on the credibility of the IOT&E report. Areas of primary concern for the test planner can be derived from the definition of OT&E, as stated in [Section 139](#) of Reference (b):

- A field test includes all of the elements normally expected to be encountered in the operational arena, such as appropriate size and type of maneuver terrain, environmental factors, day/night operational capability, austere living conditions, etc.
- Realistic combat should be replicated using appropriate tactics and doctrine, representative threat forces properly trained in the employment of threat equipment, free play responses to test stimulus, stress, dirty battle area (fire, smoke, NBC, electronic countermeasures (ECM)), wartime tempo to operations, real-time casualty assessment, and forces requiring interoperability.
- Any item means the production or production-representative configuration of the system hardware and software at that point in time, including appropriate logistics tail.
- Typical military users are obtained by taking a cross section of adequately trained skill levels and ranks of the intended operational force. Selection of golden crews or the best-of-the-best will not provide valid test data reflecting the successes or problems of typical units.

### 10.6.3 Selection of a Test Concept

An important step in the development of an OT&E program is to develop an overall test program concept. Determinations must be made regarding when OT&E will be conducted during systems development, what testing is to be done on production equipment, how the testing will be evolutionary, and what testing will have to wait until all system capabilities are developed. This concept can best be developed by considering several aspects such as test information requirements, system availability for

test periods, and the demonstration of system capabilities. The test concept is driven by the acquisition strategy and is a roadmap used for planning T&E events.

## 10.7 Test Execution

An OT plan is only as good as the execution of that plan. The execution is the essential bridge between test planning and test reporting. The test is executed through the OTA test director's efforts and the actions of the test team. For successful execution of the OT&E plan, the test director must direct and control the test resources and collect the data required for presentation to the decision authority. The test director must prepare for testing, activate and train the test team, develop test procedures and operating instructions, control data management, create OT&E plan revisions, and manage each of the test trials. The test director's data management duties will encompass collecting raw data, creating a data status matrix, and ensuring data quality by processing and reducing, verifying, filing, storing, retrieving, and analyzing collected data. Once all tests have been completed and the data are reduced and analyzed, the results must be reported.

## 10.8 Test Reporting

The Service IOT&E report is a very important document. It must communicate the results of completed tests to decision authorities in a timely, factual, concise, comprehensive, and accurate manner. The report must present a balanced view of the weapon systems successes and problems during testing, illuminating both the positive aspects and system deficiencies discovered. Analysis and evaluation of test data may be in one report (Air Force, Navy) or in separate documents (Army, Marine Corps). The Army's independent evaluation report (IER) advises the decision review principals and the MDA concerning the adequacy of testing, the systems operational effectiveness and suitability, and survivability, as well as providing recommendations for future T&E and system improvements.

Types of reports most frequently used in reporting OT&E results include status, interim, quick-look, and final reports. The status report gives periodic updates (e.g., monthly, quarterly) and reports recent test findings (discrete events such as missile firings). The interim report provides a summary of the cumulative test results to date when there is an extended period of testing. The quick-look reports provide preliminary test results, are usually prepared immediately after a test event (within 7 days), and have been used to support program decision milestones. The final T&E report (Air Force, Navy) or IER (Army, Marine Corps) presents the conclusions and recommendations including all supporting data and covering the entire IOT&E program. The Service OTA is required to provide reports of OT&E results in support of MS B and MS C, in addition to the IOT&E report required for the FRPDR.

## 10.9 Summary

The purpose of OT&E is to assess operational effectiveness and suitability at each stage in the acquisition process. Operational effectiveness is a measure of the contribution of the system to mission accomplishment under actual conditions of employment. Operational suitability is a measure of the R&M of the system; the effort and level of training required to maintain, support, and operate the system; and any unique logistics or training requirements the system may have. The OT&E may provide



information on tactics, doctrine, organization, and personnel requirements and may be used to assist in the preparation of operating and maintenance instructions and other publications. One of the most important aspects of OT&E is that provides an independent evaluation of the degree of progress made toward satisfying the user's requirements during the system development process.

## Test & Evaluation Management Guide

### Chapter 11 - OT&E to Support Decision Reviews

#### 11.1 Introduction

Mindful of principles of objectivity and impartial evaluation, OT&E may be conducted before each decision review to provide the decision authority with the latest results from testing of COIs. The philosophy of OT&E has been related to three terms-adequacy, quality, and credibility:

- **Adequacy** . The amount of data and realism of test conditions must be sufficient to support the evaluation of the COIs.
- **Quality** . The test planning, control of test events, and treatment of data must provide clear and accurate test reports.
- **Credibility** . The conduct of the test and data handling must be separated from external influence and personal biases.

OT is conducted to provide information to support executive-level management decisions on acquisition programs. OT&E is accomplished using test cycles of successive actions and evaluations. During the early stages of the program, the process is informal and modified as necessary. As programs mature, documentation for major systems and those designated by the DOT&E for oversight must be sent to OSD for approval before the testing can be conducted or the systems can be cleared to proceed beyond LRIP.

#### 11.2 OT&E During the TD Phase

During this phase, OT&E may be conducted on brassboard configurations, experimental prototypes, or advanced development prototypes. Dedicated test time may be made available to the operational tester. However, the OT&E assessments may also make use of many other additional data sources. Examples of additional sources often used by the Army during this phase include concept experimentation program tests, innovative testing, FDT/E, source selection tests, market investigations, warfighting experiments, and user participation in operational feasibility tests. The results from this testing, analysis, and evaluation are documented in an EOA or end-of-phase OT&E report. These data, along with the mission needs, CONOPS, and requirements documentation and TEMP, assist in the review of performance for the next decision review.

#### 11.3 OT&E During the EMD Phase

After program initiation, integrated DT/OT or an OA may be conducted to support the assessment of prototype development and a decision regarding a systems readiness to move into the development of the EDM. In all cases, appropriate T&E must be conducted on a mature system configuration (i.e., the EDM) before the production decision, thereby providing data for identification of risk before more resources are committed. As appropriate, LRIP will follow this phase of testing to verify system-level

performance capability and to provide insight into test resources needed to conduct future interoperability, live-fire, or operational testing.

EOAs and OAs are conducted to facilitate identification of the best design, indicate the risk level of performance for this phase of the development, examine operational aspects of the systems development, and estimate potential operational effectiveness and suitability. Additionally, an analysis of the planning for transition from development to production is initiated. OAs and EOAs supporting decision reviews are intended to:

- Assess the potential of the new system in relation to existing capabilities.
- Assess system effectiveness and suitability so that affordability can be evaluated for program cost versus military utility.
- Assess the adequacy of the employment concept; supportability; organizational doctrine, tactical, and training requirements; and related critical issues.
- Estimate the need for the selected systems in consideration of the threat and system alternatives based on military utility.
- Assess the validity of the operational concept. List the key risk areas and COIs that need to be resolved before construction of EDMs is initiated.
- Assess the need during LRIP of long-lead hardware to support IOT&E prior to the FRP decision.
- Provide data to support test planning for this phase.

The OAs during the system capability demonstration are conducted on EDMs. These operational evaluations estimate operational effectiveness and suitability and provide data on whether the system meets minimum operational thresholds.

#### **11.4 OT&E During the P&D Phase**

Just before the FRP decision, the Services dedicated OT&E is conducted on production equipment that has been formally certified by the PM during the OTRR as being ready for the final OT&E. OSD oversight programs also consider the DASD(DT&E)s AOTR. The dedicated IOT&E is conducted in a test environment as operationally realistic as possible. OSD oversight programs use the IOT&E plan approved by DOT&E.

The IOT&E conducted is characterized by testing performed by user organizations in a field exercise to examine the organization and doctrine, ILS, threat, communications, C2, and tactics associated with the operational employment of the unit during tactical operations. This includes estimates that:

- Assess operational effectiveness and operational suitability.
- Assess the survivability of the system.

- Assess reliability, maintainability, and plans for ILS.
- Evaluate manpower, personnel, training, and safety requirements.
- Validate organizational and employment concepts.
- Determine training and logistics deficiencies.
- Assess the systems readiness to enter FRP.

### 11.5 OT&E During the O&S Phase

After the FRP decision and deployment, the emphasis shifts toward procuring production quantities, repairing hardware deficiencies, managing changes, and phasing in full logistics support. During initial deployment of the system, the OT&E agency and/or the user may perform FOT&E to refine the effectiveness and suitability estimates made during earlier OT&E, assess performance not evaluated during IOT&E, evaluate new tactics and doctrine, and assess the impacts of system modifications or upgrades.

The FOT&E is performed with production articles in operational organizations. It is frequently funded with operations and maintenance (O&M) funds. FOT&E is normally funded from the appropriation most suitable to the life cycle phase of the system involved. The first FOT&E conducted during this phase may be used to:

- Ensure that the production system performs as well as reported at the MS C review.
- Demonstrate expected performance and reliability improvements.
- Ensure the correction of previously identified deficiencies.
- Evaluate performance not tested during IOT&E.

Additional objectives of FOT&E are selected to validate the operational effectiveness and suitability of a modified system during an OA of the system in new environments. The FOT&E may look at different platform applications, new tactical applications, or the impact of new threats.

The testing objectives to evaluate post-production logistics readiness and support are to:

- Assess the logistics readiness and sustainability.
- Evaluate the weapons system support objectives/metrics.
- Assess the implementation of logistics support planning.
- Evaluate the capability of the logistics support activities.

## 11.6 Summary

OT&E is that T&E (OAs, IOT&E, or FOT&E) conducted by an independent OT&E agency to provide feedback on system design and the systems potential to be operationally effective and operationally suitable. OT&E events in each phase of development will identify needed modifications; provide information on tactics, doctrine, organizations, and personnel requirements; and evaluate the systems logistics supportability. The acquisition program structure should include feedback from OAs or evaluations at critical decision points/technical reviews beginning early in and continuing throughout the systems life cycle.

## Test & Evaluation Management Guide

### Chapter 12 - TEMP

#### 12.1 Introduction

Guidance contained in References [\(d\)](#) and [\(j\)](#) stipulates that a TEMP shall be used for all ACAT I and IA or OSD-designated oversight acquisition programs.

For effective engineering development and decision-making processes, an early T&E strategy in the TD phase must be evolved into an overall integrating master plan detailing the collection and evaluation of test data on required performance parameters. Less than ACAT I programs are encouraged to tailor their T&E strategy using the TEMP format provided in Chapter 9 of Reference [\(j\)](#) as a guide.

The TEMP relates program schedule, test management strategy and structure, and required resources to COIs, CTPs, minimum performance values (thresholds), acquisition strategy, and milestone decision points. The TEMP serves as the overarching document for managing a T&E program. PMs develop the initial TEMP at MS B. Prior to each subsequent Defense Acquisition System milestone, the PMs must submit an updated TEMP. The TEMP should include sufficient detail to support development of other test-related documents.

#### 12.2 TEMP Development

The T&E strategy is highly contingent on early system concepts that are deemed appropriate for satisfying user requirements. As outlined in [Reference \(h\)](#), the priority for selecting a solution to meet a capability shortfall is as follows:

1. A non-materiel solution, such as changes to doctrine, organization, training, leadership and education, personnel, and facilities.
2. A materiel alternative, chosen according to the following priority sequence:
  - a. The procurement or modification of commercially available products, services, and technologies from domestic or international sources, or the development of dual-use technologies.
  - b. The additional production or modification of previously developed U.S. and/or allied military systems or equipment.
  - c. A cooperative development program with one or more allied nations.
  - d. A new, joint, DoD Component or Government agency development program.
  - e. A new DoD Service-unique development program.

Development of the system TEMP begins during the MSA effort with the development of an early T&E strategy for the proposed materiel solution. This T&E strategy evolves as the system is better defined in the TD phase and T&E events are consolidated in the TEMP. Effective management of the various test

processes is the primary function of a PMO T&E WIPT. The quality of the test program may directly reflect the level of effort expended in its development and execution. This effort varies in direct relationship to the management imposed by the PM and, to some extent, by the system engineer. The PM should begin the TEMP development process as early as possible. It is strongly recommended that the PM have in-house TEMP personnel with expertise in T&E WIPTs and TEMP development. The T&E WIPT will make many decisions that impact the program. It is important that the PM have experienced test staff to conduct the T&E WIPT, develop the TEMP, and provide the PM with advice and guidance.

### **12.2.1 PMO Responsibilities**

The PMO is the focal point of the development, review, and submittal process for the program TEMP. The DoD acquisition process requires a TEMP as one of the primary management strategy documents supporting the decision to begin development efforts. However, developing a TEMP at this point in time can be difficult as some Services do not formulate or staff a PMO until formal program initiation at MS B. An additional complicating factor is the nebulous condition of other program source documents (CDD, technical management plan, acquisition strategy, STA, logistics support plan, etc.) that are also in early stages of development/updating for the milestone review.

Because the TEMP must conform to the acquisition strategy and other program management documents, it frequently lags in the development process and does not receive the attention needed from PMO or matrix support personnel. PMO emphasis on early formulation of the test planning teams (T&E WIPT) is critical to the successful development of the program TEMP. These teams should consist of the requisite players so a comprehensive and integrated strategy compatible with other engineering and decision-making processes is developed. An early start in getting Service-level concurrence is important so the milestone decision document-submission schedule can be supported with the draft and final versions of the TEMP. Subsequent updates do not become easier, as each acquisition phase brings new planning, coordination, and testing requirements.

### **12.2.2 T&E Planning**

Developing an overall strategy provides the framework for incorporating phase-oriented T&E activities that will facilitate the acquisition process. The T&E strategy should be consistent with the program acquisition strategy, identifying requirements for contractor and Government DT&E, interactions between DT and OT, and provisions for the separate IOT&E.

An evolutionary acquisition strategy is the preferred strategy for the rapid acquisition of mature technology for the user and will generally include an incremental development approach using low-risk technologies that should reduce the intensity and duration of the T&E program. It does, however, include a requirement for post-production test activities as the system is modified to accommodate previously unknown new technologies, new threats, or other performance enhancements.

A Grand Design or single-step acquisition strategy incorporates all the latest technologies in the final production configuration and is generally a higher risk approach. As the contractor works on maturing emerging technologies, the T&E workload increases in direct proportion to the technology risk and

difficulty in fixing problems. There is a much higher potential for extended schedules with iterative test-fix-test cycles .

### **12.2.3 General T&E Planning Considerations**

A variety of reviews have identified several factors pertaining to DoD systems that should be considered during test planning. These considerations, along with a summary discussion, are provided below .

#### **12.2.3.1 Effects of Test Requirements on System Acquisition**

The acquisition strategy for the system should allow sufficient time and flexibility between the end of the EMD phase and the start of LRIP to adjust for modifications and associated testing. It should ensure that sufficient dollars are available not only to conduct T&E but also to allow for additional T&E that is always required due to failure, design changes, etc. The acquisition strategy should be evaluated relative to constraints imposed by:

- The level of system testing at various stages of the RDT&E cycle.
- The number of test items available and the schedule interface with other systems needed in the tests, such as aircraft, electronics, etc.
- The support required to assist in preparing for and conducting tests and analyzing the test results.
- The number of systems being evaluated to minimize the so-called T&E gap caused by lack of hardware during the test phase.

#### **12.2.3.2 Test Requirements and Restrictions**

Tests should:

- Have specific objectives.
- List, in advance, actions to be taken as a consequence of the test results.
- Be instrumented to permit diagnosis of the cause of lack of performance including random, design-induced wear-out and operator error failure.
- Not be repeated if failures occur without first conducting a detailed analysis of the failure.
- Include test rehearsals for each new phase of testing.

#### **12.2.3.3 Use of Government Test Facilities**

Programs should use DoD Government T&E capabilities and invest in Government T&E infrastructure unless an exception can be justified as cost-effective to the Government.



#### 12.2.3.4 Trouble Indicators

Programs should establish an early detection scheme/measurement process to identify program problems and issues in development as early as possible and correct them. As one of the DoD SE technical management processes, outputs from the technical assessment process can help to provide those early insights. The technical assessment process consists of EVM, TPM, and technical reviews and audits. When a program has not established such a process, indicators will show up during testing. Some of these indicators include:

- Any repetitive failure.
- A revision of schedule or incremental funding that exceeds the original plan.
- Any relaxation of the basic requirements such as lower performance.
- Cost overruns.

#### 12.2.3.5 RAM

RAM have a direct impact on both operational capability and total ownership cost (TOC) and therefore are important considerations for the Warfighter. Achieving required levels of RAM for a system is important for many reasons, some of which are identified below:

- Improved readiness. Poor reliability or maintainability causes readiness to fall below needed levels or increases the cost of achieving the needed levels.
- Improved safety. Inadequate reliability of components deemed critical safety items (CSIs) may directly jeopardize the safety of the user(s) of that components system and result in a loss of life. The ability to complete a mission safely is directly related to the reliability of the CSIs.
- Improved mission success. Inadequate reliability of equipment directly jeopardizes mission success and may result in undesirable repetition of the mission.
- Reduced TOC. The concept of TOC captures the true cost of design, development, ownership, and support of DoD weapons systems.

The T&E strategy and the TEMP must specify how reliability will be tested and evaluated during the associated acquisition phase. RGCs will be developed to reflect the reliability growth strategy and will be employed to plan, illustrate, and report reliability growth. An RGC will be included in the SEP at MS A and updated in the TEMP beginning at MS B. The RGC will be stated in a series of intermediate goals and tracked through fully integrated, system-level T&E events until the reliability threshold is achieved, see [Reference \(o\)](#). PMs and the PMO are responsible for reporting progress to plan for RAM at the Defense Acquisition Executive Summary (DAES) reviews.

#### **12.2.3.6 Requirement for Test Rehearsals**

Test rehearsals should be conducted for each new phase of testing. They provide opportunities to validate operator training, safety issues, data collection systems, implementation of scenarios, and management of post-test data analysis .

#### **12.2.4 Test Scheduling Criteria**

Specific issues associated with test scheduling are discussed in the following sections. Criteria for who and what constitutes grounds for stopping or delaying the test(s) must be established as part of the test planning process. Additionally, test schedules should have some margin for retest events and possible associated development rework to fix discovered problems.

As part of integrated testing, some OT&E is interwoven into early DT&E for maximizing the efficient use of test articles and test schedules. However, OT&E must remain a distinct thread of activity that does not lose its identity in the tapestry of test events.

##### **12.2.4.1 Building Block Test Scheduling**

A set of tests to demonstrate feasibility prior to testing the system-level EDMs should be used. This approach will allow early testing of high-technical-risk items, and subsequent tests can be incorporated into the hardware as the system concept has been demonstrated as feasible.

##### **12.2.4.2 Component and Subsystem Test Plans**

Ensure that a viable component and subsystem test plan is used. Studies show that almost all component failures will be the kind that cannot be easily detected or prevented in full-system testing. System failure must be detected and fixed at the lowest level possible in the system WBS, ideally at the component/subsystem stage. Detecting and correcting failure only at the system level and during high-visibility OT results in program cost and schedule overruns .

##### **12.2.4.3 Schedule IOT&E to Include System Interfaces with Other Systems**

Whenever possible, the IOT&E/FOT&E of a weapon system should be planned to include other systems that must have a technical interface with the new system. For example, missiles should be tested on most of the platforms for which they are programmed .

##### **12.2.4.4 Test Resources**

Planning for test resources is driven by the sequence and intensity of DT and OT events. Resource coordination is an equally arduous task, which frequently has lead times equal to major program development activities. The program T&E strategy should include an overshadowing evaluation plan, outlining methodologies, models, simulations, and test data required at periodic decision points.

### 12.3 TEMP Requirements

The TEMP should address critical human issues to provide data to validate the results of human factors engineering analyses and require identification of mission critical operational and maintenance tasks.

As early as practicable, developers and test agencies will assess survivability and validate critical survivability characteristics at as high a system level as possible. The TEMP will identify the means by which the survivability objective will be validated.

Field engineering test facilities and testing in the intended operational environments are required to verify electric or electronic systems predicted performance, establish confidence in electromagnetic compatibility design based on standards and specifications, and validate electromagnetic compatibility analysis methodology.

The TEMP should:

- Address health hazard and safety critical issues to provide data to validate the results of system safety analyses.
- Directly support the development of more detailed planning and resource documents needed to execute the actual test events and subsequent evaluations.
- Provide a roadmap for integrated simulation, test, and evaluation plans, schedules, and resource requirements necessary to accomplish the T&E program. T&E planning should address MOEs/MOSs with appropriate quantitative criteria, test event or scenario description, resource requirements, and test limitations. Test planning, at a minimum, must address all system components that are critical to the achievement and demonstration of contract technical performance specifications and threshold values specified in the CPD.
- Identify the Lead Developmental Tester and the Lead Government DT&E Organization ( [Reference \(w\)](#) ).

### 12.4 TEMP Format

The recommended TEMP format, as shown in Figure 12-1, is for all programs, regardless of acquisition category, and is available in [Chapter 9](#) of Reference (j). The TEMP is intended to be a summary document outlining DT&E, OT&E, and LFT&E management responsibilities across all phases of the acquisition process. When the development is a multi-Service or joint acquisition program, one integrated TEMP is developed with Service annexes, as required. A Capstone TEMP may not be appropriate for a single major weapon platform but could be used to encompass testing of a collection of individual systems, each with its own annex. A program TEMP is updated at milestones, upon program baseline breach, and for other significant program changes. Updates may consist of page changes and are no longer required when a program has no further development activities.

<p>Part I - Introduction</p> <p>1.1 Purpose</p> <p>1.2 Mission Description</p> <p>1.3 System Description</p> <p>1.3.1 System Threat Assessment</p> <p>1.3.2 Program Background</p> <p>1.3.2.1 Previous Testing</p> <p>1.3.3 Key Capabilities</p> <p>1.3.3.1 Key Interfaces</p> <p>1.3.3.2 Special Test or Certification Requirements</p> <p>1.3.3.3 Systems Engineering (SE) Requirements</p> <p>Part II - Test Program Management and Schedule</p> <p>2.1 T&amp;E Management</p> <p>2.1.1 T&amp;E Organizational Construct</p> <p>2.2 Common T&amp;E Database Requirements</p> <p>2.3 Deficiency Reporting</p> <p>2.4 TEMP Updates</p> <p>2.5 Integrated Test Program Schedule</p> <p>Figure 2.1 - Integrated Test Program Schedule</p> <p>Part III - Test and Evaluation Strategy</p> <p>3.1 T&amp;E Strategy</p> <p>3.2 Evaluation Framework</p> <p>Figure 3.1 - Top-Level Evaluation Framework Matrix</p> <p>3.3 Developmental Evaluation Approach</p> <p>3.3.1 Mission-Oriented Approach</p> <p>3.3.2 Developmental Test Objectives</p> <p>3.3.3 Modeling and Simulation</p> <p>3.3.4 Test Limitations</p> <p>3.4 Live Fire Evaluation Approach</p> <p>3.4.1 Life Fire Test Objectives</p> <p>3.4.2 Modeling and Simulation</p> <p>3.4.3 Test Limitations</p>	<p>3.5 Certification for IOT&amp;E</p> <p>3.5.1 Assessment of Operational Test Readiness</p> <p>3.6 Operational Evaluation Approach</p> <p>3.6.1 Operational Test Objectives</p> <p>3.6.2 Modeling and Simulation</p> <p>3.6.3 Test Limitations</p> <p>3.7 Other Certifications</p> <p>3.8 Reliability Growth</p> <p>3.9 Future Test and Evaluation</p> <p>Part IV - Resource Summary</p> <p>4.1 Introduction</p> <p>4.1.1 Test Articles</p> <p>4.1.2 Test Sites and Instrumentation</p> <p>4.1.3 Test Support Equipment</p> <p>4.1.4 Threat Representation</p> <p>4.1.5 Test Targets and Expendables</p> <p>4.1.6 Operational Force Test Support</p> <p>4.1.7 Models, Simulations and Test-beds</p> <p>4.1.8 Joint Operational Test Environment</p> <p>4.1.9 Special Requirements</p> <p>4.2 Federal, State, Local Requirements</p> <p>4.3 Manpower/Personnel Training</p> <p>4.4 Test Funding Summary</p> <p>Table 4.1 Resource Summary Matrix</p> <p>Appendix A - Bibliography</p> <p>Appendix B - Acronyms</p> <p>Appendix C - Points of Contact</p> <p>Additional Appendices as Needed</p>
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**Figure 12-1 TEMP Format**

The TEMP is a living document that must address changes to critical issues associated with an acquisition program. Major changes in program requirements, schedule, or funding usually result in a change in the test program. Thus, the TEMP must be reviewed and updated on program change, on baseline breach, and before each milestone decision to ensure that T&E requirements are current. As the primary document used in the OSD review and milestone decision process to assess the adequacy of planned T&E, the TEMP must be of sufficient scope and content to explain the entire T&E program.

Each TEMP submitted to OSD should be an integrated document, detailed enough to show the rationale for the type, amount, and schedules of the testing planned. It must clearly relate the T&E effort to technical risks, operational issues and concepts, system performance, RAM growth, logistics objectives and requirements, and major decision points. The TEMP should summarize the testing accomplished to date and explain the relationship of the various models and simulations, subsystem tests, integrated

system developmental tests, and initial operational tests that, when analyzed in combination, provide confidence in the systems readiness to proceed into the next acquisition phase.

The TEMP must address the T&E to be accomplished in each program phase, with the next phase addressed in the most detail. The TEMP is also used as a collaboration document to outline each test and support organizations role in the T&E program and identify major test facilities and resources.

The TEMP should be aligned, wherever appropriate, with the SEP that is used on the program and guides overall technical development activities.

The objective of the OSD TEMP review process is to ensure successful T&E programs that will support decisions to commit resources at major milestones. Some of the T&E questions considered during the TEMP review process include the following:

- Are DT&E, OT&E, and LFT&E initiated early to assess performance, identify risks, and estimate operational potential?
- Are critical issues, test directives, and evaluation criteria related to mission need and operational requirements established well before testing begins?
- Are provisions made for collecting sufficient test data with appropriate test instrumentation to minimize subjective judgment?
- Is IOT&E conducted by an organization independent of the developer and user?
- Do the test methodology and instrumentation provide a mature and flexible network of resources that stresses (as early as possible) the weapon system in a variety of realistic environments?
- Is an integrated approach to DT, OT, and LFT being taken where appropriate?

## 12.5 Summary

The PMO is directly responsible for the content and quality of the test strategy and associated planning activities that are documented in the TEMP and other plans. The TEMP, as an integrated summary management tool, requires a commitment of staff-hours and PM guidance for successful completion. The interactions of the various T&E players and support agencies in the T&E WIPT must be woven into the fabric of the total system acquisition strategy and an integrated testing approach. Cost and schedule implications must be negotiated to ensure a viable T&E program that provides timely and accurate data to the engineering and management decision makers.

## Test & Evaluation Management Guide

### Chapter 13 - Test Resources

#### 13.1 Introduction

This chapter describes the various types of resources available for testing, explains test resource planning in the Services, and discusses the ways in which test resources are funded.

Test resources is a collective term that encompasses elements necessary to plan, conduct, collect, and analyze data from a test event or program. These elements include items such as funding (to develop new resources or use existing ones), manpower for test conduct and support, test articles, models, simulations, threat simulators, surrogates, replicas, test beds, special instrumentation, test sites, targets, tracking and data acquisition instrumentation, equipment (for data reduction, communications, meteorology, utilities, photography, calibration, security, recovery, maintenance, and repair), frequency management and control, and base/facility support services. As a general principle, test planning and conduct should take full advantage of existing investments in DoD resources. Programs must use DoD Government T&E capabilities and invest in Government T&E infrastructure unless an exception can be justified as cost-effective to the Government.

Key DoD test resources are in great demand by competing acquisition programs. Special, unique, or one-of-a-kind test resources must often be developed specifically for the test program. Therefore, it is imperative that the requirements for these test resources be identified early in the acquisition process so adequate funding can be allotted for development of the test resources and they will be available when the test is scheduled.

#### 13.2 Obtaining Test Resources

##### 13.2.1 Test Resources and Instrumentation

As early as possible but not later than program start, the test facilities and instrumentation requirements to conduct program T&E should be identified and a tentative schedule of test activities should be prepared. This information is developed in the early T&E strategy and expanded in the TEMP and Service-specific test resource documentation. PMs must conduct a CBA when unable to use DoD Government T&E capabilities or unable to invest in Government T&E infrastructure and must document the assumptions and results of the CBA in an approved TEMP.

##### 13.2.2 MOT&E

MOT&E should be considered for weapon systems requiring new operational concepts involving more than one Service. An analysis should be conducted before the low-rate production decision about the impact of demonstration on time and resources needed to execute the multi-Service tests.

### 13.2.3 Military Construction Program Facilities

Some programs cannot be tested without military construction program facilities. Constructing these facilities will require long lead times and Military Construction funding; therefore, early planning must be done to ensure that the facilities will be available and operational when required. In accordance with [DoDD 4270.5](#) (Reference (am)), construction projects should normally be justified and funded through the planning, programming, and budgeting process. Projects shall be considered for funding under authorities available to the Heads of the DoD Components before being considered for funding under the authority of the Secretary of Defense.

### 13.2.4 Test Sample Size Considerations

The primary basis for the test sample size is usually based on one or more of the following:

- Coverage of test objectives, particularly KPPs.
- Significance of test results at some specified statistical confidence level.
- Delta the difference that needs to be detected.
- Availability of test vehicles, software, support items, etc.
- Support resources or facilities available.

### 13.2.5 Test Termination

Testers should not hesitate to terminate a test before its completion if it becomes clear that the main objective of the test has already been achieved or is unachievable (due to hardware failure, unavailability of resources, etc.) or if additional samples will not change the outcome and conclusions of the test.

### 13.2.6 Budgeting for Testing

The Acquisition Strategy, TEMP, and budgeting documents should be reviewed regularly to ensure that adequate testing funds are identified. These documents need careful scrutiny to ensure that adequate contingency funds exist to cover correction of difficulties at a level that matches industry/Government experience on the contract. Retesting to correct deficiencies found during testing without sufficient funding for proper correction results in Band-Aid approaches, which require more expensive corrections later.

#### 13.2.6.1 Cost Analysis Requirements Description (CARD)

For ACAT I and ACAT IA programs, the CARD is used to formally describe the acquisition program for purposes of preparing both the DoD Component cost estimate and the cost assessment independent cost estimate. [Reference \(d\)](#) specifies that for MDAPs, the CARD will be provided in support of major milestone decision points (MS B, MS C, or the FRPDR). In addition, for MAIS programs, the CARD is prepared whenever an economic analysis is required. For other acquisition programs, the preparation of

a CARD, or an abbreviated CARD-like document with appropriate tailoring, is strongly encouraged to provide a written program description suitable to support a credible LCC estimate.

The CARD is prepared by the program office and approved by the DoD Component PEO. For joint programs, the CARD includes the common program agreed to by all participating DoD Components as well as all unique program requirements of the participating DoD Components. [Chapter 1 of DoD 5000.4-M](#) (Reference (an)) provides further guidelines for CARD content. Common source documents for the CARD include the following:

- TRA.
- Capability needs documents (i.e., ICD/CDD/CPD).
- Acquisition Strategy.
- Life-cycle sustainment plan (LCSP) (part of the Acquisition Strategy).
- TEMP.
- Manpower estimate.
- SEP.

#### **13.2.6.2 Test and Evaluation Budget Exhibit (T&E-1)**

Optimizing, sustaining, and improving capabilities directly relates to a clear understanding of the costs that make up and flow through these test capabilities, as well as the type, mix, knowledge, and skills of the workforce. [section 139b](#) of Reference (b) requires the DASD(DT&E) to periodically review of the organizations and capabilities of the Military Departments with respect to DT&E and identify needed changes or improvements to those capabilities. The DASD(DT&E) established a process for evaluating the required funding for programs under DT&E oversight. This process identifies the resourcing requirements for MDAPs as well as some special interest programs. An updated and relevant resource section of the TEMP is required and can be evaluated in several ways:

- The total program cost can be evaluated by reviewing the SARs and the RDT&E Budget Item Justification, Exhibit R-2. These two documents allow identification of total program costs by calculating the values in the Prior Totals, Future Years Defense Program (FYDP), and To Complete sections.
- Starting with the FY 2012 budget cycle, the T&E-1 Budget Exhibit will capture numbers for prior years and cost to complete, providing an additional verification of total program costs.
- The T&E-1 data and Part IV (Resource Summary) of the TEMP can be compared. Both documents break down the FYDP costs by program element (PE). Each PE identifies funds allocated to different types of testing (DT&E, IOT&E, and LFT&E) and identifies the appropriation type (RDT&E, procurement, etc.).



Chapter 19 of Volume 2B of [DoD 7000.14-R](#) (Reference (ao)) provides guidance on completing Exhibit T&E 1.

### 13.2.7 Test Article Planning

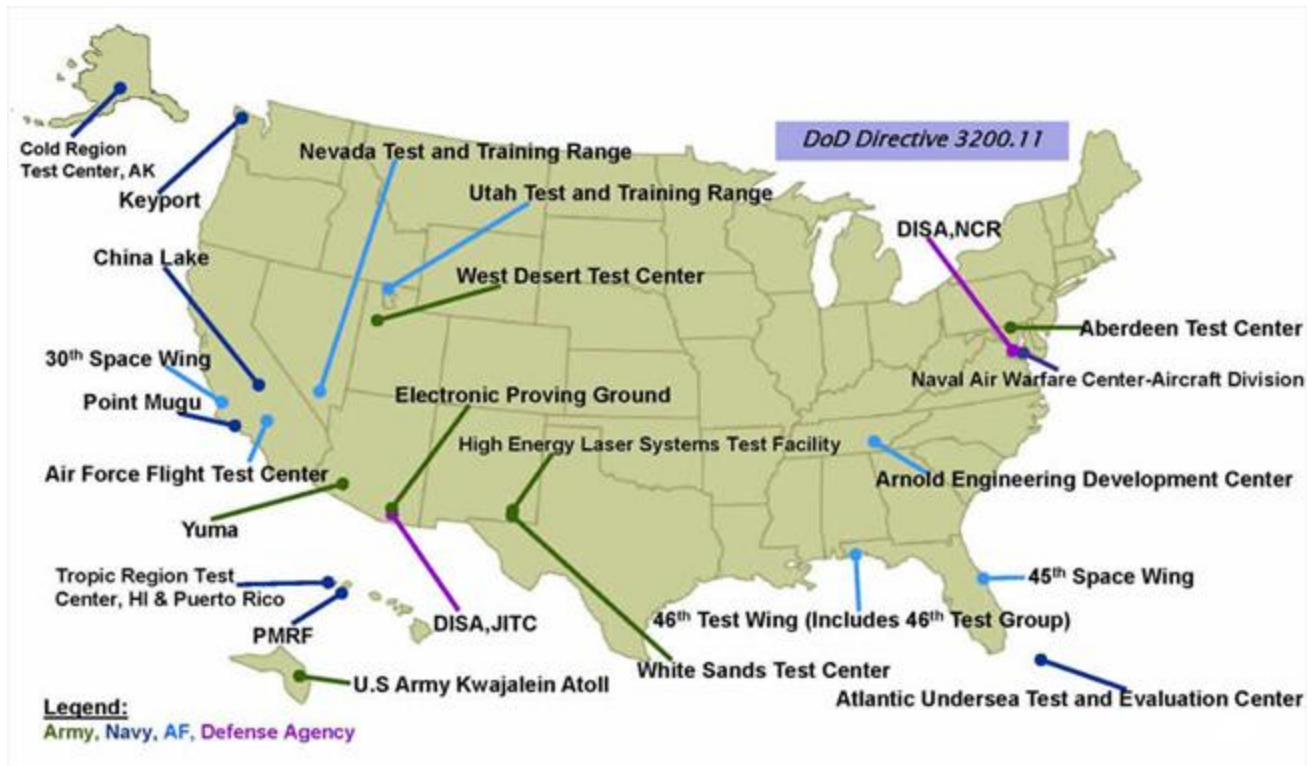
Test article planning should:

- Ensure that the whole system, including system user personnel, is tested.
- Realistically test the complete system, including hardware, software, people, and all interfaces.
- Get the user involved from the start and understand user limitations.
- Ensure that sufficient time and test articles will be available (when technology is stressed, more test articles and time may be required).
- Test parts, then subsystems, and finally systems to ensure that they work as prescribed before incorporating them into the next higher assembly.
- Plan for instrumentation to permit diagnosis of trouble.
- Allow time between major tests to analyze for failures and implement corrective action.

### 13.2.8 TRMC/MRTFB

Under the provision of [section 196](#) of Reference (b), the DoD established the Test Resource Management Center (TRMC) with the Director reporting directly to the USD(AT&L) without the interposition of any other supervising official. The Director, TRMC provides oversight for T&E strategic planning and budgets for the Departments T&E activities, including the MRTFB, Central Test and Evaluation Investment Program (CTEIP), and the T&E Science and Technology Program.

All Services operate ranges and test facilities. The MRTFB is a national asset which shall be sized, operated, and maintained primarily for DoD T&E support missions, but also is available to all users having a valid requirement for its capabilities. MRTFB consists of a broad base of T&E activities managed and operated under uniform guidelines to provide T&E support to DoD Components responsible for developing or operating materiel and weapon systems. The MRTFB sites are displayed in Figure 13-1 by DoD Component.



**Figure 13-1 DoD MRTB by DoD Component**

MRTFB facilities are available for use by all the Services, U.S. Government agencies, and in certain cases, allied foreign governments and contractor organizations. Scheduling is based on a priority system, and costs for usage are billed uniformly. The Director, TRMC sets policy for the composition, use, and test program assignments of the MRTFB. The individual Services fund, manage, and operate their activities; they are reimbursed for direct costs of testing by each user of the activity. TRMC sponsors a Joint Test Assets Database that lists MRTFB and OTA test facilities, test area and range data, instrumentation, and test systems.

Currently, 24 sites comprise the MRTFB across the United States and its territories, including many Government T&E facilities. The goal is for PMs to use Government T&E facilities rather than building or making capital investments in T&E capabilities. An important consideration for the PM focuses on the costs associated with the use of MRTFB and other Government facilities compared with contractor facilities. PMs should remain aware of and consider the use of MRTFBs to save valuable resources.

The Director, TRMC reviews the proposed T&E budgets of each Military Department and Defense Agency with T&E responsibilities, in accordance with [section 196\(e\)\(2\)](#) of Reference (b). Following the review, and not later than January 31 of the year preceding the fiscal year for which such budgets are proposed, the Director must submit to the SecDef a report containing the Directors analysis of all the proposed T&E budgets and determination as to whether these proposed budgets are adequate and provide balanced support for the Strategic Plan for DoD T&E Resources.

TRMC generates an annual T&E budget certification report focused on the MRTFB. TRMC coordinates budget issues that lead up to determining the Departments budget and serves as the SME on MRTFB funding and the MRTFB portions of [Reference \(aq\)](#) .

### **13.2.9 CTEIP**

TRMC manages the implementation of and executes the CTEIP. The CTEIP provides OSD funding and a mechanism for the development and acquisition of new test capabilities to satisfy multi-Service testing requirements. It was established in 1990 to improve the coordination and planning of DoD T&E capability investments. The program invests in T&E capabilities that will meet the test requirements of more than one Service. CTEIP funds about 50 projects or subprojects at any given time, all of which are in various states of development. These projects range from quick assessments of new technologies to full-scale efforts to develop new test capabilities. Though CTEIP operates under the oversight of TRMC, the Services and Defense Agencies propose and execute CTEIP projects. CTEIP provides a coordinated process for funding T&E investments that leverage Service investments, ensure joint development, and follow best practices. CTEIP processes also encourage reuse and the promulgation and use of standards.

#### **13.2.10 Service Test Facilities**

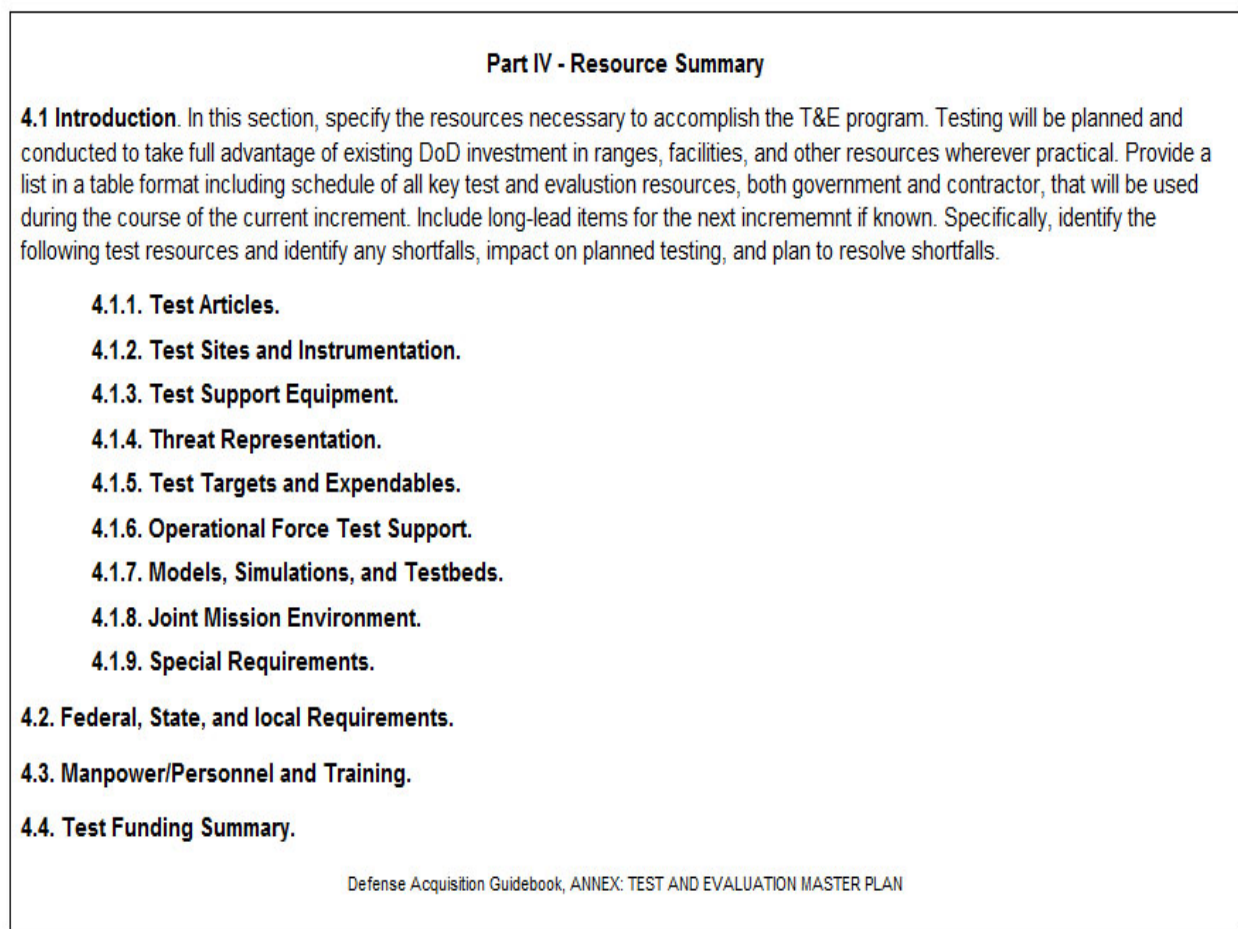
There are other test resources available besides the MRTFB. National Guard or Reserve units, commercial or international test facilities, training ranges that are not part of the MRTFB, non-DoD governmental agencies (e.g., National Aeronautics and Space Administration (NASA) ranges), and war reserve assets may be available to support DoD T&E. Testers can determine resources available by contacting their Service headquarters staff element. Within the Army, consult documents such as the ATEC database on existing Army major test facilities, major instrumentation, and test equipment; the Project Manager for Instrumentation, Targets, and Threat Simulators (PM, ITTS) Targets Information Manual for a descriptive catalogue of Army targets and foreign ground assets available (or in development) for support of T&E and training; and the PM ITTS Threat Inventory Database on available assets for both hardware simulators and software simulation systems. Information on specific Navy test resources is found in user manuals published by each range.

### **13.3 Test Resource Planning**

The development of special test resources to support a weapon system test can be costly and time-consuming. This development, coupled with the competition for existing test resources and facilities, requires that early planning be accomplished to determine all test resource requirements for weapon system T&E. The tester must use Government facilities whenever possible. One problem associated with range and facility planning is that major defense systems tend to get top priority. Range schedules are often in conflict because of unforeseen system problems, which cause schedule delays during testing, and if funds for possible retesting have not been adequately programmed, there is often a shortage of funds to complete testing.

### 13.3.1 TEMP Resource Requirements

All key test resource requirements should be stated in the TEMP and include items such as unique instrumentation, threat simulators, surrogates, targets, and test articles. Part IV of the TEMP discusses test resources, as depicted in Figure 13-2. Because the first TEMP must be prepared for program initiation, initial test resource planning must be accomplished very early as part of the TEMP preparation process. Refinements and reassessments of test resource requirements are included in each TEMP update. The guidance for the content of the test resource summary (Part IV) of the TEMP is outlined in [Reference \(j\)](#). Once the test resource requirements are identified, the PM must then work within the Service headquarters and range management structure to ensure that the assets are available when needed.



**Figure 13-2 TEMP PART IV - Resource Summary**

### 13.3.2 Service Test Resource Planning

More detailed listings of required test resources are generated in conjunction with the detailed test plans. These test plans describe test objectives, MOEs, test scenarios, and specific test resource requirements.

### **13.3.2.1 Army Test Resource Planning**

In the Army, the independent evaluator, with the assistance of the developmental and operational testers, prepares input to the TEMP and develops a SEP, which is the primary planning documents for integrated T&E of the system. These documents should be prepared early in the acquisition cycle (at the beginning of system acquisition activities). They describe the entire T&E strategy including critical issues, test methodology, MOEs, and all significant test resources. The TEMP and SEP provide the primary input to the OTP, which contains a detailed description of each identified required test resource, where and when the test resource is to be provided, and the providing organization.

The tester must coordinate the OTP with all major commands or agencies expected to provide test resources. Then the OTP is submitted to ATEC for review by the TSARC and for incorporation into the Army's Five-Year Test Program (FYTP). The initial OTP for each test should be submitted to the TSARC as soon as testing is identified in the TEMP. Revised OTPs are submitted as more information becomes available or requirements change, but a final comprehensive version of the OTP should be submitted at least 18 months before the resources are required.

The TSARC is responsible for providing high-level, centralized management of T&E resource planning. The TSARC is chaired by the Commanding General, ATEC, and consists of a general officer or equivalent representatives from the Army staff and major commands. The TSARC meets semiannually to review all OTPs, resolve conflicts, and coordinate all identified test resource requirements for inclusion in the FYTP. The FYTP is a formal resource tasking document for current and near-term tests and a planning document for tests scheduled for the out-years. All OTPs are reviewed during the semiannual reviews to ensure that any refinements or revisions are approved by the TSARC and reflected in the FYTP.

The TSARC-approved OTP is a tasking document by which the tester requests Army test resources. The TSARC coordinates resource requests, sets priorities, resolves conflicts, and schedules resources. The resultant FYTP, when approved by the HQDA Deputy Chief of Staff, G3, is a formal tasking document that reflects the agreements made by the resource providers (AMC, TRADOC, Forces Command, etc.) to make the required test resources available to the designated tests. If test resources from another Service, a non-DoD governmental agency (such as the Department of Energy or NASA), or a contractor are required, the request is coordinated by ATEC. For example, the request for a range must be made at least 2 years in advance to ensure availability. However, due to the long lead time required to schedule these non-Army resources, their availability cannot be guaranteed if testing is delayed or retesting is required. The use of resources outside the United States such as in Canada, Germany, or other NATO countries, is also handled by ATEC.

### **13.3.2.2 Navy Test Resource Planning**

In the Navy, the developing agency and the operational tester are responsible for identifying the specific test resources required in testing the weapon system. In developing requirements for test resources, the PM and OTD refer to capability documents, the programs Acquisition Strategy, threat assessments, and Secretary of the Navy Instruction (SECNAVINST) 5000 series, among other documents. Upon approval, the TEMP becomes the controlling management document for all T&E of the system. It constitutes

direction to conduct the T&E program defined in the TEMP, including the commitment of RDT&E financial support and of fleet units and schedules. The TEMP is prepared by the PM, who is provided OT&E input by the COMOPTEVFOR OTD. The TEMP defines all T&E (DT&E, OT&E, and PAT&E) to be conducted for the system and describes, in as much detail as possible, the test resources required.

The Navy uses its operational naval forces to provide realistic T&E of new and upgraded weapon systems. Each quarter, CNO (N84) and the COMOPTEVFOR fleet scheduling officer solicit RDT&E fleet support requirements from all Navy acquisition programs. RDT&E fleet support requests are to be submitted at least 9 months in advance of required support. COMOPTEVFOR uses the Unclassified Test and Evaluation System to organize RDT&E fleet requests. RDT&E fleet requests inside of 9 months are considered emergent and must be requested through record message traffic. The COMOPTEVFOR fleet scheduling officer compiles all requests and works with the fleet to schedule requested assets. CNO (N84) may be called upon to prioritize RDT&E fleet asset requests. For additional information regarding Navy fleet RDT&E support, see [SECNAV M-5000.2](#) (Reference (ap)). Requests for use of range assets are usually initiated informally with a phone call from the PM and/or OTD to the range manager and followed by formal documentation. Use of most Navy ranges should be scheduled at least a year in advance. Each range consolidates and prioritizes user requests, negotiates conflicts, and attempts to schedule range services to satisfy all requests.

The COMOPTEVFOR is authorized direct liaison with other Service-independent OTAs to obtain non-Navy OTA-controlled resources. Requests for other Government-owned resources are forwarded to the CNO (N84) for formal submission to the Service Chief (for Service assets) or to the appropriate Government agency (e.g., Department of Energy or NASA). Use of contractor resources is usually handled by the PM, although contractor assets are seldom required in OT&E because the fleet is used to provide an operational environment. Requests for use of foreign ranges are handled by the PM through the Navy International Programs Office.

### **13.3.2.3 Air Force Test Resource Planning**

The test resources required for OT&E of an Air Force weapon system are identified in detail in the TRP, which is prepared by the responsible Air Force OT&E organization. In general, AFOTEC is the test organization for OT&E programs, but other MAJCOMs also execute OT. AFOTEC obtains support from a Service MAJCOM test agency for non-major programs, with AFOTEC directing and providing assistance, as required.

During the advanced planning phase of a weapon system acquisition (5 to 6 years before OT&E), AFOTEC prepares the OT&E section of the first full TRP, coordinates the TRP with all supporting organizations, and assists the resource manager (RM) in programming required resources. The resource requirements listed in the resource information network TRP are developed by the test manager, RM, and test support group, using sources such as the Operational Requirements Document and threat assessments. The TRP should specify, in detail, all the resources necessary to successfully conduct a test once it is entered in the Test Resource Information Management System (TRIMS).

The TRP is the formal means by which test resource requirements are communicated to the Air Staff and to the appropriate commands and agencies tasked to supply the needed resources. Therefore, if a required resource is not specified in the TRP, it is likely the resource will not be available for the test. The TRP is revised and updated on a continuous basis because the test resource requirements become better defined as the OT&E plans mature. The initial TRP serves as a baseline for comparison of planned OT&E resources with actual expenditures. Comparisons of the initial TRP with subsequent updates provide an audit trail of changes in the test program and its testing requirements. AFOTEC maintains all TRPs on TRIMS to permit immediate response to all queries regarding test resource requirements.

The AFOTEC RM consolidates the resource requirements from all TRPs, coordinating with participating and supporting organizations and agencies outside AFOTEC. Twice yearly, the RM office prepares a draft of the U.S. Air Force (USAF) Program for Operational Test document. It is a master planning and programming document for resource requirements for all Headquarters (HQ) USAF-directed OT&E and is distributed to all concerned commands, agencies, and organizations for review and coordination. It is then submitted to the Air Staff for review.

All requests for test resources are coordinated by HQ AFOTEC as part of the TRP preparation process. When a new weapon system development is first identified, AFOTEC provides a test manager (TM) who begins long-term OT&E planning. The TM begins identifying needed test resources, such as instrumentation, simulators, and models, and works with the resources directorate to obtain them. If the required resource does not belong to AFOTEC, then AFOTEC will negotiate with the commands having the resource. In the case of models and simulators, AFOTEC surveys what resources are available, assesses credibility, and then coordinates with the owner or developer to use them. The Joint Technical Coordinating Group (JTCCG) publishes a document on electronic warfare (EW) models.

Range scheduling should be done early. At least a year is required, but often a test can be accommodated with a few months notice if there is no requirement for special equipment or modifications to be provided at the range. Some of the Air Force ranges are scheduled well in advance and cannot accommodate tests that encounter delays or retest requirements.

The RM attempts to resolve conflicts among various systems competing for scarce test resources and elevates the request to the Commander, AFOTEC, if necessary. Decisions on resource utilization and scheduling are based on the weapon systems assigned priority.

The RM and the TM also arrange for use of the resources of other Services, non-DoD Government agencies, and contractors. Use of non-U.S. resources, such as a Canadian range, are coordinated by AF/TE and based on formal MOUs. The U.S. Air Forces in Europe/Directorate of Operations-Operations handles requests for European ranges. Use of a contractor-owned resource, such as a model, is often obtained through the system program office (SPO) or a general support contract.

The Air Force conducts FDEs, which are a type of OT&E performed by MAJCOM operational test organizations in support of MAJCOM-managed system acquisition-related decisions prior to initial fielding, or for MAJCOM sustainment or upgrade activities. An FDE may be used for multiple purposes; for example, an FDE may be used to:

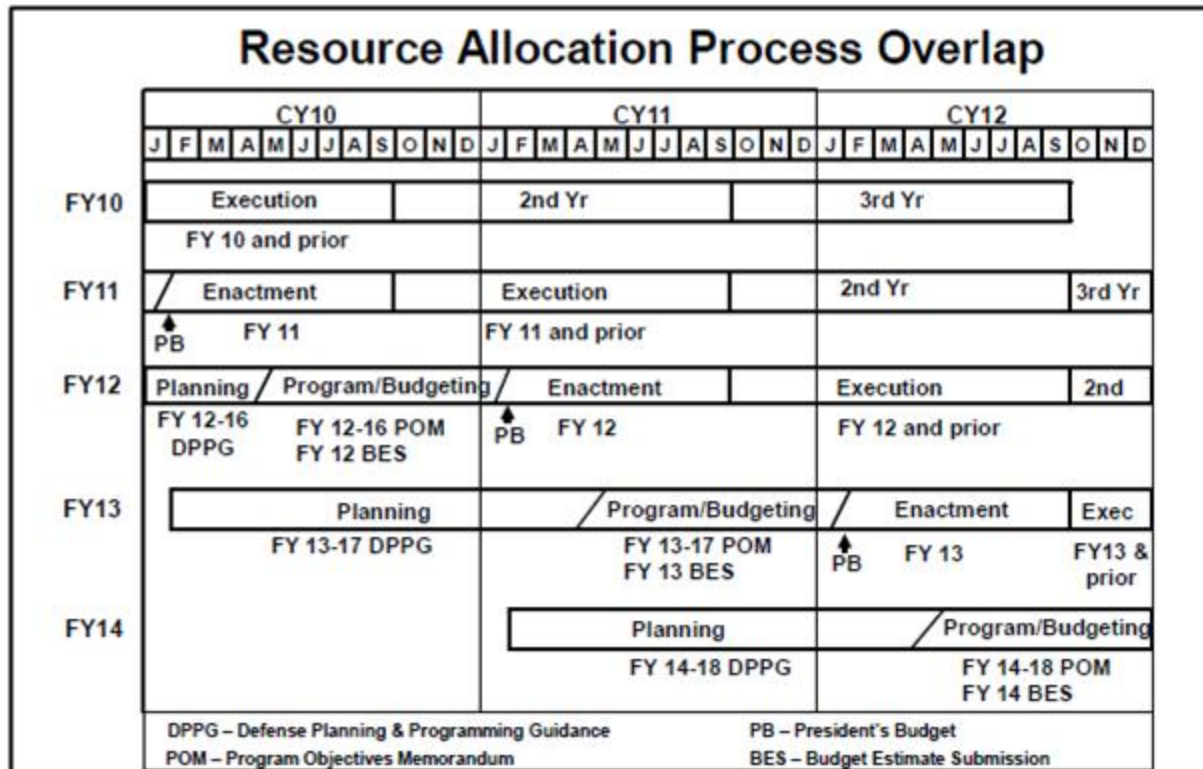
- Evaluate and verify the resolution of previously identified deficiencies or shortfalls, including those rated in AFOTECs OT&E final report as not having a substantial or severe impact on mission operations.
- Evaluate routine software modifications (e.g., operational flight programs), subsequent increments, upgrades, and other improvements or changes made to sustain or enhance the system.
- Evaluate and verify correction of new performance shortfalls discovered after fielding of the system.
- Evaluate operational systems against foreign equipment.
- Evaluate operational systems against new or modified threats.
- Evaluate military-unique portions and applications of COTS, NDI, and Government-furnished equipment (GFE) for military use.

#### **13.4 Test Resource Funding**

The FYDP, incorporating an annual budgeting process, is the basic DoD programming document that records, summarizes, and displays SecDef decisions. In the FYDP, costs are divided into three categories for each acquisition PE: R&D costs, investment costs, and operating costs. Congress appropriates to the Office of Management and Budget (OMB), and OMB apportions funding through the SecDef to the Services and to other Defense Agencies. The Services and Defense Agencies then allocate funds to others (claimants, sub-claimants, administering offices, commanding generals, etc.).

The PPBE system is a DoD internal system used to develop input for Congress for each year's budget while developing future-year budgets. PPBE is calendar oriented. There are concurrent PPBE cycles ongoing at one time. These cycles are planning, programming, budgeting, and execution. At any one time, there are multiple budgets being worked by the Services. The current 1-year budget is being executed. The next several years of defense planning are being programmed, and long-range program plans and planning guidance are being reviewed for updating. Figure 13-3 shows resourcing cycle overlaps in the DoD budget process.





**Figure 13-3 Resourcing Cycle Overlaps in the DoD Budget Process**

There are various types of funding in the PPBE process: R&D funding for maintaining the technology base; exploratory development funding for conducting the concept assessments; advanced development funding for conducting both the concept development and the early prototyping; engineering development funding for demonstrating the EDM; and procurement funding for conducting LRIP, FRP, system deployment, and operational support. RDT&E management and support funding is used throughout the development cycle until the system is operationally deployed when O&M funding is used. The RDT&E appropriation funds the costs associated with R&D intended to improve performance, including test items, DT&E and test support of OT&E of the system, or equipment test items.

Funding that is planned, programmed, and budgeted through the PPBE cycle is not always the same funding amount that Congress appropriates or the PM receives. If the required funding for a test program is not appropriated by Congress, the PM has limited courses of action. The PM can try to reprogram the needed funds or submit the shortfall as a requirement on an omnibus supplemental bill.

Generally, testing that is accomplished for a specific system before the production decision is funded from RDT&E appropriations, and testing that is accomplished after the production decision is funded from other RDT&E, procurement, or O&M appropriations. Testing of PIs, block upgrades, and major modifications is funded from the same appropriations as the program development. FOT&E is normally funded from RDT&E or O&M funds.

Funding associated with T&E (including instrumentation, targets, and simulations) is identified in the system acquisition cost estimates, Service acquisition plans, and the TEMP. General funding information for developmental and operational tests is provided in the following subsections.

#### **13.4.1 DT Funding**

Funds required for the conduct of engineering and DTs developmental tests are programmed and budgeted by the materiel developer as early as the MSA phase of acquisition and updated based upon the requirements of the TEMP. These costs may include but are not limited to procuring test samples/prototypes; support equipment; transportation costs; technical data; training of test personnel; repair parts; and test-specific instrumentation, equipment, and facilities. The DT&E funds are expended for contractor and Government DT activities.

The Service PM may be required to pay for the use of test resources, such as the MRTFB, and for the development of specialized resources needed specifically for testing the weapon system being developed.

#### **13.4.2 OT Funding**

Funds required to conduct OT are usually programmed and budgeted by the Service PM organization. The funds are programmed in the Services long-range test program, and the funds requirements are obtained from the test resourcing documentation and TEMP. The Air Force funds OT&E separate from the program office through a dedicated PE for AFOTEC-conducted OT and through MAJCOM funding for MAJCOM-funded testing.

#### **13.4.3 Army Funding**

Test resources are developed and funded under various Army appropriations. Direct-cost funding requires that test-specific (direct) costs associated with a particular test program be reimbursed by the program office to the designated test agency. The AMC and its commodity commands provide test items, spare parts, support items (such as diagnostic equipment), instrumentation, and expendables. Soldiers, ranges, fuel, test support personnel, and maneuver areas are provided by U.S. Army TRADOC or U.S. Army Forces Command (FORSCOM). Weapon system PMs use RDT&E funds to reimburse these supporting commands for costs directly related to their tests. Weapon system materiel developers are also responsible for funding the development of new test resources specifically needed to test the weapon system. Examples of such special-purpose resources include models, simulations, special instrumentation and test equipment, range modifications, EW simulators, and sometimes threat simulators. Although the Army has a separate budget and development plan for threat simulators-the PM ITTS threat simulators program-many weapon system developers still have to fund the cost of new threat systems that are specifically needed to test their weapon system. Funding for Army OT is through the PMs PE and is given to ATEC for direct control of funds for each program. Funding requirements are developed in consonance with the OTP.

#### **13.4.4 Navy Funding**

In the Navy, the weapon system PM is responsible for funding the development of all required test-specific resources from the programs RDT&E funds. Direct-cost funding requires that test-specific (direct) costs associated with a particular test program be reimbursed by the program office to the designated test agency. These resources include test articles, expendables, one-of-a-kind targets, data collection/reduction, and instrumentation. The development of generic test resources that can be used in OT&E of multiple weapon systems, such as targets, threat simulators, and range capabilities, is funded from the Office of the Chief of Naval Operations generic accounts (such as target development) and not from weapon systems RDT&E. The PMs RDT&E funds pay for all DT and OT through IOT&E. The PM pays for all post-production OT with program funds.

#### **13.4.5 Air Force Funding**

In the Air Force, direct-cost funding requires that test-peculiar (direct) costs associated with a particular test program be reimbursed by the SPO to the designated test agency. The RDT&E appropriation funds the cost associated with R&D, including test items, spare parts, expendables, instrumentation and ranges, DT&E, and AFMC support of OT&E of the system or equipment and the test items. Costs associated with IOT&E are RDT&E-funded, and costs of QOT&E are O&M-funded. AFOTEC is funded through its own PE and has direct control of OT&E funds for all programs. The IOT&E manager prepares a TRP that summarizes the resource requirements for IOT&E and related test support. All pre-test IOT&E planning is budgeted through and paid out of the O&M appropriation. The FOT&E costs are paid by AFOTEC and/or the MAJCOM operating the system and funded by the O&M appropriation.

#### **13.4.6 TRMC Certification of Certain Funding**

According to [Section 196](#) of Reference (b), the SecDef, acting through the Under Secretary of Defense (Comptroller)/Chief Financial Officer (USD(C)/CFO), requires that the Director, TRMC report annually the certification of the DoD test budgets. The Secretaries of the Military Departments and the Directors of Defense Agencies with T&E responsibilities must transmit such Secretary's or Director's proposed budget for T&E activities for a fiscal year to the Director, TRMC for review before submitting such proposed budget to the USD(C)/CFO.

### **13.5 Summary**

Test resources have many conflicting demands, and their use must be scheduled well in advance of a test. Resources specific to a particular test must often be developed and funded from the PMs own RDT&E budget. PMs must use DoD Government T&E capabilities and invest in Government T&E infrastructure unless an exception can be justified as cost-effective to the Government. Thus, the PM and testers must ensure that test resource requirements are identified early in the acquisition cycle, that they are documented in the initial TEMP, and that modifications and refinements are reported in the TEMP updates.

Funds for testing are provided by congressional appropriation to the OMB, which apportions the funds to the Services through the SecDef. PPBE is the DoD process used to formulate budget requests to Congress. Requests by PMs for test resources are usually outlined in the TEMP. PMs must conduct a CBA when using and investing in non-Government T&E capabilities and infrastructure and must document the CBA assumptions and results in an approved TEMP before proceeding with the program. Programs on DT&E oversight must provide the DASD(DT&E) with the results of the CBA for approval. Generally, system development is funded from RDT&E funds until the system is operationally deployed and maintained. O&M funds are used for FOT&E and system maintenance. The weapon system materiel developer is also responsible for funding the development of new test resources specifically needed to test the weapon system.

## Test & Evaluation Management Guide

### Chapter 14 - Introduction to Acquisition of Defense Business Systems (DBSs)

#### 14.1 Introduction

This chapter describes the incremental acquisition approach for DBSs. It introduces the Business Capability Lifecycle (BCL) Model and discusses in more details the BCL Acquisition Business Model. It describes how the BCL Acquisition Business Model supports the implementation of the BCL and depicts the phases, milestones, and decision points of the BCL acquisition process.

#### 14.2 DBSs

As stated in [Section 2222\(j\)\(2\)](#) of Reference (b), the term defense business system means an information system, other than a national security system, operated by, for, or on behalf of the DoD, including financial systems, mixed systems, financial data feeder systems, and IT and IA infrastructure, used to support business activities, such as acquisition, financial management, logistics, strategic planning and budgeting, installations and environment, and human resource management.

IT and IA infrastructures that are intended to be used to support the general activities of the Department (i.e., not solely dedicated to a specific business system) are not DBSs. These IT and IA infrastructures include local area networks, metropolitan area networks, wide area networks, and telephone systems.

#### 14.3 BCL Model

The BCL model in [Reference \(n\)](#) is the directed acquisition process for DBSs. DBSs are validated by the Defense Business Systems Management Committee (DBSMC). These systems employ a business case document using the BCL process in lieu of JCIDS documents for the capability requirements and associated solutions. The principles of BCL can be applied at the increment or the release level-BCL provides the framework for structuring the definition, development, testing, production, deployment, and support of DBSs. This model is a guideline, and tailoring, consistent with statute and sound business practice, is encouraged. As stated in [Reference \(n\)](#), it is DoD policy that :

- BCL is the overarching framework for the planning, design, acquisition, deployment, operations, maintenance, and modernization of DBSs, in accordance with [Section 2222\(f\)](#) of Reference (b). BCL facilitates DBS acquisition by providing a process tailored to the unique requirements of business systems.
- BCL shall apply to each DBS modernization with a total cost over \$1,000,000.
- When a MAIS DBS employs an incremental acquisition approach, all functional capabilities associated with a given increment shall be reflected in any resultant APB (cost, performance, and schedule) and must be achievable within 5 years from when funds were first obligated. For all DBSs that are not MAIS or otherwise designated, they must achieve IOC within 5 years from MS A. Delivery of capability within an increment (e.g., releases, sub-phases, software drops)

must be based on technologies that have been determined to be mature at the MS B decision review. Functional capabilities that are not supported by adequate cost estimates, mature technologies, etc., shall be deferred to subsequent program increment(s).

For all DBSs that meet the MAIS threshold or have been designated as special interest or other major information technology investment program shall be subject to OSD oversight. For all DBSs that do not meet the MAIS threshold or have not been otherwise designated as special interest or other major information technology investment program, the Heads of the DoD Components shall provide oversight of their acquisition processes and procedures, which shall be consistent with applicable statutes, regulations, and [Reference \(n\)](#).

#### **14.4 Incremental Acquisition Approach For DBSs**

As stated in [Reference \(n\)](#), approved business need that requires a materiel solution must be divided into discrete, fully funded, and manageable increments to facilitate development and implementation. Each increment shall be a useful and supportable operational capability that can be developed, tested, produced, deployed, and sustained. The principles of BCL can apply at the increment level and at the release level. Thus, there may be multiple releases within an increment. Multiple increments may also be approved concurrently if they have well-defined and approved requirements, are fully funded, and have appropriate entrance and exit criteria, and if the MDAs authorization to proceed is documented in an ADM. To facilitate rapid and responsive development, no more than 12 months shall normally elapse between the MDD and MS A. Following MS A, no more than 12 months shall normally elapse between the initial contract or option award and MS B. Following MS B, no more than 18 months shall normally elapse between contract or option award and the full deployment decision (FDD). The FDD is the final decision made by the MDA authorizing an increment of the program to deploy software for operational use in accordance with [Section 2445\(a\)](#) of Reference (b). Exceptions must be reviewed by the responsible Investment Review Board (IRB) and approved by the MDA. The MDA shall not grant a MS A decision if IOC cannot be achieved within 5 years and in no event shall FDD occur later than 5 years from when funds were first obligated for the program in accordance with [Section 811 of Public Law 109-364](#) (Reference (aq)).

##### **14.4.1 BCL Acquisition Business Model**

The BCL acquisition business model shown in Figure 14-1 supports the implementation of BCL and depicts the phases, milestones, and decision points of the BCL acquisition process.

##### **14.4.2 Business Capability Definition (BCD) Phase**

The purpose of the BCD phase is to analyze a perceived business problem, capability gap, or opportunity (hereinafter referred to as business need) and document the results in a problem statement to inform IRB Chair and MDA decisions. The activities performed and documentation required in the BCD phase shall be used in lieu of the JCIDS. The BCD phase begins with the identification of a business need. The business need can be identified by anyone throughout the DoD enterprise, including the Combatant Commanders (i.e., in their integrated priority lists) and capability area managers. The BCD phase ends

when the responsible IRB Chair approves the problem statement and the approved AoA study guidance and AoA study plan are submitted to the IRB Chair.

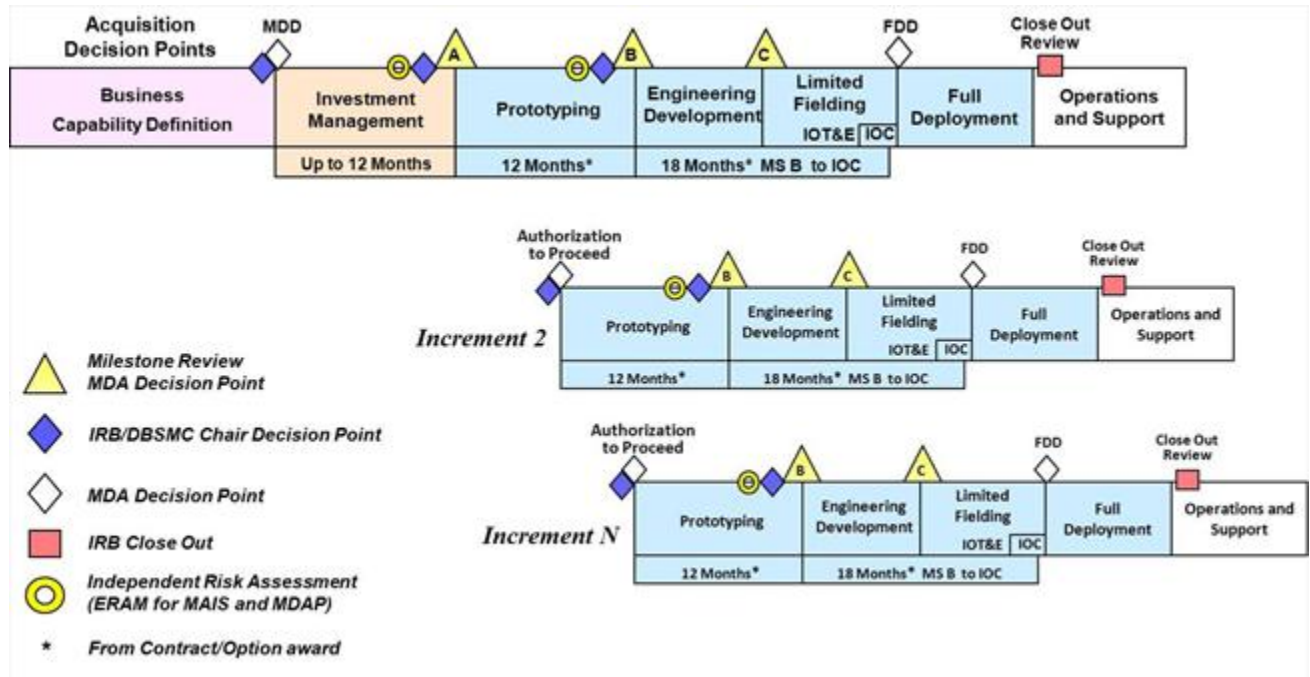


Figure 14-1 BCL Acquisition Business Model

### Investment Management (IM) Phase

The purpose of the IM phase is to assess potential materiel solutions and to satisfy the phase-specific entrance criteria designated by the MDA for the next milestone. The IM phase begins at the MDD; the MDD shall be mandatory for all DBSs. A PM is assigned for each acquisition program early in the IM phase. IM phase activities include the analysis necessary to describe the requirements for the materiel solution; the solution scope, objectives, business outcomes, outcome-based performance measures, constraints, and dependencies; the program justification, including assumptions, doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) impact, critical success factors, risks, detailed cost and benefits including return on investment analysis, funding profile, and delivery schedule; and an acquisition and contracting approach. The IM phase analysis is summarized in a business case developed and signed by the functional sponsor and PM. The business case includes the problem statement and the results of the IM phase analysis and serves as the foundation for all BCL efforts and decisions. The PM, functional sponsor, and T&E community jointly develop and include in the business case a plan that describes but is not limited to an integrated test program schedule; test management structure and processes; DT&E and OT&E phases (objectives, events, entrance criteria, scope, and limitations); CTPs; COIs, with associated MOEs and MOPs; and required resources. The DOT&E and DASD(DT&E) (or, for DBSs that do not meet the MAIS threshold, the DoD Component equivalents), in accordance with [Public Law 111-23](#) (Reference (ar)), approve the initial test plan and updates submitted at subsequent decision points. For MAIS programs and MDAPs, prior to the MS A

review, the DOT&E and DASD(DT&E) jointly approve the test sections of the business case; the DASD(SE) approves the SE sections of the business case. For MAIS programs and MDAPs, an independent risk assessment known as Enterprise Risk Assessment Methodology (ERAM) is conducted prior to MS A to review the results of phase analysis. As a result of the ERAM, the PM prepares a risk mitigation plan for MDA review and approval at MS A. The IM phase ends when phase requirements are satisfied, the responsible IRB reviews the business case, and the responsible IRB Chair forwards an MS A recommendation to the MDA.

#### **14.4.3 Prototyping Phase**

The purpose of the prototyping phase is to demonstrate the capability of the software to meet business process requirements as outlined in the business case. Prototyping includes installing IT in a relevant environment to gain the knowledge necessary to refine user requirements and inform APB development. The prototyping phase begins when the MDA approves the business case and documents the MS A decision in an ADM. Following MS A, no more than 12 months shall normally elapse between initial contract or option award and MS B unless an exception has been approved by the MDA and documented in the ADM. For MAIS programs and MDAPs, an ERAM is conducted prior to MS B. Based on the results of the ERAM, the PM prepares a risk mitigation plan for MDA review and approval at MS B. The PM compiles a MS B acquisition decision package and submits it to the responsible IRB (or, for DBSs that do not meet the MAIS threshold, the DoD Component equivalent review group) for review. In addition to other documents, this package includes an updated business case with DOT&E and DASD(DT&E) joint approval of the test sections of the business case and DASD(SE) approval of the SE sections of the business case (for MAIS programs and MDAPs). The prototyping phase ends when phase requirements are satisfied and the responsible IRB Chair forwards a MS B recommendation to the MDA.

#### **14.4.4 Engineering Development Phase**

The purpose of the engineering development phase is to demonstrate that the materiel solution for the increment has been designed, configured, developed, and tested in a manner consistent with the approved business case and program charter and that the materiel solution is ready for limited fielding and testing in an operational environment. The engineering development phase begins when the MDA approves the updated business case and the APB and documents the decision in an ADM. During the engineering development phase, the PM refines system requirements, configures the software, builds functionality as required, conducts DT, and plans for OT. The PM demonstrates that the materiel solution for the increment has been designed, configured, developed, tested, and evaluated in a manner consistent with the approved business case and program charter and that it is ready to be proven in an operational environment. Following MS B, no more than 18 months shall normally elapse between contract/option award and FDD, as described in the business case by the functional sponsor, unless an exception is approved by the MDA and documented in an ADM. The test community tests and evaluates the delivered capability to determine whether it adheres to the outcomes defined in the business case and whether it is compliant with the Business Enterprise Architecture (BEA). For MAIS programs and MDAPs, DT is conducted in accordance with the test plan, as documented in the business case, and approved by the DASD(DT&E). For MAIS programs and MDAPs, OT is conducted in accordance with the



operational test plan approved by the DOT&E. For programs on OSD T&E oversight, the DoD Components conduct an OTRR before commencing OT for any increment. The engineering development phase ends when phase requirements are satisfied and when the functional sponsor reviews the test results and determines that the outcomes and metrics as stated in the approved business case are satisfied.

#### **14.4.5 Limited Fielding Phase**

The purpose of the limited fielding phase is to limit risk by providing the capability to a limited number of users and testing it in an operational environment. The DOT&E reports on the adequacy of OT and whether that testing confirms the effectiveness and suitability of the system. Entrance criteria include completion or satisfaction of the objectives of the engineering development phase (including a developmentally tested, BEA-compliant, production-representative system, ready for IOT&E); the functional sponsors determination that the capability achieves the outcomes specified in the business case; and the programs compliance with the statutory and regulatory requirements specified for MS C. The limited fielding phase begins when the functional sponsor and the MDA approve fielding the capability into an operational environment for IOT&E and the MDA documents the decision in the MS C ADM. The PM engages an OTA to verify that the functional requirements described in the business case are satisfied and to determine the operational effectiveness and suitability of the increment. The functional sponsor, informed by IOT&E results and DOT&E recommendations (for DBSs on OSD T&E oversight), issues a written declaration that the system has achieved IOC. The limited fielding phase ends when phase requirements are satisfied, IOT&E is complete, and IOC is declared.

#### **14.4.6 Full Deployment Phase**

The purpose of the full deployment phase is to field an increment of capability for operational use in accordance with the business case. Entrance criteria for this phase include the completion of IOT&E or other required testing, declaration of IOC, and satisfaction of the DOTMLPF solution outlined in the business case. The full deployment phase begins at the FDD when the MDA reviews the business case, the IOT&E results and DOT&E recommendations (for DBSs on OSD T&E oversight), and other requirements to determine whether the capability is ready to proceed to full deployment. The MDA decision is documented in an ADM.

#### **14.4.7 O&S Phase**

The purpose of the O&S phase is to execute a support program that meets materiel readiness and operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. Planning for this phase begins prior to program initiation and is summarized in the business case. O&S has two major efforts: life cycle sustainment and disposal. The O&S phase begins when an increment or DBS has been fully deployed. A close-out review is conducted during the O&S phase to solicit user feedback and enable understanding of how well a recently completed increment meets the needs of users before finalizing the requirements for subsequent increment(s). A close-out review is held with the responsible IRB and includes a post-implementation review report. At the end of its useful life, an increment is disposed of in accordance with all statutory

and regulatory requirements and policy including but not limited to those relating to safety, security, and the environment.

#### **14.5 Summary**

DBS investments need to be managed with the kind of acquisition management rigor and discipline that is embodied in relevant guidance and best practices so that each investment will deliver expected benefits and capabilities on time and within budget.

## Test & Evaluation Management Guide

### Chapter 15 - Software and IT Testing Considerations

#### 15.1 Introduction

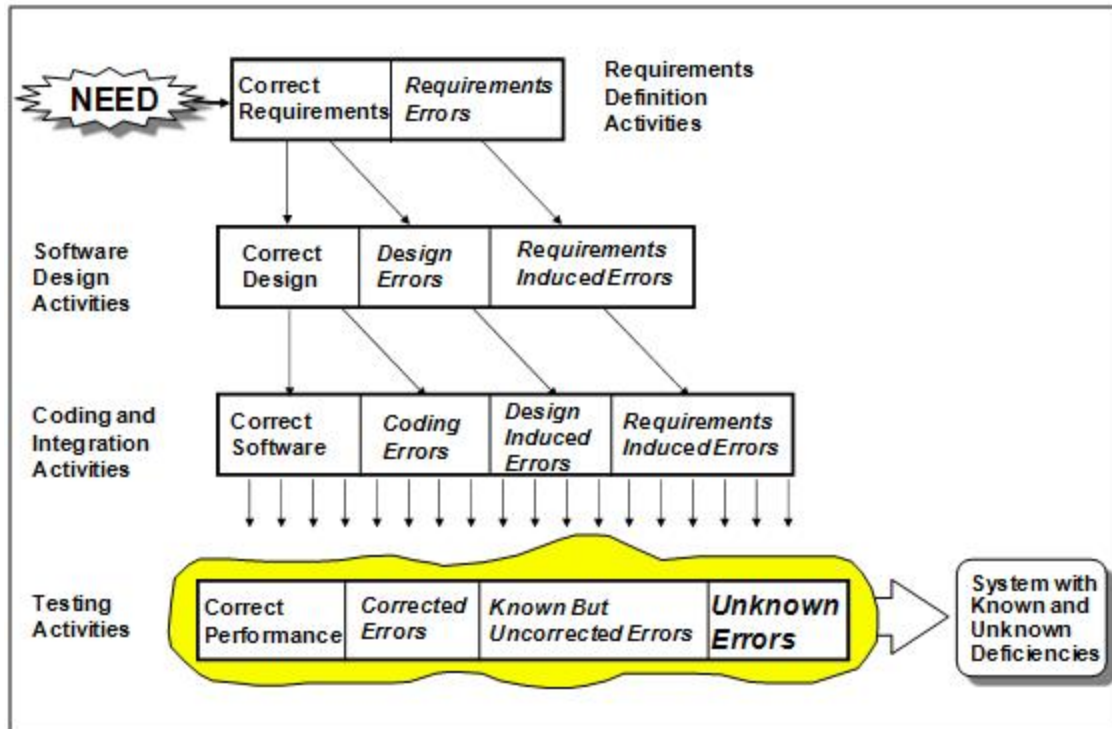
Software development has historically been a major risk for many DoD systems. This risk has been true for software embedded as part of a military weapon system as well as for that found in other AISs, such as personnel records management, financial accounting, logistics, etc. Although testing for so-called software-intensive systems follows the same general T&E precepts outlined elsewhere in this guide, certain characteristics of the software development effort are important to understand. This chapter discusses these characteristics, provides an overview of key parts of a typical software development process and the associated leverage points for more effective testing.

Software T&E encompasses the entire system development life cycle, from concept and requirements development to design, operations, maintenance, and upgrade/retirement. Difficulty in adequately testing software and the associated software quality problems are not limited to DoD or the Federal Government. AISs, once developed and tested in the host hardware that is commonly off-the-shelf, are essentially ready for fielding. On the other hand, software in weapon systems, once integrated in the host hardware, continues to be tested as a component of the subsystem(s) and ultimately the total system and is not ready until the total system has successfully demonstrated required performance and has been completely integrated. Any changes to the hardware configuration may require software changes. Sometimes hardware performance deficiencies can be solved by modification to the embedded software, potentially causing late-stage integration problems and the need for retesting. Additionally, much embedded weapons system software is safety-critical, real-time software operating under severe timing constraints. A system is real-time if the total correctness of an operation depends not only upon its logical correctness, but also upon the time in which it is performed. The classical conception is that the completion of an operation after its deadline is due is considered useless—ultimately, this delay may cause a critical failure of the complete system.

#### 15.2 Role Of The Software Specification Review

Software considerations are evaluated at several key milestones in the development process, including the Software Design Review, PDR, and CDR. The development of all software systems involves a series of development activities that are driven by an underlying SE paradigm that does not change for software. However, because software itself is an invisible, highly flexible, and easily changed product with many ways to define quality, without careful considerations of these unique characteristics, frequent opportunities exist for the introduction and insertion of errors.

Errors and defects may occur at the inception of the process when the requirements may be erroneously specified or later in the development cycle when integration is being done. Figure 15-1 illustrates how software errors can accumulate over the development process, generating downstream errors (avalanche), and why early detection of them is critical. The so-called error avalanche can include untested functions, unrepresentative environments, and insufficient repetitions, incorrect expected results, and misinterpreted results.



**Figure 15-1 "Error Avalanche" Showing How Software Errors Can Accumulate**

Numerous studies have shown that many software errors originate in the requirements stages of the contractor's software development process, yet little effort is devoted to finding and correcting software errors at this stage, when the cost of correction is cheapest. Figure 15-2 shows the distribution summary of software errors across the lifecycle software development activities.

Frequently, the Government does not have good insight into this early stage of the development process-but they should! Tester participation in the SSR or equivalent review, which occurs after software requirements analysis for the to-be-developed system is complete, is highly recommended.

Lifecycle SW Development Activity	Initial \$ Spent	Errors Introduced	Errors Found	Relative Cost
Requirements Analysis	5%	55%	18%	1.0
Design Activities	25%	30%	10%	1.0-1.5
Testing Activities	60%	10%	50%	1.5-5.0
Documentation	10%	---	---	---
Software Support	---	5%	22%	10-100

**Figure 15-2 Software Error Distribution Summary (Notional)**

The SSR is a technical review held at a subsystem level that is unique to software. It is completed prior to the software PDR. At the SSR, software requirements are defined, ultimately becoming the functional baseline for software. As part of this review, test acceptance criteria for each software requirement are

established. Typically, an SSR is held for each major software item or software configuration item (SCI) or group of SCIs comprising a subsystem. An SCI or a CSCI (older terminology still in use) is a collective set of software routines and programs, under configuration management, that accomplishes a well-defined, cohesive goal (a mission planning CSCI, a human-computer interface CSCI, an avionics CSCI, etc). The allocation of top-level requirements to them and their determination are one of the many outputs of the overall SE process.

Some of the key questions addressed at the SSR that are important from a tester's perspective include the following:

- Is a requirements verification and test matrix complete?
- As stated, are all requirements, include derived ones, "testable"?
- Are all proposed software test events traceable to system requirements?
- Is software that requires safety or other certification scheduled to be certified?
- Has an early Operational Assessment been considered for software?
- Are sufficient resources provided as part of the developer's software test plan?
- Does the proposed test schedule have provisions for re-work?
- Are there sufficient test assets, including resources and infrastructure, programmed for later testing?
- Have Software Engineering Environment key resources been identified?
- Is all required support software going to be available when required for testing?
- Is the TEMP aligned with projected software testing activities?

The completion of software requirements analysis and the SSR (or similar review) establishes the allocated baseline for the software for a particular SCI or set of SIs. This allocated baseline is then used for subsequent software design and development. Typically, this baseline is formally documented in a software requirements specification (SRS) and an associated interface requirements specification (IRS) or their equivalents. Key to the tester is the part of these documents that contains, generally as an annex, a requirements traceability matrix (RTM). The RTM should show each software requirement including derived requirements, their traces to higher level requirements and how each will be validated, and how the specifications are verified (e.g., inspection, analysis, demonstration, or test).

Derived requirements result from the analysis of system-level requirements done as part of the software requirements analysis. They are not explicitly stated in a higher level document but are needed to flesh out the software design. Software is especially rich in derived requirements, which if not carefully controlled and planned for, can add unexpected costs and schedule to the program. Indeed, the original rationale by the USAF Studies Board in the 1980s for use of the SSR was based on analysis of

a number of failed programs in which details of the complete scope of the derived software requirements was not understood until later in the program when extensive rework was needed.

It is important from a tester's perspective that completion of the SSR also initiates more detailed test planning parallel activities on the part of the developer. These culminate in SCI/CSCI test(s) that will qualify, via a software qualification test (SQT), the software as correct. Correct in this sense is that it meets its baselined requirements as specified by the SRS/IRS RTM. After SQT, the SCI/CSCI is ready to be integrated into a larger subsystem. These activities, which occur after the SSR, vary by development approach/contractor but generally happen as shown in Figure 15-3.

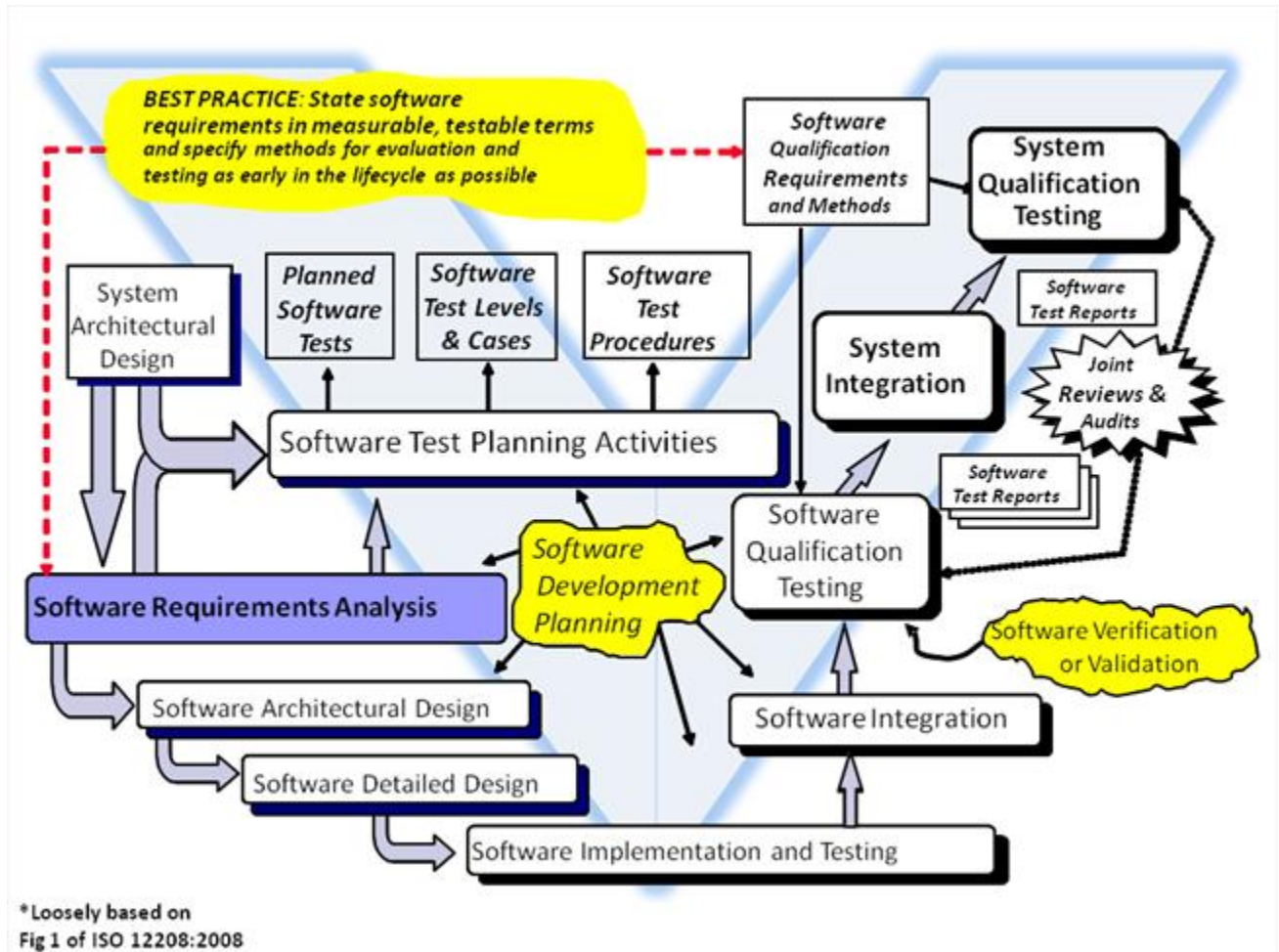


Figure 153 Illustrative Software Test Planning Activities

### 15.3 Role Of The TRR For Software

The TRR, previously discussed at the system level in Chapter 7, is a multi-disciplined technical review designed to ensure readiness to proceed into formal test. As stated in [Reference \(j\)](#), the TRR assesses test objectives, test methods and procedures, scope of tests, and safety and confirms that required test resources have been properly identified and coordinated to support planned tests. The TRR verifies the traceability of planned tests to program requirements and user needs. It determines the completeness of test procedures and their compliance with test plans and descriptions. The TRR also assesses the system under review for development maturity, cost/schedule effectiveness, and risk to determine readiness to proceed to formal testing.

Historically, much like the SSR, the TRR was originally developed as a review dealing with readiness to start SQT. Over the years, it was recognized that a formal review of readiness for the start of testing is a universal best practice for all parts of a system under development and so its use has expanded to where the TRR is generally considered to be a formal gating event to determine readiness for systems-level testing. However, its use as part of the software development process is still valid and highly recommended. A software TRR helps testers gain visibility of potential software test problems and correct them earlier in the development life cycle before software items get integrated into larger subsystem(s) or even into the system, where rework can become prohibitively more expensive. Some of the key items typically examined at software TRR can include:

**Requirements Changes** . Any changes to the SRS or IRS or other software allocated baseline documents that have been approved since SSR and that impact testing.

**Design Changes** . Any changes to the software design document that have been made since PDR and CDR and that impact software testing.

**Software Test Plans and Descriptions** . Any changes to previously approved software test plans and software test descriptions.

**Software Test Procedures** . Procedures to be used in conducting testing, including retest procedures for test anomalies and corrections.

**Software Unit Testing** . Software unit integration test cases and procedures used in conducting prior software unit tests and other lower level tests and the test results. Closure status on software problem reports.

**Software Test Resources and Tools** . Status of the development facility hardware, any Government-furnished software or GFE essential to success of the test, availability of test personnel, and supporting test software and materials, including software test tools used, and their qualification and certification if required.

**Requirements Traceability** . The traceability between requirements and their associated tests.

**Software Measures** . Status of the program based on relevant software measures. Examples include breadth and depth of testing, requirement test levels, problem report status, actual versus planned staffing profiles, and software complexity.

**Dry Run Results** . Results from a dry run of planned procedures.

#### 15.4 Software Development Process

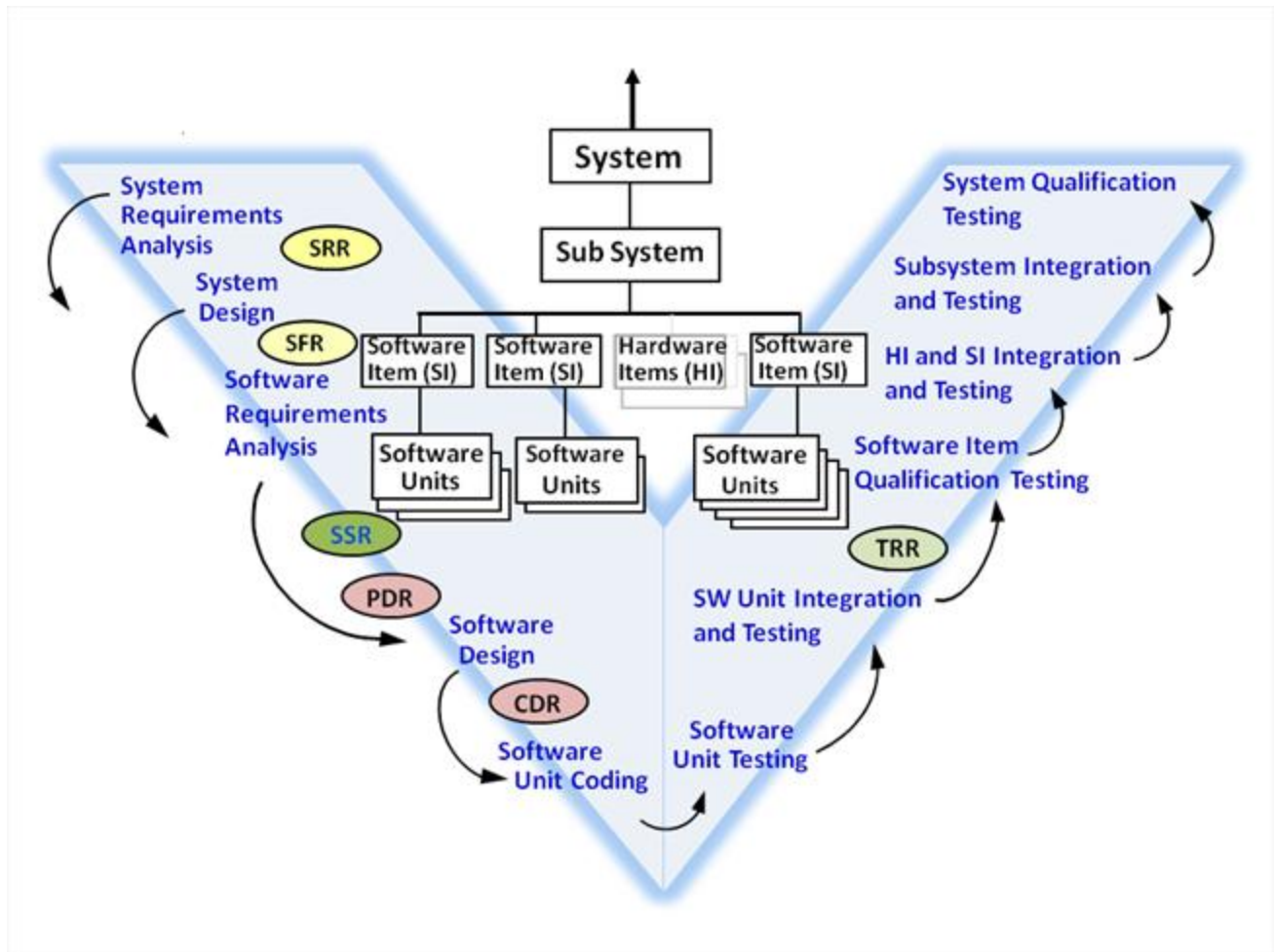
Generally, for DoD safety-critical systems, software development follows a classic top-down approach consisting of overlapping phases of requirement analysis, architecture/preliminary design, detailed design, coding, and a series of tests beginning with software unit testing followed by integration and associated qualification testing. Qualified SCIs are integrated into subsystems and finally into the complete system.

Typically, a software unit is considered to be the smallest independently testable component of software making up an SCI. Software units are low-level routines and programs. An SCI may be composed of hundreds of software units that have to be tested and integrated.

These stages of development are separated by various lower level reviews for the software and at the subsystems and system level that examine development progress and assess risks. For safety-critical systems, analysis of the effort will also include formal evaluation of various work products in accordance with [MIL-STD-882E](#) (Reference (as)), provisions of which are generally contractually imposed as appropriate for these types of DoD systems.

These activities, displayed in the context of a notional system-level WBS, are illustrated in Figure 15-4. Not shown are the various subsystem- and system-level reviews (PDRs, CDRs, etc.) that occur at higher levels in the WBS as the system is integrated. When the various activities are drawn in this manner, the diagram mimics a V and sometimes is referred to as a V-diagram. V-diagrams are a common way of depicting SE processes as well.





**Figure 15-4 Illustrative Software Development Activities in System WBS Context**

### 15.5 The Potential Power Of Human-Based Testing

As shown in Figure 15-2, software errors generated during the software requirements analysis phase are the most difficult to find and the most costly to fix. This late discovery phenomenon leads to more expensive corrections later on, exacerbated at all stages of development by the software error avalanche depicted in Figure 15-1. The obvious solution, therefore, is to prevent those errors from being inserted into the system in the first place, which would minimize the amount of discovered errors and/or needed rework later on. However, software testing in the classic sense of running software on the target computer does not occur until the upward leg of the Figure 15-4 V-diagram. What can be done to improve this state of affairs?

One way to improve this situation is to use human-based testing. Human-based testing occurs on the downward leg of the software V-diagram. The earliest stages of software development are characterized by heavy human involvement in basic requirements analysis, design, and coding processes. Human-based testing (sometimes called static testing) encompasses non-computer-based methods of evaluating documentation and discovering errors covering such areas as software requirements,

architectures, designs, interfaces, and code. Human-based tests are performed multiple times as software development proceeds and matures and are typically performed as part of requirements analysis, design, and early coding stages of development.

Several activities are encompassed by the term human-based testing. These activities include the following, which are listed in order of increasing rigor and effectiveness:

- **Desk Checking** . A self-evaluation is made by programmers of their own work. There is a low probability of identifying their errors of logic or coding.
- **Walk- through** . A group of peers evaluates the work of others and gives direct feedback to the authors. Roles can be shared among the participants. The walk-through leader or the author may serve as the recorder. The walk-through leader may be the author.
- **Formal Inspection** . Consists of two to six participants (including the author). An inspection is a highly disciplined effort led by an impartial trained facilitator trained in inspection techniques. Determination of remedial or investigative action for a discovered anomaly is a mandatory element, although this resolution does not normally occur in the actual inspection. Per [IEEE Std 1028-2008](#) (Reference (at)), collection of data for the purpose of analysis and improvement of software engineering procedures is a mandatory element of software inspections.

Initially developed and proofed many years ago at IBM Federal Systems Division, formal inspections are fairly straightforward and simple, and if properly done, can be highly effective in eliminating errors early in the development process.

Although walk-throughs have the potential of 30 percent to 40 percent early defect removal, repeated studies have shown that formal inspections, properly done, have a defect removal rate on the order of 70 percent. The results mean the size of the error avalanche is a lot smaller and makes later, computer-based testing more effective. Use of formal inspections is strongly recommended as a contractor best practice.

Although Government testers are not normally part of the contractor's formal inspection team, they should determine whether the contractor is actually using such a process properly and gain insight into its effectiveness. Its use (or lack of use) can give testers early insights into possible later software testing risks and associated schedule slips due to unforeseen rework.

## 15.6 "Black Box" Versus "White Box" Testing

Software computer-based testing involves using a combination of black box and white box testing. These terms are defined as follows:

- **Black Box Testing** . Functional testing of a software unit without knowledge of how the internal structure or logic will process the input to obtain the specified output. Within-boundary and out-of-boundary stimulants test the software's ability to handle abnormal events and to produce the expected outputs given appropriate inputs. The most likely cases are tested to

provide a reasonable assurance that the software will demonstrate specified performance. Most computer-based testing after software unit tests consists of are black box tests.

- **White Box Testing** . Structural testing with insight into the internal logic and software structure. This process provides an opportunity for more extensive identification and testing of critical paths. Test scripts are developed with an understanding of the internal structure of the software under test. Software unit testing is performed as a white box test.

Testing, as illustrated by the upward portion of the V-diagram in Figure 15-4, should be performed from the bottom up. The smallest controlled software modules-software units-are tested individually via white box tests, and discovered errors are resolved at the lowest possible level in the system structure. Modules are then combined or integrated and tested in larger aggregate groups or builds. When this process is complete, the software item (SCI) is tested in its entirety and, after a successful TRR, ultimately qualified.

Although the Government tester is not directly involved in the white box testing at the software unit level, gaining visibility into how well this testing was performed will give good insights into later test problems. Frequently, when the baseline schedule for a program is compressed, in order to maintain key schedule dates (one of which is typically the SQT, noted in Figure 15-3), software unit testing suffers and is not adequately performed by the developer. The result can be that these undiscovered errors remain until later black box integration testing, when their removal is more expensive and requires rework of code at the software unit level.

### 15.7 The Impossibility of Exhaustive Software Testing

A truism in the software testing community states that software testing can only indicate the presence of errors, not their absence. This statement is true because even the simplest software designs rapidly exceed the capacity to test all possible alternatives.

For instance, in the power distribution panel example from [Combinatorial Testing](#) by Rick Kuhn (Reference (au)), depicted in Figure 15-5, there is a set of 34 power distribution switches (two rows of 17 switches). A software program monitors the positions of these two-way switches to determine appropriate actions. Because this is a safety-critical system, suppose we wanted to exhaustively test all possible switch combinations to absolutely ensure safe operation. How many individual test cases would be required to be run? The number of individual test cases required would be quite large.

Because the switches are two-position switches and there are 34 of them, the total individual test cases required would be  $2^{34} = 17,179,869,184 \approx 1.7 \times 10^{10}$  tests. There are around 31 million seconds in a year, and assuming each test takes 1 second to manually physically set the switches, etc., the time for a complete exhaustive test would be  $1.7 \times 10^{10} / 31 \times 10^6 \approx 548$  years. Clearly, exhaustive testing for this or any other nontrivial software system is out of the question!

However, various methods and engineering techniques can be used to improve test efficiency and gain confidence in the limited scope of software testing that can be performed given typical schedule

constraints. These include such techniques as combinatorial or pairwise testing, done within the context of DOE, which maximizes the utility of each test case.



**Figure 15-5 Testing Example**

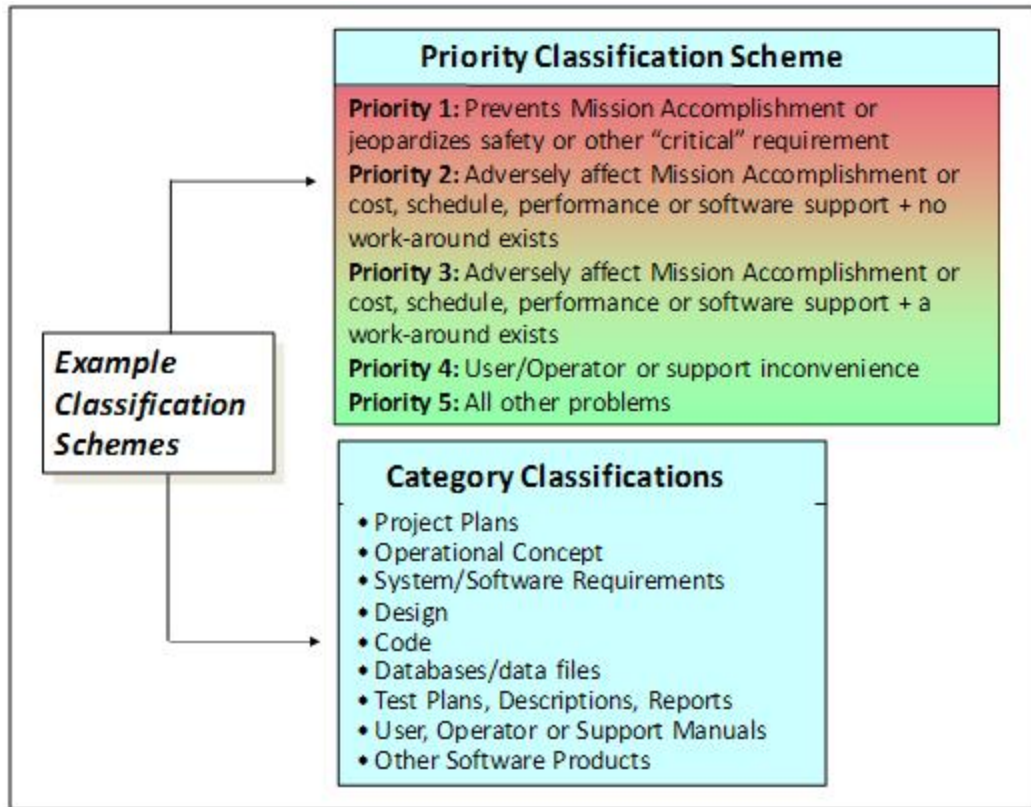
Additionally, many other test tools exist that typically are part of the developer's software engineering environment and can dramatically improve productivity of software testing. Some of these types of tools can automatically parse proposed test cases and evaluate the breadth and depth of testing to ensure that every program branch and line of code is tested at least once. Others evaluate the logical complexity of the code and identify areas in which the software could be simplified to improve its correctness and maintainability. Other design tools are used to plan software testing activities and can generate test artifacts that drive later testing activities.

Although the operation and use of these types of tools is beyond the scope of this chapter, the Government tester should nevertheless be aware of their use. If employed effectively, they are a way to increase the effectiveness of the developers computer-based testing. Their absence or improper use in a developer's organization is a risk to the testing effort. This is why an assessment of these types of tools should be one of the review items at a software TRR.

### **15.8 Software Error Categorization And Priority**

Not all discovered software errors are equal. Some have significant functional and operational impacts whereas others are in the realm of suggested improvements and cosmetic engineering. Although currently there is no DoD policy as such mandating how errors are classified, at one time a priority scheme was mandated by a now-retired DoD software development military standard.

This was a simple, workable classification scheme that stood the test of time. It subsequently appeared as a suggested methodology in various replacement commercial standards as well. This software error priority classification scheme is illustrated in Figure 15-6.



**Figure 15-6 Priority Classification Scheme for Software Errors**

As software errors are discovered, it is important from a process improvement perspective to attempt to identify at what point in the development process they were made. Therefore, many developers also categorize the source where or how the error was introduced into the development process with a view toward improving that part of the process. The data in Figure 15-2 showing software error distributions was derived from such analyses performed over many projects.

Keep in mind that Figure 15-6 is generic. One suggested best practice that some programs have used quite successfully is to tailor the priority classification categories with respect to the actual system domain in coordination with end users. For example, for a medical system, the priority classifications would be restated in terms of medical issues; for an avionics system, they would be restated with respect to flight safety, etc. Issues occasionally arise at scoring conferences in which software problems are being adjudicated into one of these five priorities; restatement of priorities into operational terms before that stage can eliminate a lot of these issues.

### 15.9 Overview of Software Measurement With T&E Applications

Because software is an invisible product with many ways to define its quality ilities (suitability, reliability, maintainability, etc.) and many ways to measure them, it was realized early on in the DoD that a formal way to measure and gauge software development progress and associated quality was needed. Over many years, the discipline of software measurement has been developed and refined; and used

appropriately, software measurement is an essential way to get visibility into potential development, quality, and testing issues.

One of the DoD SE technical management core processes is technical assessment. Technical assessment consists of three interrelated activities: (1) EVM, (2) Technical reviews and audits, and (3) TPM. Software measurement is a specific subset of TPM that is tailored to the unique characteristics of the software product.

Software measures are risk and issue driven. Given a set of identified risks and issues, a set of metrics are developed that quantify and measure the impact of those identified risks and issues. Typically, software measures are plotted and formatted as various curves. Assessment of the shape of the curves and their changes over time can give good insights to predicting potential later problems. Ideally, action can be taken early enough before Brooks Law takes effect.

Brooks Law states that adding staff to a late software project makes it later. It was coined by Fred Brooks in his 1975 book, *The Mythical Man-Month*. Two factors are at work: (1) It takes some time for the people added to a project to become productive; they must become educated about the work, and this education requires diverting resources; and (2) Communication overheads increase as the number of people (or subcontractors) increases. The number of different communication channels increases along with the square of the number of people; so, for example, doubling the number of people on a project results in four times as many different conversations. Although there are exceptions to Brooks Law, it has generally held true for many programs.

Some relevant software measures of interest to testers include requirements stability, computer resource utilization, complexity, test progress, test resource utilization, problem report status, problem report aging, problem report priority, and depth of testing. Some of these measures are briefly summarized in sections 15.9.115.9.7.

Much of the discussion and examples in this section have been derived from handbooks published by the Practical Software and Systems Measurement organization. The Practical Software and Systems Measurement project is a DoD effort that has developed tools and handbooks concerning software measurement. The Practical Software and Systems Measurement Website at <http://www.psmc.com/> is an excellent resource.

### **15.9.1 Requirements Stability**

Requirements stability measures changes in requirements over time, as shown in Figure 15-7. If software requirements are still changing when the developer is in detailed design or even worse, during coding, it is a problem. Each requirement should be baselined by the SSR; if not, the associated RTM (with testing criteria) may need to be re-baselined before testing.



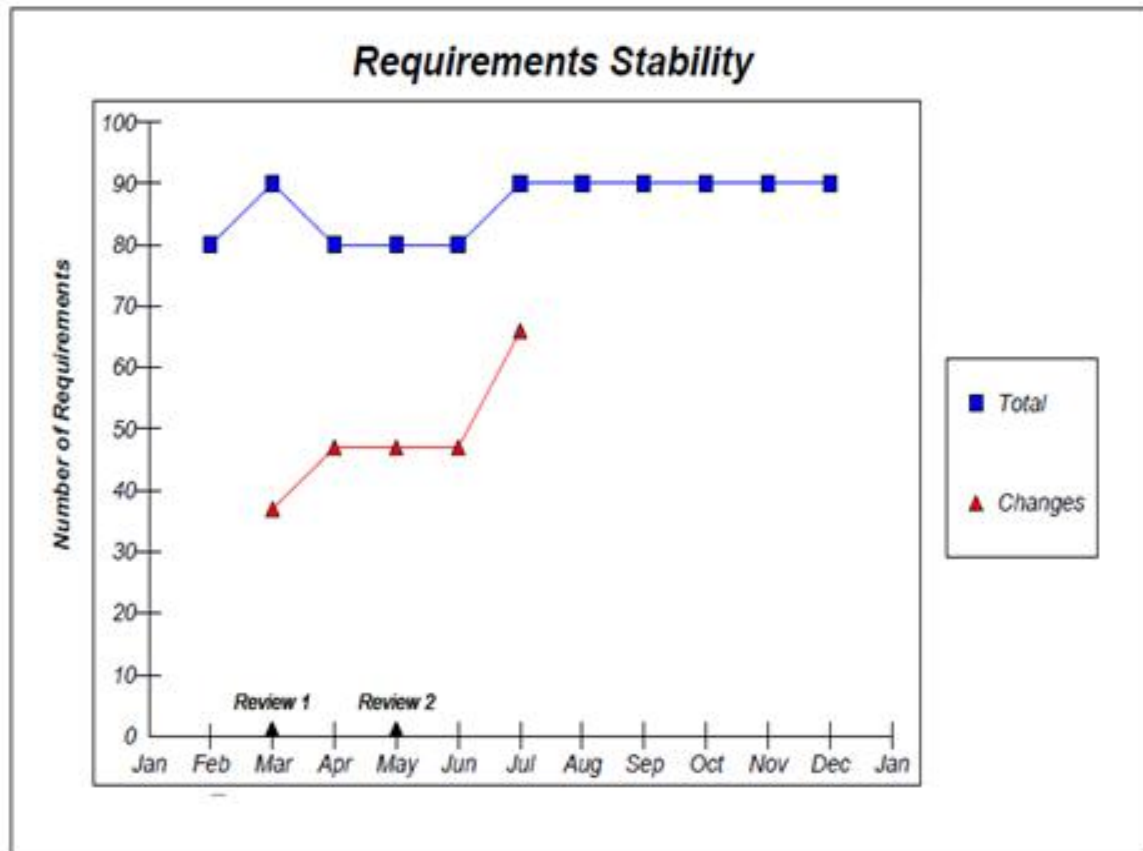
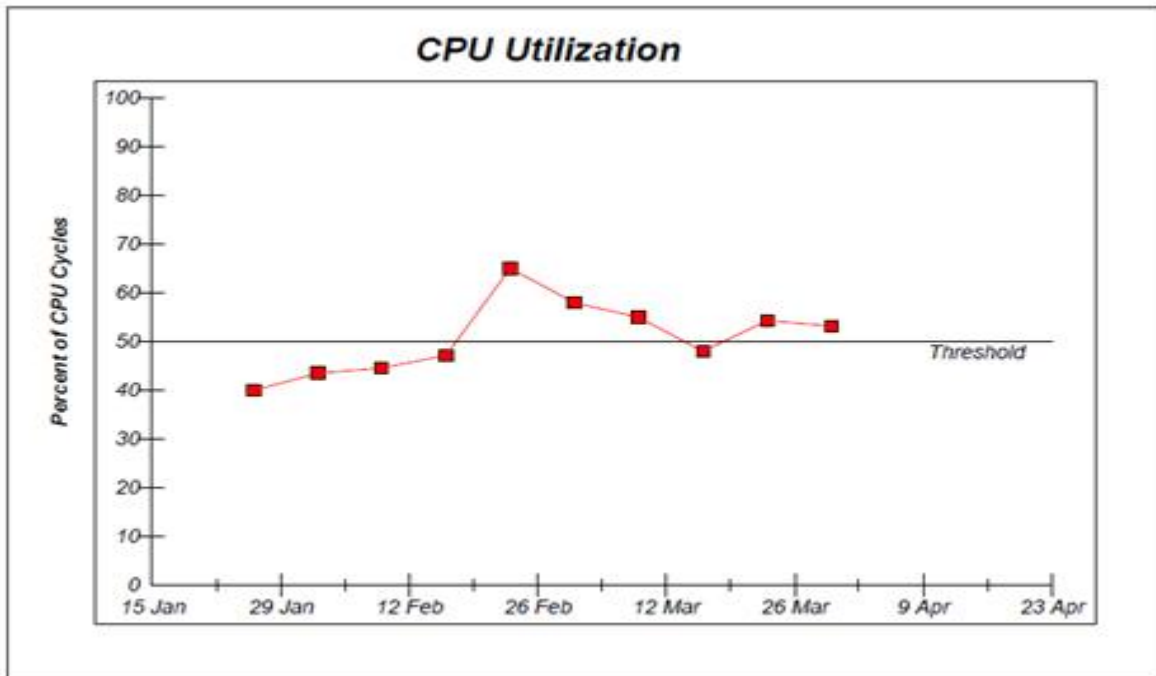


Figure 15-7 Example of Requirements Stability Measure

### 15.9.2 Computer Resource Utilization

Computer resource utilization measures the utilization of some capacity of the underlying hardware (e.g., processing power, memory size, bus transfer rates) that is deemed critical to the performance of the system, as shown in Figure 15-8.



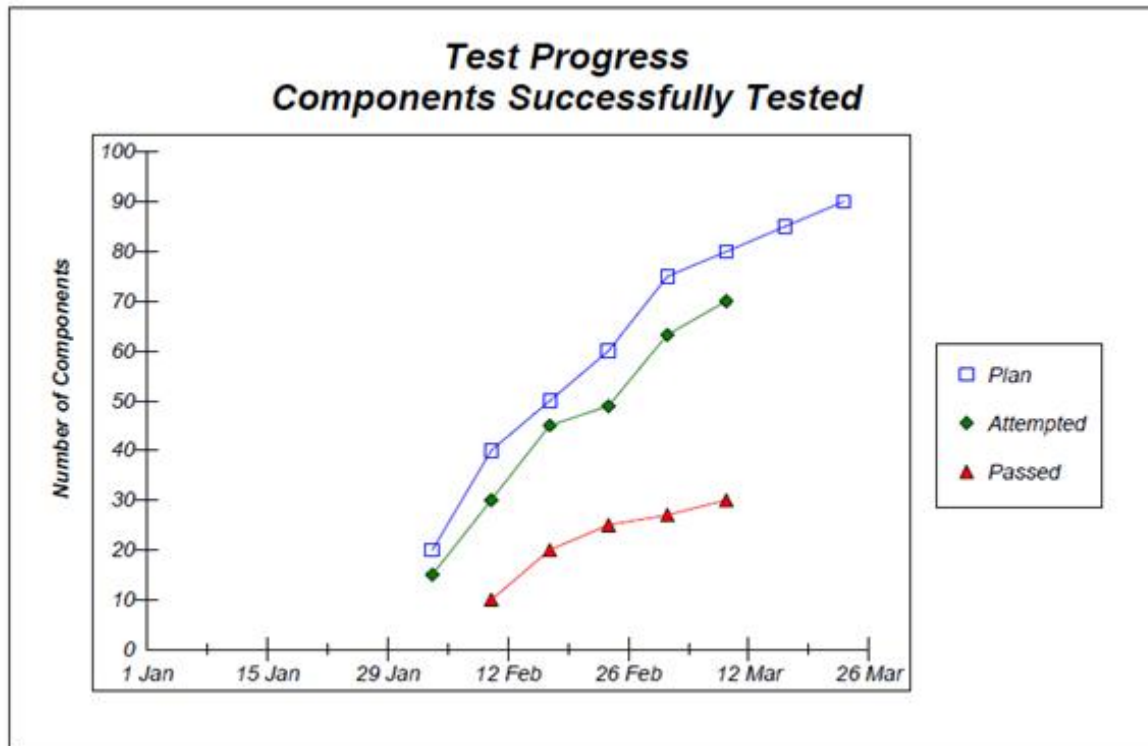
**Figure 15-8 Example of Computer Resource Utilization Measure**

This measure is important because as reserve capacity is approached, software performance may be degraded and provisions for adding new functionality in subsequent increments may be compromised. Typically, initial thresholds are set at a lower level (shown in Figure 15-8 as 50 percent) to allow for this type of growth and evolution.

### 15.9.3 Test Progress

Test progress measures progress of low-level software unit testing against the plan. In Figure 15-9, the simple linear extrapolation of the passed line against the original planned schedule indicates a significant slip until the projected 90 tests are completed.





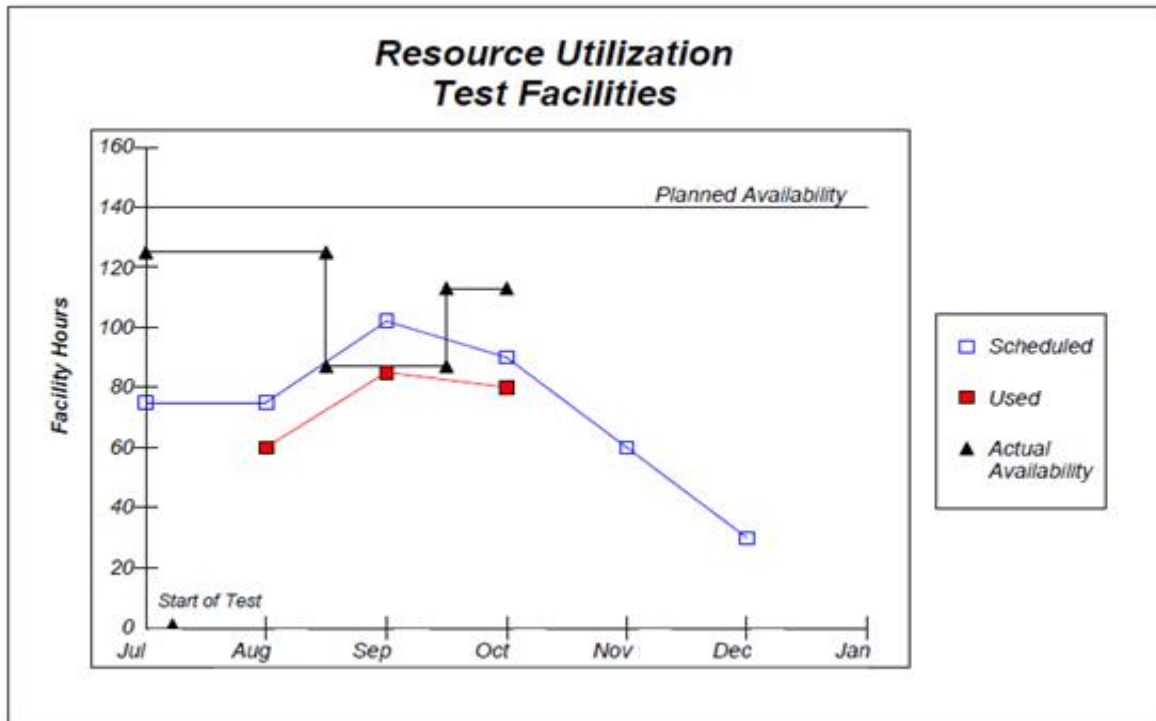
**Figure 15-9 Test Progress Measure Indicating Schedule Slip**

Because these software units collectively make up an SCI that will undergo later qualification testing, the significant slip in low-level software unit testing is indicative of a substantial slip in that test. If that SCI has critical functionality, the subsequent DT&E and even the start of OT&E may be impacted as well.

#### 15.9.4 Test Resource Utilization

As depicted in Figure 15-10, this measure compares planned usage of test resources with actual usage. In this case, the actual amount of test resource usage is less than projected. This difference may be due to several possibilities: (1) The software is of better quality than anticipated and fewer errors are being found, (2) The software test cases are deficient in terms of depth and breadth of testing and therefore are being finished too quickly, and/or (3) Not enough testers are available to run the planned tests due to staffing shortfalls.

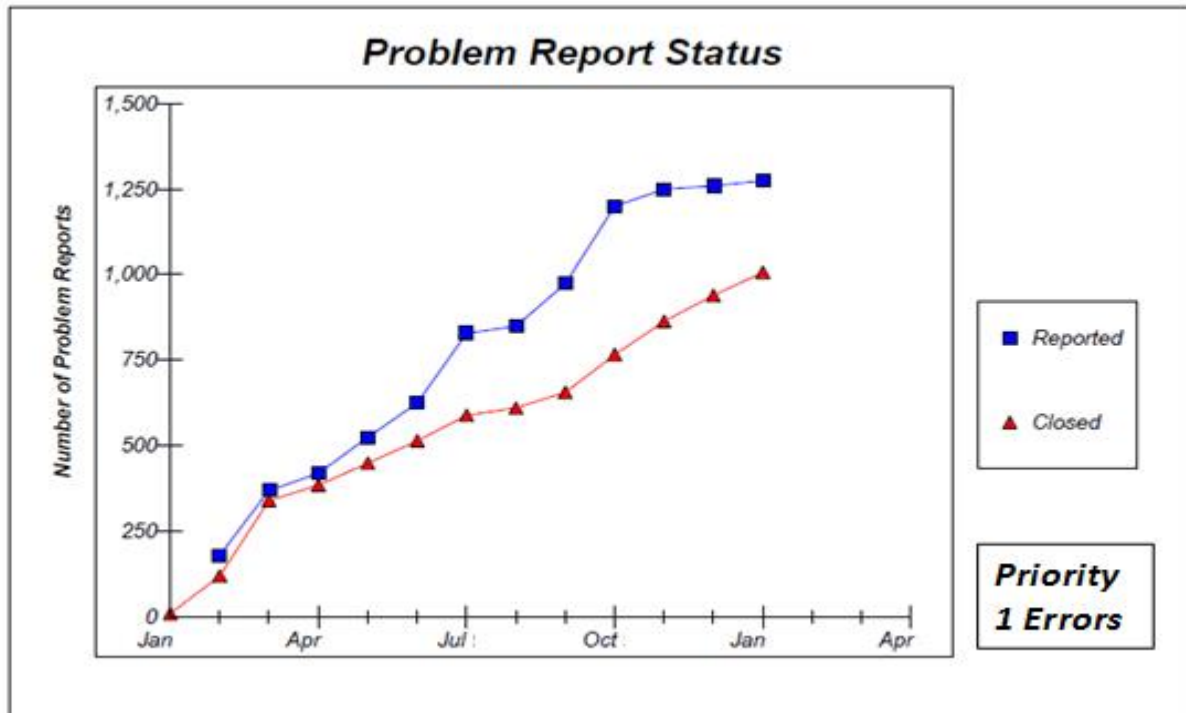
The measure itself does not provide the root cause, and further investigation is warranted. If the test facility is of a special nature (e.g., a secure facility or one that is specially instrumented) and thus is not readily available except on a long-lead time scheduling basis, this underutilization could also indicate a future potential schedule slip.



**Figure 15-10 Test Facility Underutilization Example**

### 15.9.5 Problem Report Status

This measure compares reported software problem reports with closed problem reports. Typically, these types of reports are segregated by software error priority. The example in Figure 15-11 shows a troubled project with many priority 1 errors, and at the current closure rate by extrapolation, there is a looming (around 4 months) schedule slip until all priority 1 errors are closed out.



**Figure 15-11 Problem Report Closure Rate Status Problems**

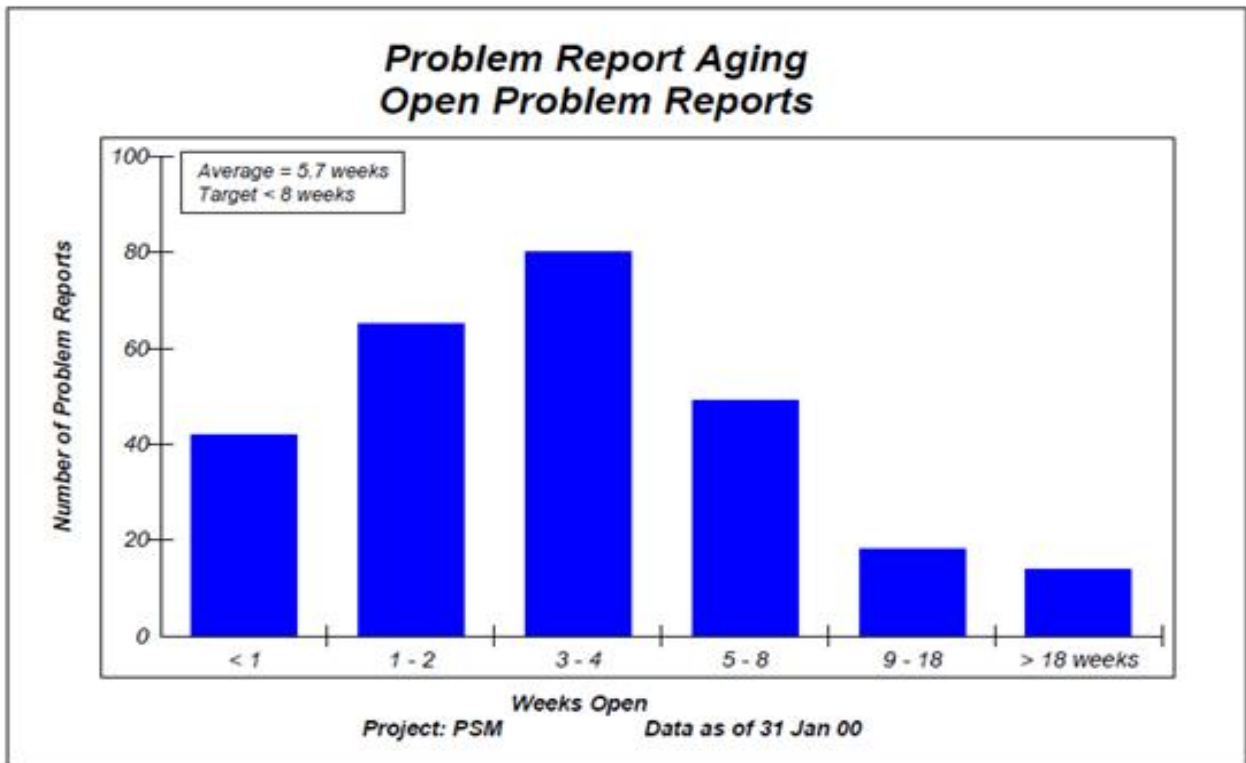
Regression testing is conducted to close problem reports. The number of problem reports will stabilize and eventually decrease for well-designed software.

#### 15.9.6 Problem Report Aging

This measure keeps track of the time taken to clear problem reports. Generally, there will be a target closure time, shown in Figure 15-12 as less than 8 weeks. This rate is one of the assumptions the developer makes, for rework time, and is factored in as part of initial scoping of the length of the overall development schedule.

In this case, the average time being taken to clear problem reports is higher than anticipated. This may indicate an underlying staffing problem (not enough personnel to fix discovered problems) or rework taking longer than anticipated due to lack of test resources.

At any rate, it is likely there will be some impact to the overall schedule including any follow-on tests that may have been programmed. If this situation persists, the overall development schedule may require restructuring.



**Figure 15-12 Problem Report Aging Example**

#### 15.9.7 Problem Report Status - Open by Priority

This measure rank orders the open problem reports by priority, as shown in Figure 15-13. Over time, you would expect to see the developer's efforts focused on the high-priority problem reports and that the number of those reports would decrease over time. If not, it may indicate that the developer is working problems that are easy to fix instead of the important ones. Also, it may indicate that the developer is reclassifying high-priority problem reports to lower categories. If this reclassification is being done without Government knowledge, that is a potential problem as well.

Figure 15-14 shows an alternative way of tracking problem report severity over time. The columns show the number of defects that have been open for a given time period by severity, with the values in parentheses reflecting the status from the previous reporting period. By using this format the reader can see the aging by severity as well as closure rate (current versus prior period) without needing multiple charts or sources.

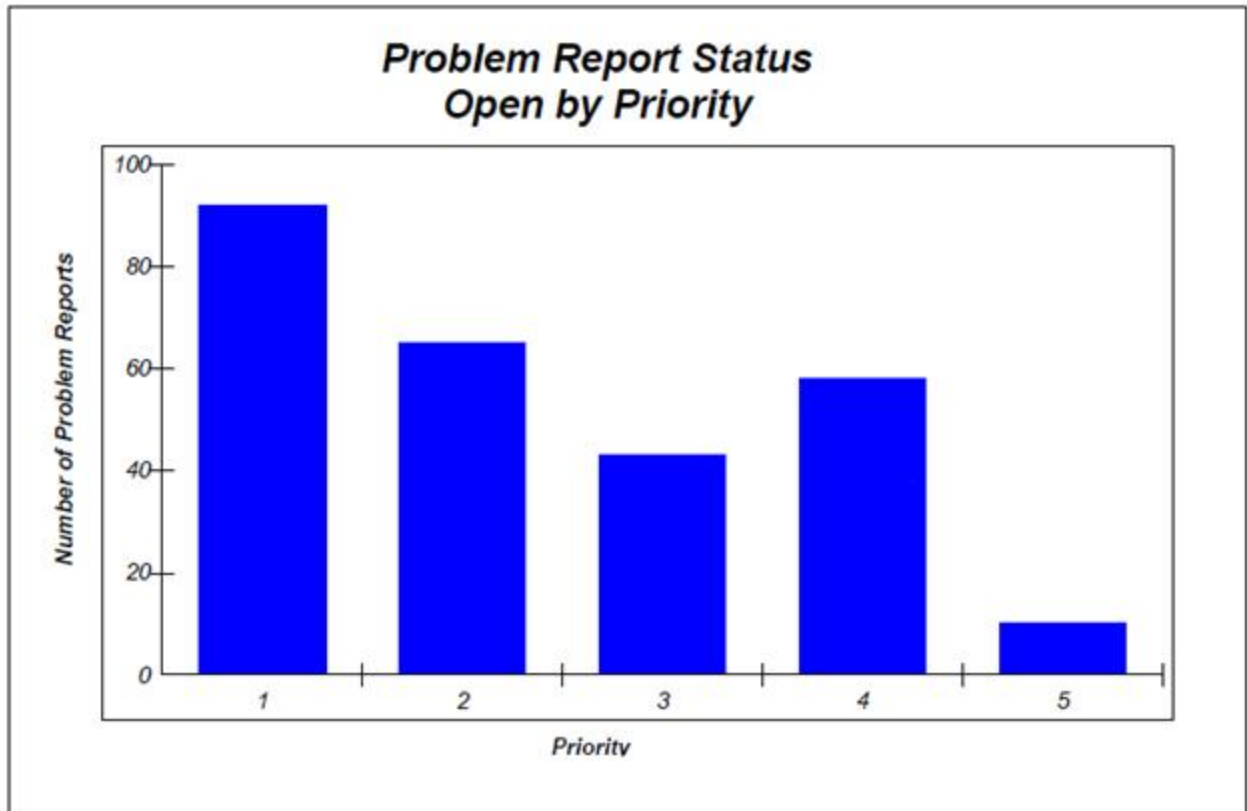


Figure 15-13 Problem Report Open Status Example

	<b>Assigned and Submitted Defects - Days Open</b>				
<b>Severity</b>	<b>0-30</b>	<b>31-60</b>	<b>61-90</b>	<b>91-120</b>	<b>&gt;120</b>
1	9 (18)	12 (3)	1 (1)	2 (3)	4 (2)
2	92 (99)	41 (28)	13 (11)	5 (8)	19 (18)
3	48 (45)	6 (4)	8 (11)	3 (0)	16 (18)
4	16 (15)	3 (3)	3 (3)	1 (1)	4 (4)
5	0 (1)	5 (4)	0 (1)	3 (4)	4 (3)
<b>Total</b>	<b>165 (178)</b>	<b>67 (42)</b>	<b>25 (27)</b>	<b>14 (16)</b>	<b>47 (45)</b>

Figure 15-14 Tracking Problem Report Severity

Some Service test agencies have lists of desirable measures and procedures for measurement that are recommended within their Service to use as a tool for software testing. Also, although some developers may use some sort of software measurement program internally, software metrics in general and those appropriate for software testing must be contractually specified with Government access provisions. This section only briefly summarized the discipline of software measurement. For more information, many online software measurement training resources are available through DAU.

### 15.10 Independent Verification and Validation (IV & V)

IV&V is a process that is appropriate for some categories of systems. Per [IEEE Standard 1012](#) (Reference (av)), the three components of IV&V can be defined as follows:

- **Independent** . Independent means that the process is independent, both managerially and financially, from the developer whose activities are being evaluated and that the staff members performing IV&V tasks are not the same staff members as those doing development tasks.
- **Verification** . In the context of IV&V, verification is defined as the process of evaluating software at the end of the software development process to ensure compliance with software requirements.
- **Validation** . In the context of IV&V, validation is defined as the process of determining whether the products of a given phase of the software development cycle fulfill the requirements for that cycle established in the previous phase.

NOTE: The terms verification and validation as used in the context of IV&V are different from the V&V technical processes that are part of the DoD SE process set and are different from the use of these terms in the VV&A process described in Chapter 18 for M&S.

Although developers perform V&V as an inherent part of their development process, for high-risk systems (e.g., safety-critical systems or systems processing classified data) in which the investment can be justified, these processes are repeated and performed by an independent agent working directly for the Government. That agent is the IV&V contractor.

For DoD safety-critical systems, the IV&V agent typically works within the processes specified in [Reference \(as\)](#) . Other services that are performed by IV&V contractors can vary widely depending on the needs of the program and generally include some of the following:

- **Management Support Services** . These services include reviews of program/project plans, schedules, milestones, and proposals as well as management plans such as quality assurance and configuration management. The goal is to identify inconsistencies, errors, or other issues that may present a risk to the program/project, providing management with an early identification of potential problems.

- **Engineering Support Services** . These services include evaluation of the adequacy and completeness of individual technical/development products to ensure that their content conforms to applicable standards, contractual provisions, or other requirements.
- **Test Support Services** . These services include evaluation of test documentation such as plans, test cases, and test procedures to ensure that their content conforms to applicable standards, contractual provisions, or other requirements. The evaluation would verify that the test documents correctly link to each other and correctly reflect the life cycle needs, security, performance, and other requirements based on the level of testing. Additionally, the IV&V agent may witness the actual testing performed.
- **Technical Review and Audits Support Services** . The IV&V agent often provides input concerning the adequacy of project artifacts or life cycle processes, in the form of reports or presentations, in support of technical reviews and audits.

Special contractual provisions must be imposed that allow the IV&V agent to access developer materials, facilities, working documents, etc.

## 15.11 T&E Issues Associated With Spiral and Agile Development Approaches

### 15.11.1 Spiral Model

Spiral development is a risk-driven, prototype-based, cyclical, iterative build-test-fix-test-deploy software development process. It can help evolve the software product to better meet user needs. Spiral development, properly applied, can provide a variety of benefits including the following:

- Facilitate changes to software requirements that are defined by operational mission needs, technology opportunities, experimentation results, and technology obsolescence.
- Support a continuous process of realistic integrated testing that evolves over time to measure the operational effectiveness, suitability, and supportability of each increment of the software-intensive system.
- Improve the visibility of product development baselines to allow early inputs via prototyping from the systems user.

The spiral development process may also impact the software measurement process by changing the priorities of the information needs of a project as the product evolves. Spiral development usually increases the number of changes that will be made to the requirements and systems design baselines, expanding the need for configuration control and related measures. The spiral model also has other potential problems if not carefully controlled. Mismanagement of the prototyping effort can drive up costs. Because it is risk driven, an inconsistent or weak risk management process that does not openly identify risks on the part of either the developer or the acquirer will dramatically reduce the chance of program success. Strong configuration management and a flexible contracting approach are essential.

Because the product in spiral development evolves continuously, testing can be a challenge. Careful coordination with the development team and strict baseline control for interim products are essential. Additionally, because spiral development uses prototypes extensively as risk mitigation approaches to better understand requirements before the complete system is built, knowledge of whether these prototypes will be reused in the final system or recoded will drive the amount of regression testing necessary. Spiral development is generally not appropriate for safety-critical systems in which the provisions of [Reference \(as\)](#) must be applied.

### 15.11.2 Agile Development Methods

Agile software development refers to a group of software development methodologies based on iterative and incremental development in which requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. Agile development is being embraced by segments of the DoD as a potentially effective approach for software development under the right circumstances for some categories of software-intensive systems.

Terms such as scrum, extreme programming, and crystal clear are also sometimes used to refer to agile approaches. They are characterized by their proponents as lightweight software development methods. So-called lightweight software development methods evolved in the mid-1990s as a reaction against heavyweight methods, which were characterized by their critics as heavily regulated, regimented, micromanaged approaches to software development.

Definitions of what characterizes agile development have evolved over time as developers have gained experience with these methods. Because of ambiguity in defining agile development, its adherents have outlined its key principles via the so-called Agile Manifesto, reproduced in Figure 15-15.

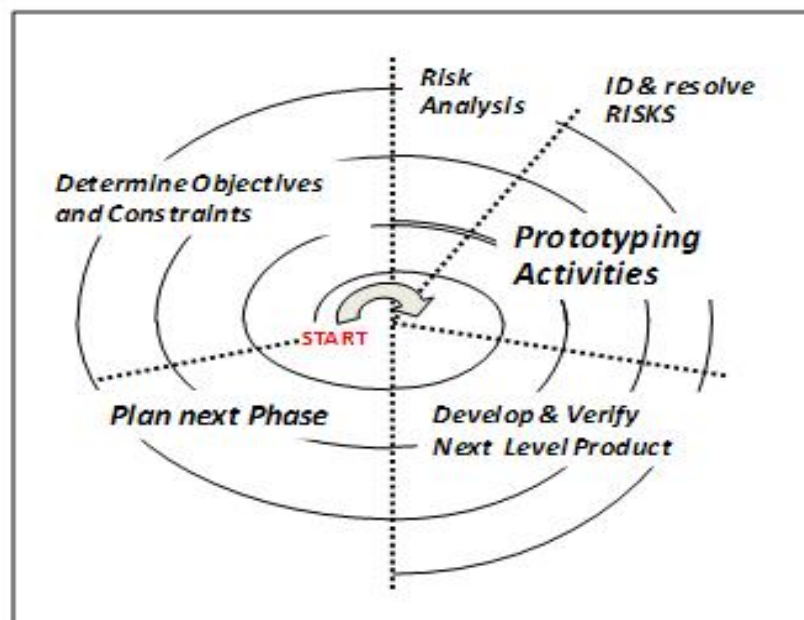


Figure 15-15 Spiral Model Software Development Approach



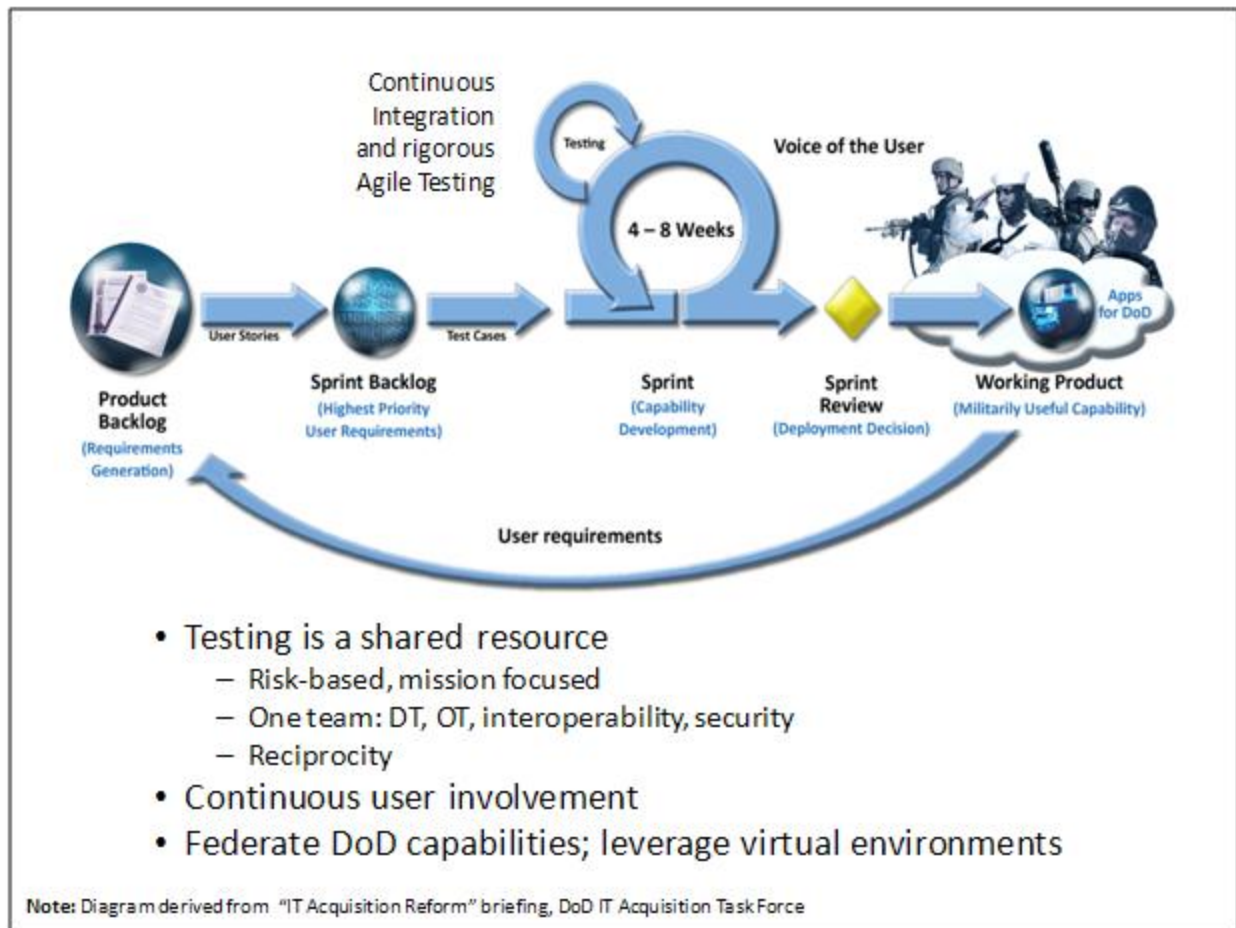
Agile development releases products in small, frequent releases, and testing of these small releases is performed incrementally as part of the release cycle. Close user coordination is key, and user participation as a member of the agile development team is essential for success. Issues remain regarding scalability to large systems, work scope, contracting approaches, efficiency, requirements creep, and risk management.

### 15.11.3 Agile Development and Testing

Testing within an agile development model has many challenges including the following: (1) there are many variations of agile development, all with the goal of frequent deliveries and shorter development times; (2) regression testing in the classic sense may be difficult because of the flux in baselines; (3) the development process itself encourages requirements changes as the product evolves in order to better meet the need of the end users and limit the need for post-fielding rework; (4) agile development is not appropriate for all systems.

DoD testing for agile development will evolve as more experience is gained with the process itself. Given the wide range of possibilities falling under the agile development umbrella, it is likely that each test program will require tailoring by the tester to get the best return for the T&E investment. Integrated testing should be an essential part of the testing approach.

The DoD is becoming interested in using agile approaches as a method to help improve IT system development outcomes for certain categories of AISs. One suggested agile life cycle that incorporates testing is depicted in Figure 15-16.



**Figure 15-16 Notional Agile Development Model Depicting Testing**

## 15.12 COTS Considerations

DoD policies require development of an appropriate T&E strategy for CIs that includes evaluating potential CIs in a system test bed, when practical; focusing test beds on high-risk items; and testing CI upgrades for unanticipated side effects in areas such as security, safety, reliability, and performance.

Many DoD systems employ COTS software. The amount used typically varies by domain, with weapons systems generally using fewer COTS products than AISs. Indeed, some AISs may be implemented as a so-called enterprise resource planning (ERP) system, in which the complete functionality is provided by a tailored COTS product. An ERP system is a collection of software programs that ties together an enterprise's various functions, such as human resources, finance, logistics, etc.

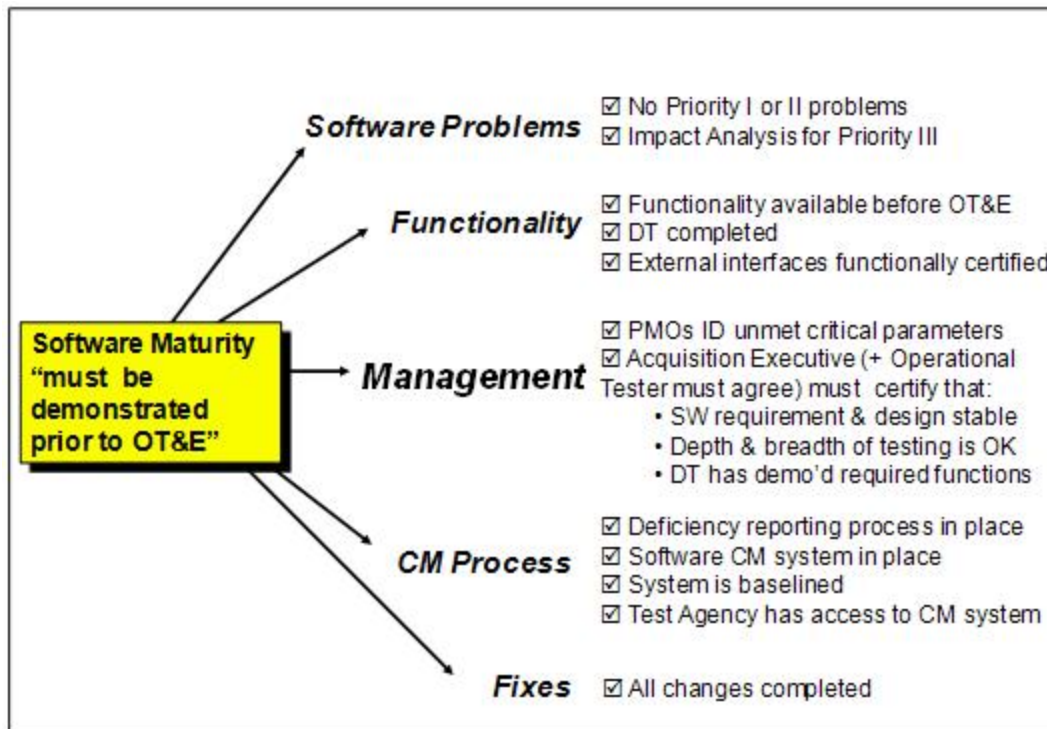
Properly used and understood, COTS software can have great advantages in certain application settings. At one time, the extensive use of COTS software in DoD systems was felt by some to be a universal panacea for DoD software development problems; however, numerous lessons learned from less-than-successful COTS implementations showed otherwise. Some of these lessons learned include the following:

- Unit level testing/component testing is generally impossible.
- Documentation of many COTS products is not complete or robust or incorrect.
- Complex, non-standard interfaces, which may not be well-defined, abound in COTS products.
- Market leverage may not exist to force vendor bug fixes for DoD unique needs.
- Component understanding depends mostly on vendor claims.
- Formal requirements documents as such are generally not available.
- Current COTS use in the DoD environment may not match its original design environment in the commercial market place.
- Real-time performance may be marginal.
- Robustness and reliability of many COTS products are generally lower when compared with DoD custom code.
- Higher COTS use implies more difficult system level integration testing due to the number of applications that have to be integrated and associated "glue code". The number of interfaces that have to be integrated grows as the square of the number of COTS products to be integrated. Frequently, this integration is done by using custom software euphemistically called glue code.
- "Evaluation" of product suitability occurs long before formal testing.
- Frequent market-driven releases complicate regression testing.
- Vendor configuration management of COTS products is frequently poorly done and can lead to conflicting baselines in a system.

### 15.13 Mature Software

Typically, test plans cite the need for mature software as a criterion to move forward (typically for OT&E) in the testing process but never specifically define the term. Obviously, this is a program-specific criterion. To be effective, such criteria have to be multidimensional, encompassing a range of measures such as software problems, functionality, configuration control, and management.

One set of suggested software maturity criteria (developed many years ago by the DoD, in response to several OT&E deficiencies cited by the Government Accountability Office) per the [DOT&E memorandum](#) (Reference (aw)) is provided for consideration in Figure 15-17.



**Figure 15-17 Example of Software "Maturity" Criteria**

Other related considerations can be found in the [DOT&E memorandum](#) (Reference (ax)). This document presents a set of guidelines for tailoring pre-deployment test events to the operational risk of a specific system increment being acquired under OSD oversight.

#### 15.14 Summary

There is a growing body of software testing technologies that can be applied to testing of AIS and weapon system software. Systematic T&E techniques are far superior to ad hoc testing. Implementation of an effective software T&E plan requires a set of strong technical and management controls, effective use of human-based testing techniques, close coordination with the developers test activities, metrics, and an understanding of how the unique nature of the software product impacts the testing process.

## Test & Evaluation Management Guide

### Chapter 16 - Testing for Vulnerability and Lethality

#### 16.1 Introduction

This chapter addresses the assessment of the vulnerability and lethality aspects of a system via T&E practices and procedures. In particular, this chapter describes the legislatively mandated LFT program, which has been established to evaluate the survivability and lethality of developing systems. It also discusses the role of T&E in assessing a systems ability to perform in a nuclear combat environment. The discussion of testing for nuclear survivability is based primarily on information contained in Appendix E of the [Nuclear Matters Handbook](#) (Reference (ay)). The handbook, located at the Deputy Assistant Secretary of Defense for Nuclear Matters website, is intended to be an unofficial reference and is, therefore, neither authoritative nor directive .

#### 16.2 LFT

##### 16.2.1 Historical Background

In March 1984, OSD chartered a joint T&E program designated The Joint Live-Fire Program. This program was to assess the vulnerabilities and lethality of selected U.S. and threat systems already fielded. The controversy over joint LFT of the Army's Bradley Fighting Vehicle System, subsequent congressional hearings, and media exposure resulted in provisions being incorporated in the [National Defense Authorization Act \(NDAA\) of FY 1987](#) (Reference (az)). Specifically, this law stipulates that major program (ACAT I and II) development may not proceed beyond LRIP until realistic survivability or (in the case of missiles and munitions) lethality testing has been completed. This act requires an OSD-managed LFT program for major acquisition programs fitting certain criteria (so-called covered systems).

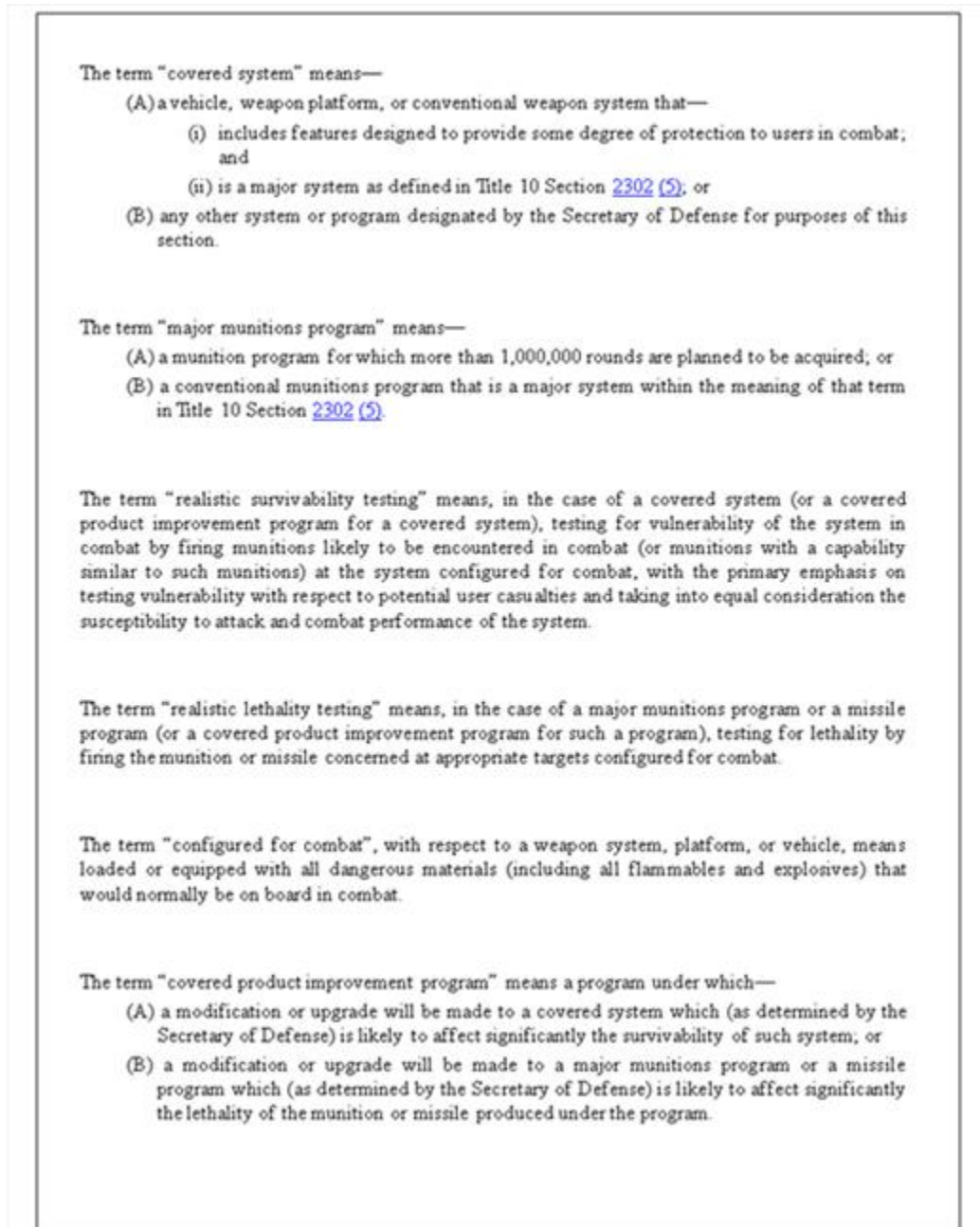
In accordance with the [DOT&E Memorandum](#) (Reference (bb)), the term covered system has been clarified as a system that the DOT&E, acting for the SecDef, has determined to be a major system that is (1) user-occupied and designed to provide some degree of protection to its occupants in combat, or (2) a conventional munitions program or missile program, or (3) a conventional munitions program for which more than 1,000,000 rounds are planned to be acquired, or (4) a modification to a covered system that is likely to affect significantly the survivability or lethality of such a system, or (5) any other system or program designated for LFT&E oversight by the DOT&E.

The SecDef has delegated the authority to waive requirements for the full-up, system-level LFT&E before the system passes the program initiation milestone to the USD(AT&L) for ACAT ID and to the CAE for ACAT II programs when LFT&E would be unreasonably expensive and impractical. However, in that case, an alternate LFT&E program must still be accomplished. Programs subject to LFT or designated for oversight are listed on the OSD annual T&E oversight list.

The DoD agent for management of the LFT program is the DOT&E. This type of test must be planned to start early enough in the development process to impact design and to provide timely test data for the OSD LFT report required for the FRPDR and interested congressional committees. The Service-detailed

LFT plan must be reviewed and approved by the DOT&E, and LFT must be addressed in Part III of the program TEMP.

LFT criteria are explicitly specified in [section 2366](#) of Reference (b). These provisions are summarized in Figure 16-1.



**Figure 16-1 Summary of Key Parts of the U.S.C. Regarding LFT**



## 16.2.2 LFTs

There are varying types of LFTs. The matrix in Figure 16-2 illustrates the various possible combinations. Full-scale, full-up testing is usually considered to be the most realistic.

The importance of full-up testing has been well demonstrated by the joint live-fire (JLF) tests. Many examples exist; in one case, these tests contradicted earlier conclusions concerning the flammability of a new hydraulic fluid used in F-15 and F-16 aircraft. Laboratory tests had demonstrated that the new fluid was less flammable than the standard fluid. However, during the JLF tests, 30 percent of the shots on the new fluid resulted in fires contrasted with 15 percent of the shots on the standard fluid.

Although much insight and valuable wisdom are to be obtained through the testing of components or subsystems, some phenomena are only observable when full-up systems are tested. The interaction of such phenomena has been termed cascading damage. Such damage is a result of the synergistic damage mechanisms that are at work in the real world and likely to be found during actual combat.

LFT provides a way of examining the damages inflicted not only on materiel, but also on personnel. For example, per the [DOT&E Memorandum](#) (Reference (bb)), between 2007 and 2010, extensive ballistic testing against hard body armor was conducted without a sound test operations procedure. At the recommendation of the DoD Inspector General, the DOT&E developed test operations procedures for body armor ballistic inserts and verified that the procedures were implemented DoD-wide.

The crew casualty problem is an important issue that the LFT program is addressing. The program provides an opportunity to assess the effects of the complex environments that crews are likely to encounter in combat (e.g., fire, toxic fumes, blunt injury shock, and acoustic injuries).

	Loading	
	Full-up	Inert*
System Level	Completes system configured for combat: with combustibles (e.g., personnel carrier tests, aircraft "proof" tests)	Complete system: no combustibles (e.g. tests of new armor on actual tanks, aircraft flight control tests)
Subsystem Level	Components, subcomponents: with combustibles (e.g., fuel cell tests, behind armor penetration, mock-up aircraft, engine fire test)	Components, subcomponents, structures, terminal ballistics, munitions performance, behind-armor tests, warhead characterization (e.g., armor/warhead interaction tests, aircraft component structural tests)
*In some cases, targets are "semi-inert," meaning some combustibles are on board but not all. (Example: Tests of complete tanks with fuel and hydraulic fluid, but dummy ammunition)		

**Figure 16-2 Summary of Degrees of LFT**

### 16.2.3 Role of M&S

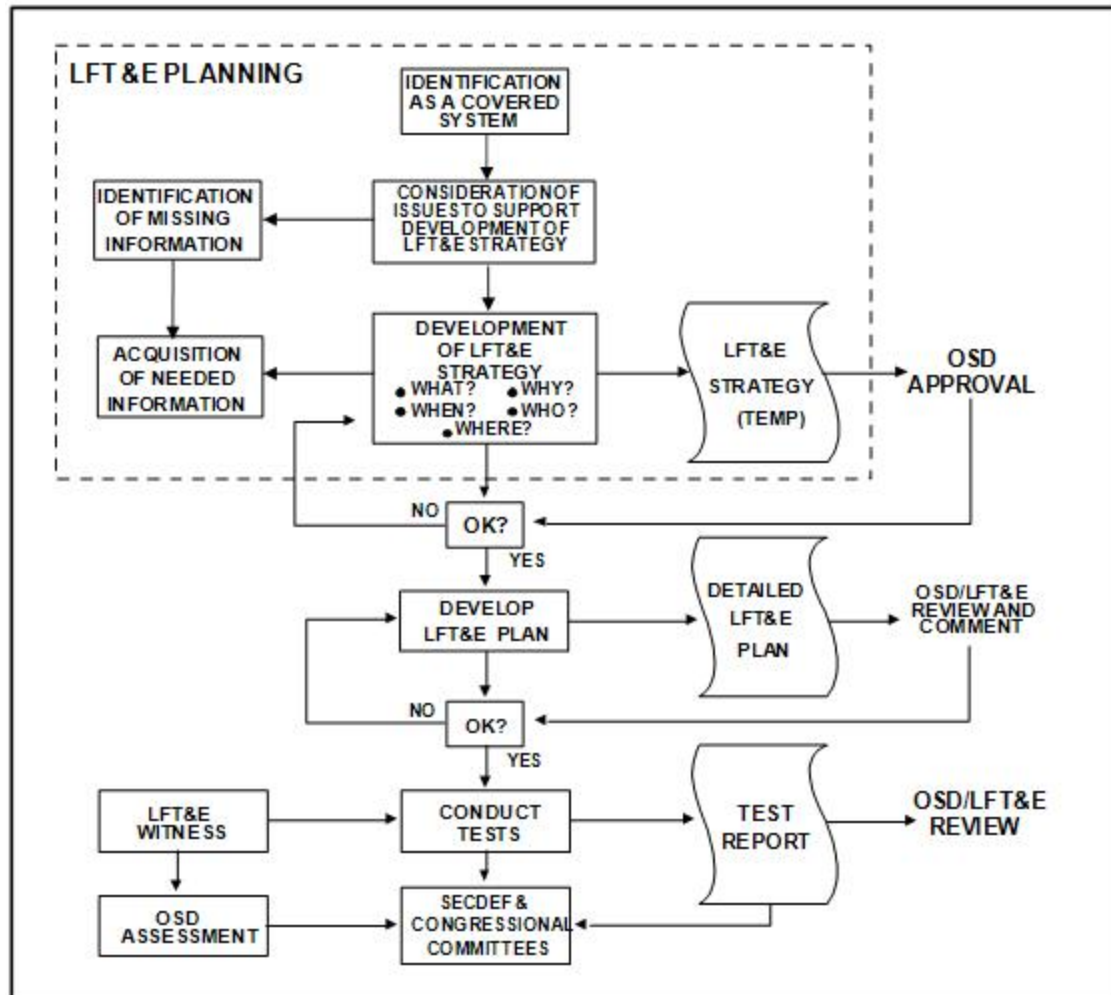
Survivability and lethality assessments have traditionally relied largely on the use of M&S techniques. The LFT program does not replace the need for such techniques. Such predictions are useful for several reasons. First, they assist in the test planning process. If a model predicts that no damage will be inflicted, test designers and planners should reexamine the selection of the shot lines and/or reassess the accuracy of the threat representation. Second, pre-shot model predictions provide the Services with the opportunity to validate the accuracy of the models by comparing them with actual LFT results. At the same time, the LFT program reveals areas of damage that may be absent from existing models and simulations. Third, pre-shot model predictions can be used to help conserve scarce target resources.

### 16.2.4 Illustrative LFT Process

Plans for LFT&E must be considered as part of test planning and included in the TEMP. Figure 16-3 is an illustrative example of the LFT&E planning and execution process. Key points include the following:

- The LFT&E detailed T&E plan is the basic planning document used by OSD and the Services to plan, review, and approve LFT&E. Services will submit the plan to the DOT&E for comment at least 30 days before test initiation.
- The LFT&E plan must contain general information on the systems required performance, operational and technical characteristics, critical test objectives, and the evaluation process.
- Each LFT&E plan must include testing of complete systems. A limited set of LFTs may involve production components configured as a subsystem before full-up testing.
- A Service report must be submitted within 120 days of the completion of the LFT. The report must include the firing results, test conditions, limitations, and conclusions and must be submitted in classified and unclassified form.
- Within 45 days of receipt of the Service report, a separate LFT report will be produced by the DOT&E, approved by the SecDef, and transmitted to Congress. The conclusions of the report will be independent of the conclusions of the Service report. Reporting on LFT&E may be included in the weapon systems BLRIP report completed by the DOT&E.
- Congress shall have access to all LFT data and all LFT reports held by or produced by the Secretary of the concerned Service or by OSD.
- The costs of all LFTs shall be paid from funding for the system being tested. In some instances, the Deputy for LFT&E, DOT&E may elect to supplement such funds for the acquisition of targets or target simulators, although the ultimate responsibility rests on the concerned Service.





**Figure 16-3 Illustrative LFT&E Planning and Execution Process**

### 16.2.5 The Role of the Survivability/Vulnerability Information Analysis Center (SURVIAC)

The Survivability, Vulnerability Information Analysis Center (SURVIAC) is the DoD focal point for nonnuclear survivability/vulnerability data, information, methodologies, models, and analysis related to U.S. and foreign aeronautical and surface systems. SURVIACs role is to collect, analyze, and disseminate scientific and technical information related to all aspects of survivability and lethality for aircraft, ground vehicles, ships, and spacecraft, as well as conventional homeland security threats including chemical, biological, directed-energy, and nonlethal weapons.

SURVIAC is a contractor-operated DoD Information Analysis Center sponsored by the Defense Technical Information Center (DTIC) with support from several organizations including the Joint Aircraft Survivability Program Office and the JTCG on Munitions Effectiveness. Among other available services, SURVIAC provides the following:

- An extensive library of relevant survivability and lethality.

- A database of historical combat damage.
- Access to an approved set of models and simulations.

### 16.3 Nuclear Weapons Testing

The testing of nuclear weapons is highly specialized and regulated. PMs involved in this area are advised to consult authorities within their chain of command for the specific directives, instructions, and regulations that apply to their individual situations. Nuclear weapons tests are divided into categories in which the responsibilities of the Department of Energy, the Defense Threat Reduction Agency (DTRA), and the Military Services are clearly assigned. The Department of Energy is responsible for nuclear warhead technical tests; DTRA is responsible for nuclear weapons effects tests. The Services are responsible for the testing of Service-developed components of nuclear subsystems. All nuclear tests are conducted within the provisions of the Limited Test Ban Treaty that generally restricts nuclear detonations to the underground environment. Nuclear weapons testing requires extensive coordination between Service and Department of Energy test personnel.

### 16.4 Testing For NH&S

#### 16.4.1 Background

Nuclear hardness is a quantitative description of the physical attributes of a system or component that will allow it to survive in a given nuclear environment. Nuclear survivability is the capability of a system to survive in a nuclear environment and to accomplish a mission. DoD policy requires the incorporation of NH&S features in the design, acquisition, and operation of major and non-major systems that must perform critical missions in nuclear conflicts. Nuclear hardness levels must be quantified and validated.

The T&E techniques used to assess NH&S include nuclear testing, physical testing in a simulated environment, M&S, and analysis. Although nuclear tests provide a high degree of fidelity and valid results for survivability evaluation, they are not practical for most systems because of cost, long lead times, and international treaty constraints.

Underground testing is available only on a prioritized basis for critical equipment and components and is subject to a frequently changing test schedule. Physical testing provides an opportunity to observe personnel and equipment in a simulated nuclear environment. M&S, and analysis are particularly useful in the early stages of development to provide early projections before system hardware is available. These methods are also used to furnish assessments in an area that cannot be directly observed through nuclear or physical testing because of safety or testing limitations.

Nuclear survivability must be incorporated into the design, acquisition, and operation of all systems that must perform critical missions in a nuclear environment. Nuclear survivability is achieved through a combination of methods such as hardness, avoidance, proliferation, and reconstitution. Hardness allows a system to physically withstand a nuclear attack. Avoidance encompasses measures taken to avoid encountering a nuclear environment. Proliferation involves having sufficient systems to compensate for probable losses. Reconstitution includes the actions taken to repair or resupply damaged units in time to

complete a mission satisfactorily. There are many possible effects from a nuclear detonation, including electromagnetic pulse (EMP), ionizing and thermal radiation, blast, shock, dust, debris, blackout, and in some cases, transient radiation effects on electronics (TREE). TREE is the damage to electronic components by initial nuclear radiation gamma rays and neutrons. Each weapon system is susceptible to some but not all of these effects. Testers must identify the effects that may have an impact on the system under development and manage the design, development, and testing of the system in a manner that minimizes degradation. The distinction between nuclear weapons effects survivability and nuclear weapons system survivability is shown in Figure 16-4.

Nuclear Weapons Effects Survivability	Nuclear Weapons System Survivability
<p><b>Survivability of Everything</b></p> <ul style="list-style-type: none"> <li>• Nuclear Weapons</li> <li>• Nuclear Force Personnel</li> <li>• Nuclear Force Equipment</li> <li>• Conventional Weapons</li> <li>• Conventional Force Personnel</li> <li>• Conventional Equipment</li> </ul> <p><b>Against the Effects of Nuclear Weapons</b></p> <p><i>After Figure C.1, Nuclear matters - A Practical Guide</i></p>	<p><b>Survivability of Nuclear Forces</b></p> <ul style="list-style-type: none"> <li>• Nuclear Weapons</li> <li>• Nuclear Force Personnel</li> <li>• Nuclear Force Equipment</li> </ul> <p><b>Against the Effects of Any Threat:</b></p> <ul style="list-style-type: none"> <li>• Nuclear Weapons</li> <li>• Chemical, Biological Weapons</li> <li>• Conventional Weapons</li> <li>• Advanced Technology Weapons</li> <li>• Special Operations Attacks</li> <li>• Terrorist Attacks</li> </ul>

**Figure 16-4 Nuclear Weapons Effects vs. Systems Survivability**

#### 16.4.2 Assessing Nuclear Survivability Throughout the System Acquisition Cycle

The PM must ensure that nuclear survivability issues are addressed throughout the system acquisition cycle. During assessment of concepts, the survivability requirements as stated in the Service capability and requirements documents should be verified, refined, or further defined. During the systems early design stages, trade-offs between hardness levels and other system characteristics (such as weight, decontaminability, and compatibility) should be described quantitatively. Trade-offs between hardness, avoidance, proliferation, and reconstitution as a method for achieving survivability should also be considered at this time. During advanced engineering development, the system must be adequately tested to confirm that hardness objectives, criteria, requirements, and specifications are met. Plans for NH&S testing should be addressed in the TEMP. The appropriate commands must make provision for test and hardness surveillance equipment and procedures so required hardness levels can be maintained once the system is operational.

During production, deployment, and operational support, system hardness is maintained through an active hardness assurance program. Such a program ensures that the end product conforms to hardness design specifications and that hardness aspects are reevaluated before any retrofit changes are made to existing systems.

Once a system is operational, a hardness surveillance program may be implemented to maintain system hardness and to identify any further evaluation, testing, or retrofit changes required to ensure survivability. A hardness surveillance program consists of a set of scheduled tests and inspections to ensure that a systems designed hardness is not degraded through operational use, logistics support, maintenance actions, or natural causes.

### **16.4.3 NH&S Test Planning Challenges**

The following challenges are associated with NH&S testing:

The magnitude and range of effects from a nuclear burst are much greater than those from conventional explosions that may be used to simulate nuclear bursts. Nuclear detonations have effects not found in conventional explosions. The intense nuclear radiation, blast, shock, thermal, and EMP fields are difficult to simulate.

The yields and configurations for underground testing are limited. It is generally not possible to test all relevant effects simultaneously or to observe possibly important synergism between effects.

System-level testing for nuclear effects is normally expensive, takes years to plan and conduct, and requires specialized expertise. Often, classes of tests conducted early in the program are not repeated later. Therefore, operational requirements should be folded into these tests from the start, often early in the acquisition process. This mandates a more extensive, combined DT&E/OT&E test program than normally found in other types of testing.

PMs and TMs must remain sensitive to the ambiguities involved in testing for nuclear survivability. For example, there is no universal quantitative measure of survivability, and statements of survivability may lend themselves to a variety of interpretations. Moreover, it can be difficult to combine system vulnerability estimates for various nuclear effects into an assessment of overall survivability.

### **16.5 Summary**

The survivability and lethality aspects of certain systems must be evaluated through LFT. These tests are used to provide insights into the weapon systems ability to continue to operate/fight after being hit by enemy threat systems. Such testing provides a way of examining the damages inflicted not only on materiel, but also on personnel. LFT also provides an opportunity to assess the effects of complex environments that crews are likely to encounter in combat. Provisions of the U.S.C. apply to certain aspects of LFT.

Nuclear survivability must be carefully evaluated during the system acquisition cycle. Trade-offs between hardness levels and other system characteristics, such as weight, speed, range, cost, etc., must

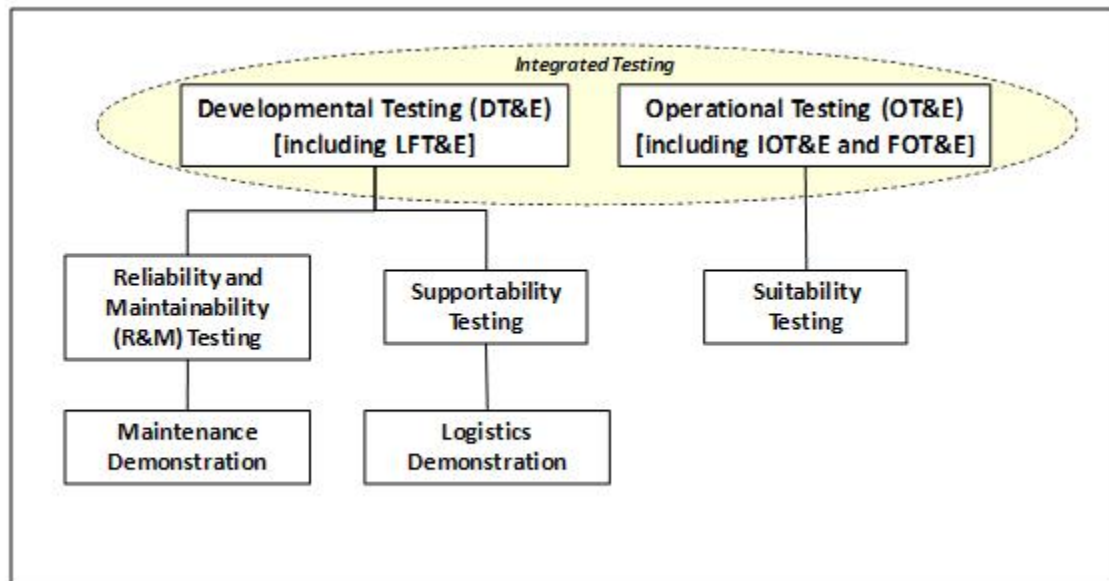
be evaluated. Nuclear survivability testing is difficult, and the evaluation of test results may result in a variety of interpretations. Therefore, PMs must exercise caution when developing test objectives related to nuclear survivability.

## Test & Evaluation Management Guide

### Chapter 17 - Logistics Support T&E

#### 17.1 Introduction

Logistics support planning for materiel acquisition programs begins early in the capabilities assessments of mission needs, continues throughout the acquisition life cycle, and extends past the deployment phase into the O&S phase. To be most effective, logistics support test and evaluation (LOG T&E) must mirror this timeline. Careful planning and execution of the LOG T&E process is necessary to ensure that the RAM objectives of the system are adequately identified and achieved. Additionally, the importance of the PSMs participation in integrating key aspects of the LCSP with the TEMP is essential. Such coordination will ensure that LOG T&E objectives are properly reflected in the TEMP and that adequate resources are available. Figure 17-1 is an overview of the different aspects of LOG T&E.



**Figure 17-1 Illustrative Scope of LOG T&E**

Logistics system support planning is a disciplined, unified, and iterative approach to the management and technical activities necessary to integrate support considerations into system and equipment design; to develop support requirements that are related consistently to readiness objectives, design, and each other; to acquire the required support; and to provide the required support during deployment and operational support at affordable cost. LOG T&E planning is a similar disciplined approach that addresses effective T&E design to assess these support planning considerations.

A key part of the LOG T&E planning effort occurs at the T&E WIPT with the assignment of the projects lead logistician to that team. This assignment is critical! A common theme among programs having difficulty in successfully completing reliability, maintainability, and supportability T&E is failure to include the projects logistician in the test planning process, or involving logisticians too late. It is important to engage the lead design engineers during the design phase and do LOG T&E planning early

so that reliability, maintainability, and sustainability T&E can be performed during DT&E. The logisticians mantra of up front and early is very much applicable in the test planning phases of program development to accurately forecast readiness and cost objectives post-fielding.

It is critical to include the designated OTA during early planning to lay the groundwork for future integrated testing. One function of DT&E is to perform tests that provide acquisition personnel with an indication of how the system will fare in OT&E. Bringing in the OTA early to develop an integrated test schedule will save time and conserve resources for the program.

LOG T&E seeks to verify and validate that support requirements enhance the systems design, are not in conflict with one another, and are directly related to readiness objectives. Early planning and continued compliance of a robust LOG T&E program will ensure that the required support is available during deployment and operational support at an affordable cost.

Figure 17-1 provides an overview of the different types of testing involved in LOG T&E. Integrated testing brings in OTAs early during the programs test planning to work with the program office to jointly design tests that can fulfill data-gathering requirements for both DT&E and OT&E (see Chapter 8 of this guide). Integrated testing is particularly relevant for LOG T&E and can result in significant savings in time and other resources.

Logistic support can be categorized into integrated product support (IPS) elements (referred to in some older documents as the 10 ILS elements but subsequently expanded to 12), as illustrated in Figure 17-2. Per Appendix A of the [DoD PSM Guidebook](#) (Reference (bc)), these elements are evaluated in the supportability T&E phase of LOG T&E.

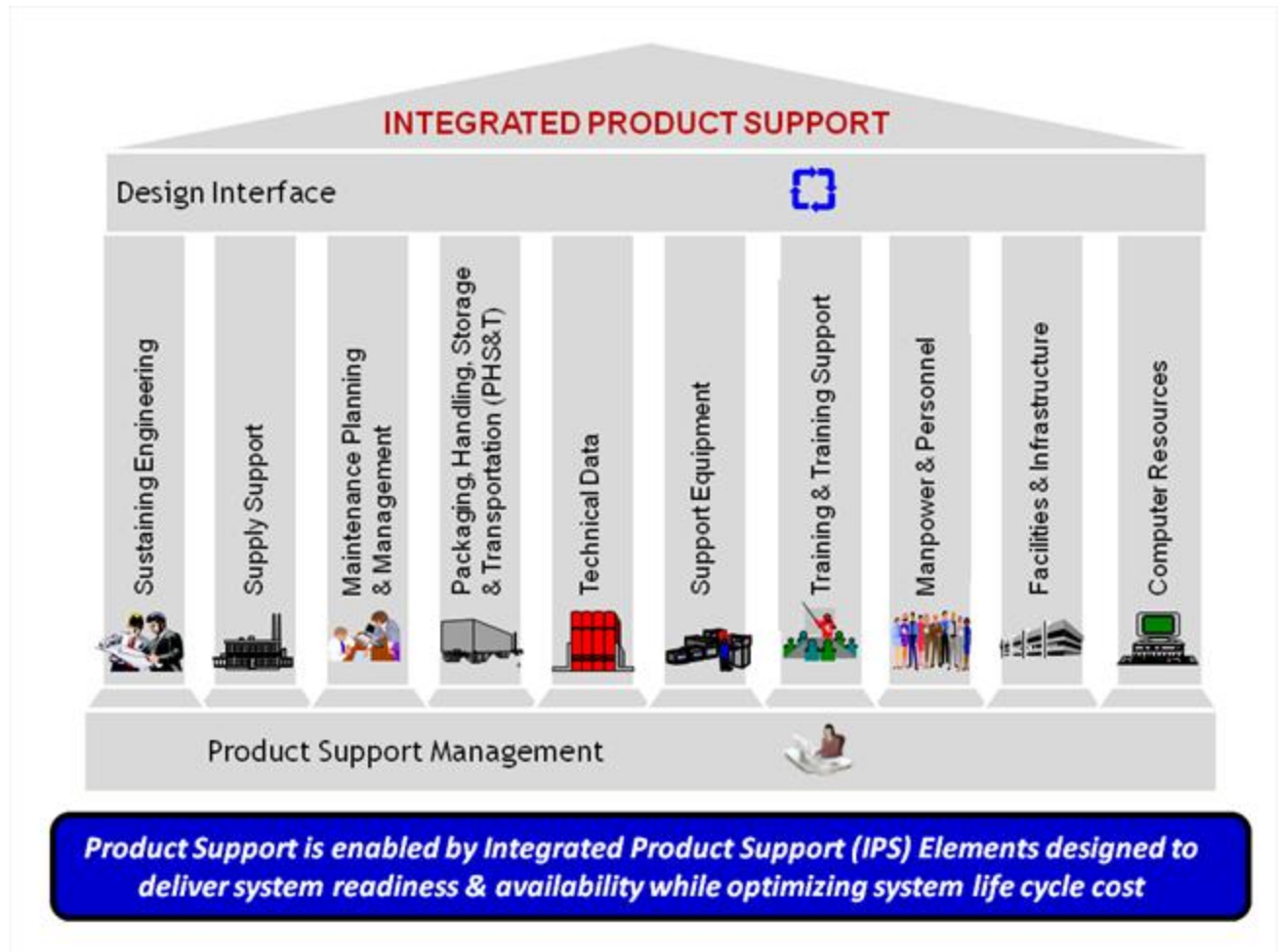


Figure 17-2 IPS Elements

The IPS elements are described as follows:

- **Design Interface** . The integration of the quantitative design characteristics of SE (reliability, maintainability, etc.) with the functional logistics elements (i.e., IPS elements). These design parameters reflect operational suitability requirements and specifically relate to system requirements. The basic items that need to be considered as part of design interface include the following:
  - Reliability
  - Maintainability
  - Supportability
  - IPS elements
  - Affordability



- Configuration management
- Safety requirements
- Environmental and hazardous material requirements
- HSI
- Anti-tamper
- Habitability
- Disposal
- Legal requirements
- **Sustaining Engineering** . Involves the identification, review, assessment, and resolution of deficiencies throughout a systems life cycle. Sustaining engineering returns a system to its baselined configuration and capability and identifies opportunities for performance and capability enhancement.
- **Supply Support** . Consists of all management actions, procedures, and techniques necessary to determine requirements to acquire, catalog, receive, store, transfer, issue, and dispose of spares, repair parts, and supplies. This means having the right spares, repair parts, and all classes of supplies available in the right quantities, at the right place, at the right time, and at the right price.
- **Maintenance Planning and Management** .Establishes maintenance concepts and requirements for the life of the system for both hardware and software.
- **Packaging, Handling, Storage, and Transportation (PHS&T)** . The combination of resources, processes, procedures, design, considerations, and methods to ensure that all systems, equipment, and support items are preserved, packaged, handled, and transported properly, including environmental considerations, equipment preservation for short and long storage, and transportability.
- **Technical Data** . Identifies, plans, resources, and implements management actions to develop and acquire information to:
  - Operate, install, maintain, and train on the equipment to maximize its effectiveness and availability.
  - Effectively catalog and acquire spare/repair parts, support equipment, and all classes of supply.
  - Define the configuration baseline of the system to effectively support the Warfighter with the best capability at the time it is needed.

- **Support Equipment** . Consists of all equipment (mobile or fixed) required to support the operation and maintenance of a system. This includes but is not limited to ground handling and maintenance equipment, trucks, air conditioners, generators, tools, metrology and calibration equipment, and manual and automatic test equipment.
- **Training and Training Support** . Consists of the policy; processes; procedures; techniques; training aids, devices, simulators, and simulations; planning; and provisioning for the training base including equipment used to train civilian and military personnel to acquire, operate, maintain, and support a system.
- **Manpower and Personnel** . Involves the identification and acquisition of personnel (military and civilian) with the skills and grades required to operate, maintain, and support systems over their lifetime.
- **Facilities and Infrastructure** . Consists of the permanent and semipermanent real property assets required to support a system, including studies to define types of facilities or facility improvements, location, space needs, environmental and security requirements, and equipment.
- **Computer Resources** . Identify, plan, resource, and acquire facilities, hardware, software, documentation, manpower and personnel necessary for planning and management of mission critical computer hardware and software systems. Includes Automated Logistics Environment systems (i.e., Autonomic Logistics Information System of the Joint Strike Fighter), hardened laptop computers, personal electronic digital devices used in electronic technical manuals, etc.
- **Product Support Management** . To plan and manage cost and performance across the product support value chain, from design through disposal.

## 17.2 Planning For Logistics T&E

### 17.2.1 Objectives of Logistics T&E

The main objective of LOG T&E is to verify and validate that the R&M predictions as specified in the design documents, user requirements, and capabilities documents (CDD/CPD) are in concert with the support structure (generally considered as the 12 IPS elements) as documented in the LCSP. Additional information about the LCSP can be found in [Chapter 5](#) of Reference (j). As shown in Figure 17-1, during DT, LOG T&E consists of RAM testing. It should be noted that R&M testing will require enough test hours to validate that requirements are being met and will generally continue into OT&E or until the requirements have been validated. R&M are elements of design and drive future supportability requirements. They determine what, how many, and how much of each of the 12 IPS elements are required. This impact is measured in supportability T&E and serves as verification that the support structure (the 12 IPS elements), as defined in the systems LCSP, is designed correctly.

During OT, the LOG T&E emphasis shifts from evaluating supportability to testing and evaluating logistics suitability. Whereas supportability measures the degree to which system design characteristics and

planned logistics resources meet system peacetime readiness and wartime utilization requirements, suitability measures the degree to which a system can be placed and sustained satisfactorily in field use. While continuing to measure the impact of R&M on the 12 IPS elements, during OT, the system is typically validated against standardized suitability COIs.

COIs are key operational effectiveness or suitability issues that must be examined in OT&E to determine the systems capability to perform its mission. COIs must be relevant to the required capabilities and of key importance to the system being operationally effective, operationally suitable, and survivable, and represent a significant risk if not satisfactorily resolved. A COI is normally phrased as a question that must be answered in the affirmative to properly evaluate operational effectiveness (e.g., Will the system detect the threat in a combat environment at adequate range to allow successful engagement?) and operational suitability (e.g., Will the system be logistically supportable?). COIs are critical elements or operational mission objectives that must be examined. COIs are broken down into MOEs (how well can the system perform its mission) and MOSs (how well can the system be supported in the field), which in turn are further defined by MOPs.

COI examples include reliability, availability, compatibility, transportability, interoperability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, documentation, environmental effects, and training requirements. Of these, the COIs directly correlating to the 12 IPS elements evaluated in DT are manpower supportability, logistics supportability, documentation, and training requirements.

At first glance, the difference between LOG T&E DT and LOG T&E OT seems subtle. In reality, the differences are much greater. Specifically:

- In DT, the design of the logistics support structure is measured against the design elements of R&M. Much of this testing is performed in a simulated environment.
- In OT, the design of the logistics support structure is measured on a fully integrated system against the CDD/CPD design elements of R&M and includes operational suitability that is evaluated in a mission context-real environmental conditions/locations using real field maintainers-in order to provide meaningful results. Only through this type of evaluation can DoD gain insight into the interactions of the various suitability factors.

Figure 17-3 shows DT, OT, and logistics supportability objectives for each acquisition phase.

		Materiel Solution Analysis	Technology Development	Engineering & Manufacturing Development	Production & Deployment	Operations & Support
Integrated Testing	Developmental T&E	Assess preferred system support concepts  Input to AoA  Supportability Modeling & Simulation	Assess technical approach, logistics, risks and alternative support solutions  Evaluate logistics related technologies  Assess thresholds/objectives for logistics parameters  Assess testability of potential product support elements	Conduct T&E of product support elements  ID design problems  Evaluate system CDD log parameters, ram prediction, suitability COIs  Conduct maintenance demos, log demos, level of repair assessments, and maintenance task analyses  Conduct failure mode effects, and criticality analyses (FMECA)  Perform support systems engineering design reviews  Monitor reliability growth	Verify product support parameters for the production systems  Provide insight into readiness for operational suitability testing of product support elements  Conduct assessments of maintenance concepts and processes  Utilize data to update support lifecycle-cost estimates	Evaluate impact of engineering changes on product support parameters  Assess adequacy of fixes for logistics deficiencies identified by field units  Evaluate fixes for IOT&E deficiencies  Demonstrate attainment of RAM/readiness criteria
	Operational T&E	Assess potential of operational suitability of preferred concept  Assist in selecting preferred system support concept	Examine operational aspects of supportability technical solutions  Develop measures and COIs for future suitability assessments  Estimate potential operational suitability of logistics systems and sustainment	Assess ability of logistic system to provide support in a relevant operational environment  Assess improvement in operational suitability from prototype to EDM systems  Refine concepts for evaluation of the CPD logistics parameters regarding supportability	Assess operational suitability for production systems  Provide reliability data for reliability growth model updates	Evaluate operational suitability and supportability of design changes  Identify any improvements for supportability parameters  Provide data for adjusting parameters and models  Evaluate any logistics parameters waived for IOT&E for inclusion in FOT&E

**Figure 17-3 Logistics Supportability Objectives in the Overall T&E Program**

### 17.2.2 Logistics Testability

Based upon the logistics requirements -- RAM and IPS elements (supportability) -- both stated and derived, the PSM, in conjunction with the project lead for T&E, develops supportability assessment plans. These plans identify the testing approach and the evaluation criteria that will be used to assess the adequacy of supportability and design requirements and associated test resources. These plans should include logistics participation in the assessment of the mandatory sustainment KPP for materiel availability and KSAs for reliability and ownership cost requirements. The fact that the availability (or sustainment) KPP and the two supporting KSAs (reliability and ownership cost) are mandatory is not coincidental. Achieving high reliability has a cost, as does achieving superior maintainability and high availability. These sustainment metrics taken together bound the trade space for designing in supportability and planning affordable life-cycle product support.

The logistics support manager may apply the best practices of logistics support analysis as described in [Reference \(af\)](#), portions of which describe how to develop measurable and testable supportability requirements. Some examples of suggested testability criteria derived from the handbook are summarized below:

- **Availability Example** . The item will have an operational availability of .95 measured by the total operating time divided by the sum of the total operation time, total corrective maintenance time, total preventive maintenance time, and the total administrative and logistics downtime. The vehicle will have a maintenance ratio of the total scheduled and unscheduled maintenance man-hours per hour of operation (excluding operator/crew checks and daily operating service) that does not exceed the following values: (1) Organizational 0.140; (2) Direct Support 0.043; (3) Total 0.183.
- **Operational Availability Example** . The system (e.g., aircraft, tank, ship, radio) will have an operational availability of completing a sustained 4-day operation using only onboard equipment and spares without resupply or support from personnel other than the operators. The operational test of the system will be used to verify the requirement is met. The test will consist of two systems performing four each of Scenario A, as identified in [enter appropriate source here], and two each of Scenario B (surge), as identified in [enter appropriate source here]. Nine of the 12 scenarios must be fully executed without outside resupply/assisted maintenance. Additionally, at least one surge scenario must be completed without outside resupply/assisted maintenance.
- **Transportability Example** . The vehicle must be capable of being rigged for air drop by the using unit without the use of special tools, within X minutes. The vehicle shall be capable of being sling-loaded beneath the CH-47D or the CH-53E helicopters using integral vehicle lift points.
- **Maintainability Example** . Performance of duties will be accomplished by Soldiers within the physical capabilities specified in [enter appropriate Service regulation here] for each military occupational specialty designated to support, operate, maintain, repair, and supervise the employment of the system. Introduction of the system into the unit inventory will not cause an increase in the number of personnel to operate or support personnel in excess of those currently required.
- **Materiel Availability Example** . Materiel availability appears to be very similar to operational availability (e.g. (uptime)/(uptime+downtime)); however, materiel availability is calculated for the entire fleet (i.e., all units in force structure), not just the items/platforms assigned to a particular unit. The calculation includes assets in the repair pipeline, at depot for overhaul, etc. The numeric value for materiel availability will naturally be lower than the numeric value for operational availability, but it will portray a more accurate picture of total cost and availability of the capability to the force structure.
- **Reliability Example** . Reliability may initially be expressed as a desired failure-free interval that can be converted to a failure frequency for use as a requirement (e.g., 95 percent probability of completing a 12-hour mission free from mission-degrading failure; 90 percent probability of completing five sorties without failure). Specific criteria for defining operating hours and failure criteria must be provided together with the reliability .

### 17.2.3 TEMP

Appropriate LOG T&E information should be included in the TEMP. Such input, derived from logistics supportability planning, should include specific plans for testing logistics support, descriptions of required operational suitability, and required testing resources. The TEMP is the primary program document for test resource budgets and scheduling. Therefore, it is of critical importance that all key test resources required for IPS element testing (DT, OT, integrated testing, and post-deployment supportability) be identified in the TEMP.

### 17.2.4 Planning Guidelines for LOG T&E

Planning guidelines for logistics support T&E include the following:

- Develop a test strategy for each logistics support-related objective. Ensure that DT&E, integrated testing, and OT&E planning encompasses all IPS elements. The general objectives shown in Figure 17-3 must be translated into quantitative and qualitative requirements for each acquisition phase and each program. Quantitative requirements are those stated as KPPs and KSAs in the CDD/CPD, whereas qualitative requirements relate to the 12 IPS elements.
- Incorporate logistics support testing requirements into the formal DT&E and OT&E integrated testing plans.
- Identify logistics support T&E that will be performed outside of the normal DT&E and OT&E. Include subsystems that require off-system evaluation.
- Identify all required resources, including test articles and logistics support items for formal DT/OT/integrated testing and separate logistics support testing.
- Ensure that planned T&E will provide sufficient data on high-cost and high-maintenance burden items (e.g., for high-cost critical spares, early test results can be used to reevaluate selection).
- Participate early and effectively in the TEMP development process to ensure that the TEMP includes critical logistics T&E designated test funds from program and budget documents.
- Identify the planned utilization of all data collected during the assessments to avoid mismatching of data collection and information requirements.
- Ensure that key items (e.g., parameters to be measured, methods for measurement and time frames, and any penalties/incentives associated with the achieved demonstrated performance) are well-defined in the procurement contract.
- Specify in the TES and the TEMP how reliability will be tested and evaluated during the associated acquisition phase.
- Develop RGCs that reflect what is in the reliability growth strategy and employ the RGCs to plan. Include an RGC in the TEMP beginning at MS B. State RGCs in a series of intermediate goals that

can be tracked through fully integrated, system-level T&E events until the reliability threshold is achieved. If a single curve is not adequate to describe overall system reliability, curves will be provided for critical subsystems with rationale for their selection.

- PMs and OTAs shall assess the reliability growth required for the system to achieve its reliability threshold during IOT&E and report (progress to plan) the results of that assessment to the MDA at MS C ([Reference \(o\)](#)).

### 17.3 Aspects Of LOG T&E

#### 17.3.1 Process for Conducting Logistics Support T&E

LOG T&E measures the supportability of a developing system throughout the acquisition process to identify supportability deficiencies and potential corrections/improvements as test data become available and to assess the operational suitability of the planned support system. It also evaluates the system's ability to achieve planned readiness objectives for the system/equipment being developed. Specific LOG T&E tasks include the following:

- Determining improvements in supportability and supportability-related design parameters needed for the system to meet established goals and thresholds.
- Identifying areas in which established goals and thresholds have not been demonstrated within acceptable confidence levels.
- Developing corrections for identified supportability problems such as modifications to hardware, software, support plans, logistics support resources, or operational tactics.
- Projecting changes in costs, readiness, and logistics support resources due to implementation of corrections.
- Analyzing supportability data from the deployed system to verify achievement of the established goals and thresholds, and for situations in which operational results deviate from projections, determination of the causes and corrective actions.

LOG T&E may consist of a series of logistics demonstrations and assessments that are usually conducted as part of system performance tests but may require dedicated T&E. Logistics support systems may also be evaluated as part of an R&M test event such as a maintenance demonstration. Special end-item equipment tests are rarely conducted solely for logistics parameter evaluation.

#### 17.3.2 Testing for Supportability

Supportability testing is conducted to ensure that requirements for the 12 IPS elements are verified (DT supportability testing) and validated (OT suitability testing, supportability T&E). Determining these requirements is not always a straightforward process and therefore should be started as early in the process as possible. At the establishment of the T&E WIPT, the PSM should appoint a logistician

representative to that team specifically to develop supportability T&E objectives and monitor their testing. The T&E WIPT should be established as early as possible during Material Solutions Analysis.

One of the first tasks the LOG T&E representative should undertake is to contact the OTA suitability representative to lay groundwork for future integrated testing. Although involvement by OTA representatives will be limited at first, it is never too early to bring them into the process.

The second and more formidable task for the logistician is to identify all of the supportability requirements to be tested. Some of these requirements are listed verbatim in the requirements documents (ICD/CDD/CPD) as KPPs or KSAs. Examples may include logistics footprint, supply availability, mean logistics delay time, etc. For these requirements, all that the LOG T&E representative must do is read the documents and identify the logistics requirements as stated.

It is far more difficult to determine implied or derived supportability requirements. For example, if there is an operational availability requirement for the weapon system stated in the CDD, by definition it follows that supply availability and component delivery times will have to be at a certain level. Supply availability and component delivery times are subsets of mean logistics delay time (MLDT), which is part of the downtime in the operational availability equation. Most likely, several other IPS elements will be impacted as well. (See the explanation of operational availability in section 17.3.3.2 of this guide for the explanation of the equation.) Design engineers should have reliability block diagrams that derive and allocate the systems operational availability parameters to the component level and define the equipment's MLDT, mean time to repair (MTTR), and appropriate design parameters, which will be validated during testing.

Other types of derived or implied requirements are those generated in preparation for meeting suitability COIs in OT. For example, there may not be a requirement in the CDD to have accurate, logical, well-written technical manuals, but having these manuals is an obvious implied requirement for maintenance personnel to do their job. Because of this implied requirement, it is a certainty that the OTA will evaluate technical publications; therefore, it behooves the program office to evaluate the publications in DT to avoid unpleasant surprises in OT. Similarly, requirements for all 12 IPS elements must be developed by the LOG T&E representative. (See paragraph 17.2.1 for explanation of logistics suitability and COIs.)

Both derived and implied requirements should be worked in cooperation with the OTA, either through joint development of test plans/assessments or by comparing independent assessments of the requirements documents to ensure that opportunities for integrated testing are not overlooked. At a minimum, LOG T&E representatives should forward the requirements (those requirements stated in the ICD/CDD/CPD and those derived from other requirements they have identified) to the OTA suitability representative for concurrence so that there are no surprises during OT. Optimally, the OTAs suitability representative would be a contributing member of the T&E WIPT from its initial implementation.

A third responsibility of the LOG T&E representative is to ensure that logistics products are available in time to test. It is critical that all logistics requirements be tested during DT. Historically, assets for testing logistics requirements are delivered too late in the acquisition process (i.e., too close to IOT&E) for LOG



T&E to make a significant difference in IOT&E. If there are serious threats to long-term suitability, often logistics requirements testing is deferred to FOT&E, which is of limited immediate use at the systems fielding. The LOG T&E representative must work with the PSM and the PM to accelerate test asset delivery dates so that any needed design changes can be implemented prior to IOT&E.

The LOG T&E representative, in conjunction with the PM, PSM, and lead for T&E, must ensure that test personnel are trained and available, that there is enough flexibility in the test facility scheduling to permit normal delays, and that the test support package is on-site and delivered on time.

Once all requirements are identified, the LOG T&E representative must write the test plans that will be used in DT so that the requirements will be tested and verified. This activity should be done via coordination with the test lead. The OTA will write the test plans for OT. Again, the optimal solution is one of cooperation between the LOG T&E representative and suitability test personnel working in an environment of integrated testing. Because test plan preparation procedures vary throughout the Services, additional information is provided in each agency's T&E policies and regulations.

Often, test plans for supportability T&E during DT involve the LOG T&E representative interviewing maintenance technicians over the shoulder or requesting maintainers to complete survey forms after each maintenance action. These forms assist in determining whether the IPS element(s) pertaining to the subsystem/component/part under consideration meets the requirements. These surveys are gathered throughout the DT period and are compiled, usually in databases, so that at any time, test personnel can request the supportability posture of a given part number/work unit code/logistics control number/etc. The composite score of multiple technicians working with the same component over an extended time is then used as an indicator to determine whether further research is required as to why supportability is substandard for that component. The LOG T&E representative would then research quantifiable maintenance data to determine causes for supportability issues.

Alternately, the supportability evaluation could be performed via logistics demonstrations (LOG Demos). Like supportability T&E, LOG Demos are conducted to confirm that support resources and tasks that are developed to sustain the system will function as intended. Both supportability T&E and LOG Demo data are supplemented by supportability-related data obtained during other types of testing.

The LOG Demo normally consists of the following:

- Disassembly/Reassembly. All operator tasks and specified field-level maintenance tasks contained in the technical manuals are performed by personnel representative of those skill levels typically found in field activities. This portion of the LOG Demo also serves to review the technical and other support manuals for accuracy and readability.
- Maintainability and prognostics/embedded diagnostics demonstration. Maintenance and troubleshooting tasks as the result of operations or fault simulation or insertion are to be accomplished by typical user personnel to meet the intent of [MILHDBK470A](#) (Reference (bd)), [DoDD 4151.18](#) (Reference (be)), and [DoDI 4151.22](#) (Reference (bf)). Complex systems may

require additional demonstrations prior to fielding of test program sets or other support capabilities that are not available for the initial fielding.

Supportability T&E and LOG Demos complement each other and, in a perfect world, both would be performed during evaluation of the support system and products. With LOG Demos, specific, high-interest components/systems can be targeted for evaluation, whereas supportability T&E provides long-term, multi-maintenance technician perspectives on other areas of supportability. Both are useful and should be utilized in verifying/evaluating the 12 IPS elements.

### 17.3.3 RAM

RAM requirements should be based on operational requirements and LCC considerations; stated in quantifiable, operational terms; measurable during DT&E and OT&E; and defined for all elements of the system, including support and training equipment. It is important to understand that RAM is a function of design not logistics. RAM is designed into the system based on capability needs and user requirements and is augmented by supportability measures (IPS elements). The tested equipments R&M design features have a great influence over its supportability. For example, if the support system (12 IPS elements) is developed concurrently with equipment design, and some aspect of the system fails to meet the predicted level of performance (reliability or maintainability), the equipment must be redesigned or modifications must be made to the affected product support element(s) to compensate for the failed design feature. The risk of not mitigating the R&M design requirements will result in additional maintenance to keep the system operational and lead to unexpected failures that will draw on the supply chain at an unplanned rate of demand.

#### 17.3.3.1 Reliability

Reliability is the ability of a system and its parts to perform its mission without failure, degradation, or demand on the support system under a prescribed set of conditions. A common MOE is mean time between failures (MTBF) or mean time between operational mission failures (MTBOMF). MTBF is defined as a measure of, for a particular interval, the total functional life of a population of an item divided by the total number of failures (requiring corrective maintenance actions) within the population. MTBOMF is the measurement for mission-essential equipment to operate without failure during a defined mission timeline or event. Another related measure is mean time between maintenance (MTBM), a measure of reliability that represents the average time between all maintenance actions, both corrective and preventive.

Reliability considerations include the following:

- **Environmental Stress Screening (ESS)** . A test or series of tests during engineering development specifically designed to identify weak parts or manufacturing defects. Test conditions should simulate failures typical of early field service rather than provide an operational life profile.

**RDT/RGT** . A systematic engineering process of TAFT in which equipment is tested under actual, simulated, or accelerated environments. It is an iterative methodology intended to rapidly and steadily

improve reliability. Test articles are usually subjected to ESS prior to beginning RDT/RGT to eliminate those with manufacturing defects. Reliability growth and its projection can be depicted via RGCs, which are required to be part of the SEP early in the program life cycle and updated in the TEMP as the program matures. Figure 17-4 provides an example of an RGC, taken from [MIL-HDBK-189C](#) (Reference (bg)). This RGC was developed via the Planning Model Based on Projection Methodology (PM2)-Discrete, one of several reliability growth planning model options.

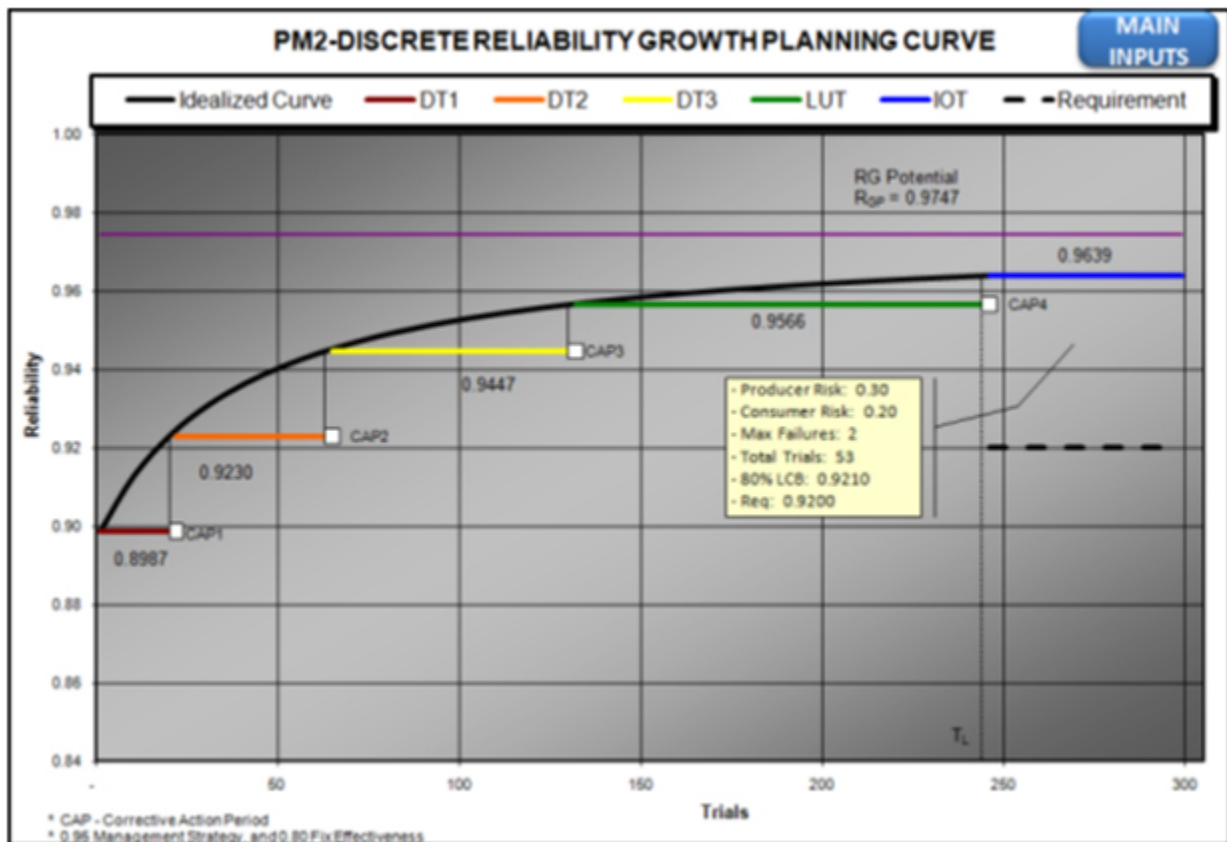


Figure 17-4 Example RGC

- **Reliability Qualification Test** . A test to verify that threshold reliability requirements have been met, before items are committed to production. A statistical test plan is used to predefine criteria, which will limit Government risk. Test conditions must be operationally realistic.
- **Production Reliability Acceptance Test (PRAT)** . A test intended to simulate in-service use of the delivered item or production lot. Because it must provide a basis for determining contractual compliance and because it applies to the items actually delivered to operational forces, PRAT must be independent of the supplier if at all possible. PRAT may require expensive test facilities, so 100 percent sampling is not recommended.

DoD is attempting to enhance reliability in the acquisition process. PMs and PMOs are required to institutionalize reliability planning methods and reporting requirements to monitor reliability growth in

accordance with [Reference \(o\)](#) . RGCs will be stated in a series of intermediate goals and tracked through fully integrated, system-level T&E events until the reliability threshold is achieved. If a single curve is not adequate to describe overall system reliability, curves will be provided for critical subsystems with rationale for their selection. PMs and OTAs shall assess the reliability growth required for the system to achieve its reliability threshold during IOT&E and report the results of that assessment to the MDA at MS C. PMs will report the status of reliability objectives and/or thresholds as part of the formal design review process, during program support reviews, and during SETRs. RGCs must be employed to report reliability growth status at DAES reviews.

### 17.3.3.2 Availability

Availability is a measure of the degree to which an item is in an operable state and can be committed at the start of a mission when the mission is called for at an unknown (random) point in time. The four availability measurements are as follows:

- **Achieved Availability (  $A_A$  )** . Measured for the early prototype and EDM systems developed by the system contractor when the system is not operating in its normal environment. Availability of a system with respect to operating time and both corrective and preventive maintenance. It ignores MLDT and may be calculated as MTBM divided by the sum of MTBM and mean maintenance time (MMT); that is:

$$A_A = \text{MTBM} / (\text{MTBM} + \text{MMT}) .$$
- **Inherent Availability (  $A_I$  )** . Availability of a system with respect only to operating time and corrective maintenance. It may be measured during DT&E or when testing in the contractor's facility under controlled conditions.  $A_I$  ignores standby and delay times associated with preventive maintenance as well as MLDT and may be calculated as the ratio of MTBF divided by the sum of MTBF and MTTR; that is:

$$A_I = \text{MTBF} / (\text{MTBF} + \text{MTTR}) .$$
- **Operational Availability (  $A_O$  )** . Measured for mature systems that have been deployed in realistic operational environments,  $A_O$  is the degree to which a piece of equipment works properly when it is required for a mission. The degree (expressed as a decimal between 0 and 1, or the percentage equivalent) to which one can expect a piece of equipment or weapon system to work properly when it is required; that is, the percent of time the equipment or weapon system is available for use.  $A_O$  represents system uptime and considers the effect of reliability, maintainability, and MLDT.  $A_O$  may be calculated by dividing MTBM by the sum of MTBM, MMT, and MLDT; that is:

$$A_O = \text{MTBM} / (\text{MTBM} + \text{MMT} + \text{MLDT}) .$$

$A_O$  is the quantitative link between readiness objectives and supportability.
- **Materiel Availability (  $A_M$  )** . A measure of the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition. This can be expressed mathematically as the number of operational end items/total population. Materiel availability addresses the total population of

end items planned for operational use, including those temporarily in a nonoperational status once placed into service (such as for depot-level maintenance). The total life-cycle timeframe, from placement into operational service through the planned end of service life, must be included. This is often referred to as equipment readiness. Development of the materiel availability metric is a PM responsibility.

### 17.3.3.3 Maintainability

Maintainability is the ability of an item to be retained in or restored to a specified condition when maintenance is performed by personnel having specific skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.

A common maintainability MOS is MTTR. MTTR is the total elapsed time (clock hours) for corrective maintenance divided by the total number of corrective maintenance actions during a given period. It is a basic technical measure of maintainability, and contractually, time and repair must be carefully defined for contractual compliance purposes.

Maintainability design factors and test/demonstration requirements used to evaluate maintainability characteristics must be based on program objectives and thresholds. Areas for evaluation might include the following:

- **Accessibility** . Assess how easily the item can be repaired or adjusted.
- **Visibility** . Assess the ability/need to see the item being repaired.
- **Testability** . Assess ability to detect and isolate system faults to the faulty replaceable assembly level.
- **Complexity** . Assess the impact of the number, location, and characteristic (standard or special purpose) on system maintenance.
- **Interchangeability** . Assess the level of difficulty encountered when failed or malfunctioning parts are removed or replaced with an identical part not requiring recalibration.

A true assessment of system maintainability generally must be developed at the system level under operating conditions and using production configuration hardware. Therefore, a maintainability demonstration should be conducted prior to the FRP decision. The risk of not mitigating the R&M design requirements will result in additional maintenance to keep the system operational and lead to unexpected failures that will draw on the supply chain at an unplanned rate of demand.

### 17.3.3.4 Operational R&M Value

The operational R&M value is any measure of reliability or maintainability that includes the combined effects of item design, quality, installation, environment, operation, maintenance, and repair.

RAM program objectives are defined as system parameters derived from capability-driven KPPs early in the design and development process. They will be used as evaluation criteria throughout the design, development, and production processes. These objectives should be translated into quantifiable contractual terms and ultimately will be allocated via the SE process through the system design hierarchy to specific components.

A more detailed description about how this allocation flow-down process affects RAM, among other topics, can be found in the [DoD Guide for Achieving Reliability, Availability, and Maintainability](#) (Reference (bh)). The guide notes that RAM and its measurement will vary over the life cycle, stating:

Many factors are important to RAM: system design; manufacturing quality; the environment in which the system is transported, handled, stored, and operated; the design and development of the support system; the level of training and skills of the people operating and maintaining the system; the availability of materiel required to repair the system; and the diagnostic aids and tools (instrumentation) available to them. All these factors must be understood to achieve a system with a desired level of RAM. During pre-systems acquisition, the most important activity is to understand the user's needs and constraints. During system development, the most important RAM activity is to identify potential failure mechanisms and to make design changes to remove them. During production, the most important RAM activity is to ensure quality in manufacturing so that the inherent RAM qualities of the design are not degraded.

#### **17.3.4 T&E of Training Materials, Equipment and Facilities**

The development and subsequent T&E of trainers and training equipment is an activity that closely parallels the activity associated with system acquisition events. Design engineering, system integration, support system identification, and development, manufacturing, and production processes are all applicable to trainers and training equipment. Occasionally, however, milestone schedules may require delivery of the trainers and training equipment before or at the same time as the major system. Trainers and training equipment must be identical representations of the system they support; therefore, their development must follow system development. Expedious completion of all engineering and logistics tasks is necessary in order to meet delivery schedules and to complete T&E activities.

#### **17.3.5 Data Collection and Analysis**

The logistics support manager should coordinate with the testers to ensure that the methods used for collection, storage, and extraction of LOG T&E data are compatible with those used in testing the materiel system. As with any testing, the test planning must ensure that all required data are identified; that the data are sufficient to evaluate a systems readiness and supportability; and that plans are made for a data management system that is capable of the data classification, storage, retrieval, and reduction necessary for statistical analysis. Large statistical sample sizes may require a common database that integrates contractor, DT&E, integrated testing, and OT&E data so required performance parameters can be demonstrated.

### 17.3.6 Use of LOG T&E Results

The emphasis on the use of the results of testing changes as the program moves from initiation to post-deployment. During early phases of a program, the evaluation results are used primarily to verify analysis and develop future projections. As the program moves into advanced engineering development and hardware becomes available, the evaluation addresses design, particularly the R&M aspects; trainers and training programs; support equipment adequacy; personnel skills and availability; adequacy of supply support; computer resources; and technical publications.

The PSM must make the PM aware of the impact on the program of logistical shortcomings that are identified during the T&E process. The PM in turn must ensure that the solutions to any shortcomings are identified and reflected in the revised specifications and that the revised test requirements are included in the updated TEMP as the program proceeds through the various acquisition stages.

### 17.4 Limitations to LOG T&E

Concurrent testing or tests that have accelerated schedules frequently do not have sufficient test articles, equipment, or hardware to achieve statistical confidence in the testing conducted. An acquisition strategy may stipulate that support resources such as operator and maintenance manuals, tools, support equipment, training devices, etc., for major weapon system components would not be procured before the weapons system/component hardware and software design stabilizes. This shortage of equipment is often the reason that shelf-life and service-life testing is incomplete, leaving the logistics support evaluator with insufficient data to predict future performance of the test item. Some evaluations must measure performance against a point on the parameters growth curve. The logistics support testing will continue post-production to obtain required sample sizes for verifying performance criteria. Some aspects of the logistics support may not be available for IOT&E and become testing limitations requiring waivers. The PMO must develop enough logistics support to ensure that the user can maintain the system during IOT&E without requiring system contractor involvement (legislated constraints). Any logistics support limitations upon IOT&E will need to be evaluated during FOT&E.

### 17.5 Summary

T &E is a key tool for measuring the ability of the planned support system to fulfill the materiel systems readiness and supportability objectives. The effectiveness of the LOG T&E effort is based upon the completeness and timeliness of the planning effort. A comprehensive R&M program using an appropriate reliability growth strategy to improve R&M performance will be executed by all programs.

The LOG T&E requirements must be an integral part of the TEMP to ensure budgeting and scheduling of required test resources. Data requirements must be completely identified, with adequate plans made for collection, storage, retrieval, and reduction of test data. At the FRPDR, decision makers can expect that some logistics support performance parameters may not have finished testing because of the large sample sizes required for high confidence levels in statistical analysis.

## Test & Evaluation Management Guide

### Chapter 18 - M&S Support to T&E

#### 18.1 Introduction

This chapter discusses the applications of M&S in T&E. DoD policies encourage the early use of M&S as a key tool throughout the acquisition life cycle. M&S, when properly employed, provides the T&E community with valuable information that can increase confidence levels, decrease field test time and costs, and provide data for pre-test prediction and post-test validation. A symbiotic relationship exists between M&S and T&E. All DoD M&S requires VV&A for each use in the acquisition process, and T&E is needed to validate most models. M&S must be well understood to ensure a reasonable return on investment for its use. This chapter discusses using M&S to increase the efficiency of the T&E process, reduce time and cost, provide otherwise unattainable and immeasurable data, and provide more timely and valid results.

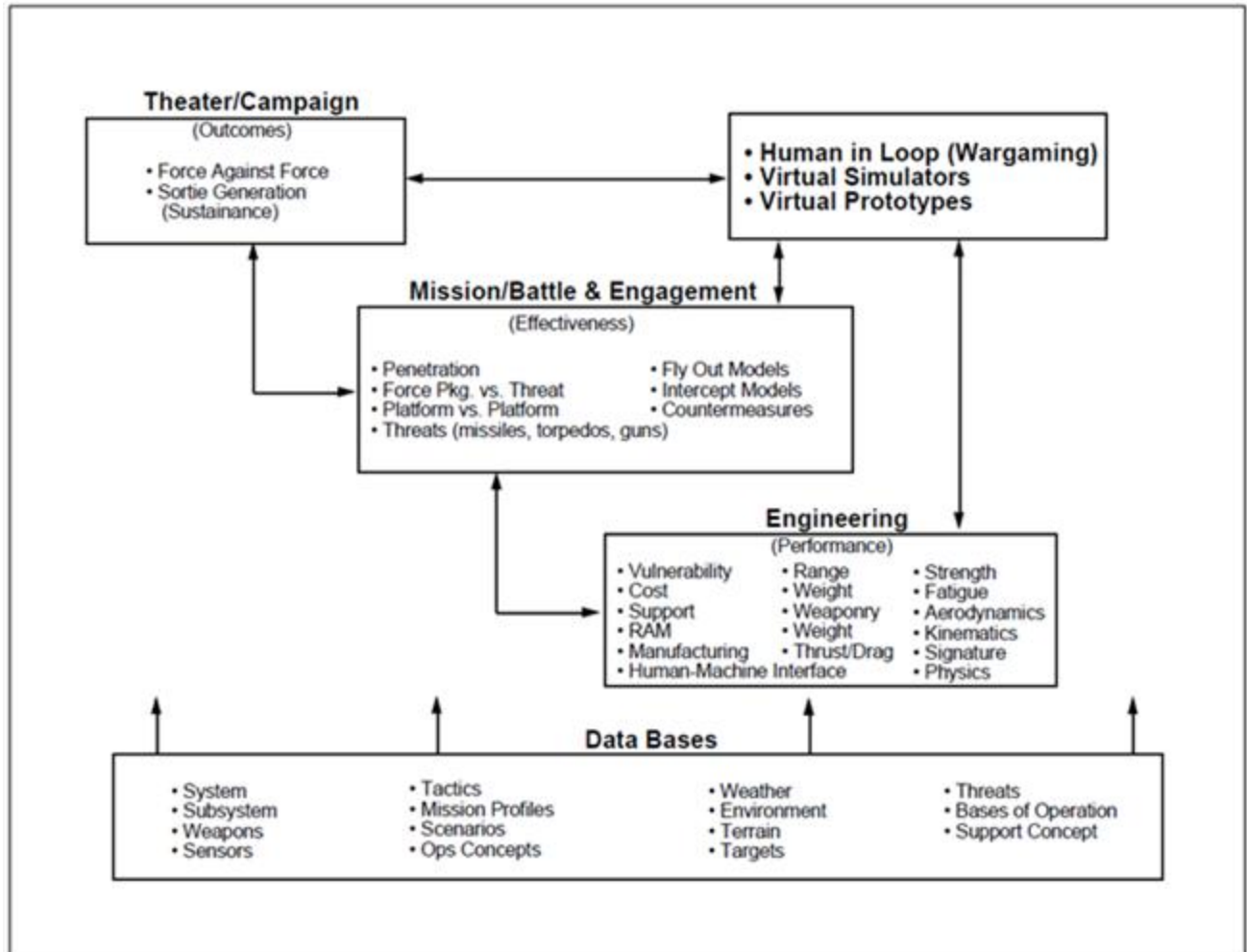
#### 18.2 Types of Models and Simulations

The term modeling and simulation is often associated with huge digital computer simulations, but it also includes manual and man-in-the-loop war games, HWIL simulations, test beds, hybrid laboratory simulators, and prototypes.

A mathematical model is an abstract representation of a system that provides a means of developing quantitative performance requirements from which candidate designs can be developed. Static models are those that depict conditions of state, whereas dynamic models depict conditions that vary with time, such as the action of an autopilot in controlling an aircraft. Simple dynamic models can be solved analytically, and the results represented graphically.

As illustrated in Figure 18-1, there is a broad spectrum of simulation types ranging from theater/campaign simulations to detailed engineering simulations. A program will likely use a suite of models and simulations. The engineering-level models assess MOPs along with design, cost, producibility, and supportability information for components, subsystems, and systems. The military utility of systems can be evaluated within engagement and mission/battle-level models. At the highest level, theater/campaign models can be used to simulate the outcomes of major conflicts. Clearly, there is no single model or simulation to suit all of a programs needs. Each model or simulation has a specific purpose for which it was intended and the tester should carefully evaluate its utility for T&E purposes.





**Figure 18-1 The Simulation Spectrum**

One way of looking at the role of simulations used in T&E is by categorizing the simulations into a three-part continuum, which is described below.

**Constructive Simulations** . Constructive simulations are strictly mathematical representations of systems and do not employ any actual hardware. They involve simulated people operating simulated systems. Real people stimulate (provide inputs to) constructive simulations but are not involved in determining the outcomes. Constructive simulations may, however, incorporate some of the actual software that might be used in a system. Early in a systems life cycle, computer simulations may provide the most system evaluation information. In many cases, computer simulations can be readily developed as modifications of existing simulations for similar systems.

**Virtual Simulations** . Virtual simulations involve real people operating simulated systems. A system test bed usually differs from a computer simulation as it contains some, but not necessarily all, of the actual hardware that will be a part of the system. Other elements of the system are either not incorporated or, if they are incorporated, are in the form of computer simulations. The system operating environment

(including threat) may either be physically simulated, as in the case of a flying test bed, or computer simulated, as in the case of a laboratory test bed. Aircraft cockpit simulators used to evaluate pilot performance are good examples of system test beds. As development of a system progresses, more subsystems become available in hardware form. These subsystems can be incorporated into system test beds that typically provide a great deal of the system evaluation information used during the middle part of a systems development cycle.

Another type of virtual simulation used in T&E is the system prototype. Unlike the system test bed, all subsystems are physically incorporated in a system prototype. The system prototype may closely represent the final system configuration, depending on the state of development of the various subsystems that compose it. Preproduction prototype missiles and aircraft used in OT by the Services are examples of this class of simulation. As system development proceeds, eventually all subsystems will become available for incorporation in one or more system prototypes. HWIL simulators or full-up man-in-the-loop system simulators may provide the foundation for continuous system testing and improvement. These simulators can provide the basis for transitioning hardware and software into operationally realistic training devices with mission rehearsal capabilities. OT of these prototypes frequently provides much of the system evaluation information needed for a decision on full-scale production and deployment.

**Live Simulations** . Live simulations involve real people operating real systems. Some say that everything except global combat is a simulation, even limited regional engagements. Live exercises in which troops use equipment under actual environmental conditions approach real life in combat while conducting peacetime operations. Training exercises and other live simulations provide a testing ground with real data on actual hardware, software, and human performance when subjected to stressful conditions. These data can be used to validate the models and simulations used in an acquisition program.

The complexity of testing in a joint environment will require testing in a distributed environment that combines live, virtual, and constructive models. Hardware, software, databases, and networks are integrated into a system and tested to make sure they can operate as intended.

M&S accuracy is dependent on the technical level of confidence or credibility of the simulation. To ensure that confidence in a particular use of M&S for a given purpose is justified, a rigorous process must be followed, such that (1) Modeling assumptions are accurate and well documented; (2) Results produced by the M&S are stable, consistent, and repeatable; and (3) The correlation between the M&S behavior and real world behavior is clearly understood.

Model credibility is established via a VV&A set of increasingly rigorous criteria. [DoDI 5000.61](#) (Reference (bi)) defined VV&A as follows:

- **Verification** . The process of determining that a model or simulation implementation and its associated data accurately represent the developer's conceptual description and specifications.

- **Validation** . The process of determining the degree to which a model or simulation and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model.
- **Accreditation** . The official certification that a model or simulation and its associated data are acceptable for use for a specific purpose.

### 18.3 Scope of M&S

Simulations are not a substitute for live testing. There are many things that cannot be adequately simulated by computer programs, including the decision process and the proficiency of personnel in the performance of their functions. Therefore, models and simulations are not a total substitution for physical T&E events. Simulations, manual and computer-designed, can complement and increase the validity of live T&E events by proper selection and application. Figure 18-2 contrasts the test criteria values that are conducive to physical testing with those conducive to M&S. Careful selection of the simulation, knowledge of its application, and meticulous selection of input data will produce representative and valid results.

THE SIMULATION SPECTRUM		
CRITERIA	VALUES CONDUCTIVE TO:	
	PHYSICAL TESTING	MODELING AND SIMULATION
TEST SAMPLE SIZE/NUMBER OF VARIABLES	SMALL/FEW	LARGE/MANY
STATUS OF VARIABLES/UNKNOWN	CONTROLLABLE	UNCONTROLLABLE
PHYSICAL SIZE OF PROBLEM	SMALL AREA/ FEW PLAYERS	LARGE AREA/ MANY PLAYERS
AVAILABILITY OF TEST EQUIPMENT	AVAILABLE	UNAVAILABLE
AVAILABILITY OF TEST FACILITIES	RANGES, OTHER TEST AVAILABLE	BENCHMARKED, VALIDATED COMPUTER MODELS AVAILABLE
TYPES OF VARIABLES/UNKNOWN	SPATIAL/TERRAIN	LOW IMPORTANCE OF SPATIAL/TERRAIN
DIPLOMATIC/POLITICAL FACTORS	CONVENTIONAL CONFLICTS	NUCLEAR OR CHEMICAL CONFLICTS

Figure 18-2. Criteria Values Conducive to Use of M&S

Conversely, certain highly complex simulations can be more effective analytical tools than limited live testing, generally due to the significance of the external constraints. For example, nuclear weapons effects testing can be done only in simulation because of international treaties. Testing depleted uranium ammunition is very expensive with its related environmental considerations. Finally, much confidence-building iteration of multimillion-dollar missile defense tests can be executed using only simulated events in conjunction with a few instances of real firings.

The important element in using a simulation is to select one that is representative and either addresses or is capable of being modified to address the level of detail (issues, thresholds, and objectives) under investigation.

#### **18.4 Support to Test Design and Planning**

M&S can assist in the T&E planning process, may reduce the cost of testing, and can provide environments and sample sizes not otherwise achievable. In Figure 18-3, areas of particular application include scenario development and the timing of test events; the development of objectives, essential elements of analysis, and MOEs; the identification of variables for control and measurement; and the development of data collection, instrumentation, and data analysis plans. For example, using simulation, the test designer can examine system sensitivities to changes in variables to determine the critical variables and their ranges of values to be tested. The tester can also predict the effects of various assumptions and constraints to help formulate the test design. For example, in the live-fire vulnerability testing of the F-22 wing panel, a mechanical deformation model was used extensively in pre-test predictions. The pre-test analysis was used to design the experiment that assisted in shot-line selection and allowed elimination of the aft boom testing, saving test schedule and about \$100,000. Real data in post-test analysis verified the capability to predict impulse damage within acceptable limits, resulting in greater use of the model in future applications.

During pre-MS A and the TD phase, models for LFT&E and survivability are needed to help establish design factors and considerations and help support initial vulnerability assessment reports. These models can be used in the early stages of development and if properly validated, can support later stages of survivability assessments. Models should help replicate the environment during test to realistically stress the system under test.

Caution must be exercised when planning to rely on simulations to obtain test data as they tend to be expensive to develop or modify, tend to be difficult to integrate with data from other sources, and often do not provide the level of realism required for OTs. Although simulations are not a cure-all, they should be explored and used whenever feasible as another source of data for the evaluator to consider during the test evaluation. Simulation fidelity is improving rapidly with enhancements to computer technology.

Computer simulations may be used to test the planning for an exercise. By setting up and running the test exercise in a simulation, the timing and scenario may be tested and validated. Critical events may include interaction of various forces that test the MOEs and in turn the test objectives. Further, the simulation may be used to verify the statistical test design and the instrumentation, data collection, and data analysis plans. Essentially, the purpose of computer simulation in pre-test planning is to preview

the test to evaluate ways to make test results more effective. Pre-testing attempts to optimize test results by pointing out potential trouble spots. It constitutes a test setup analysis, which can encompass a multitude of areas. The model-test-model process is an integrated approach to using models and simulations in support of pre-test analysis and planning, conducting the actual test and collecting data, and performing post-test analysis of test results along with further validation of the models using the test data.

As an example of simulations used in test planning, consider a model that portrays aircraft versus air defenses. The model can be used to replicate typical scenarios and provide data on the number of engagements, air defense systems involved, aircraft target, length and quality of the engagement, and a rough approximation of the success of the mission (i.e., if the aircraft made it to the target). With such data available, a data collection plan can be developed to specify, in more detail, when and where data should be collected, from which systems, and in what quantity. The results of this analysis impact heavily on long lead-time items such as data collection devices and data processing systems. The more specificity available earlier, the fewer the number of surprises that will occur downstream in the development process. As tactics are decided upon and typical flight paths are generated for the scenario, an analysis can be prepared on the flight paths over the terrain in question, and a determination can be made regarding whether the existing instrumentation can track the numbers of aircraft involved in their maneuvering envelopes. Alternative site arrangements can be examined and trade-offs can be made between the amount of equipment to be purchased and the types of profiles that can be tracked for this particular test.

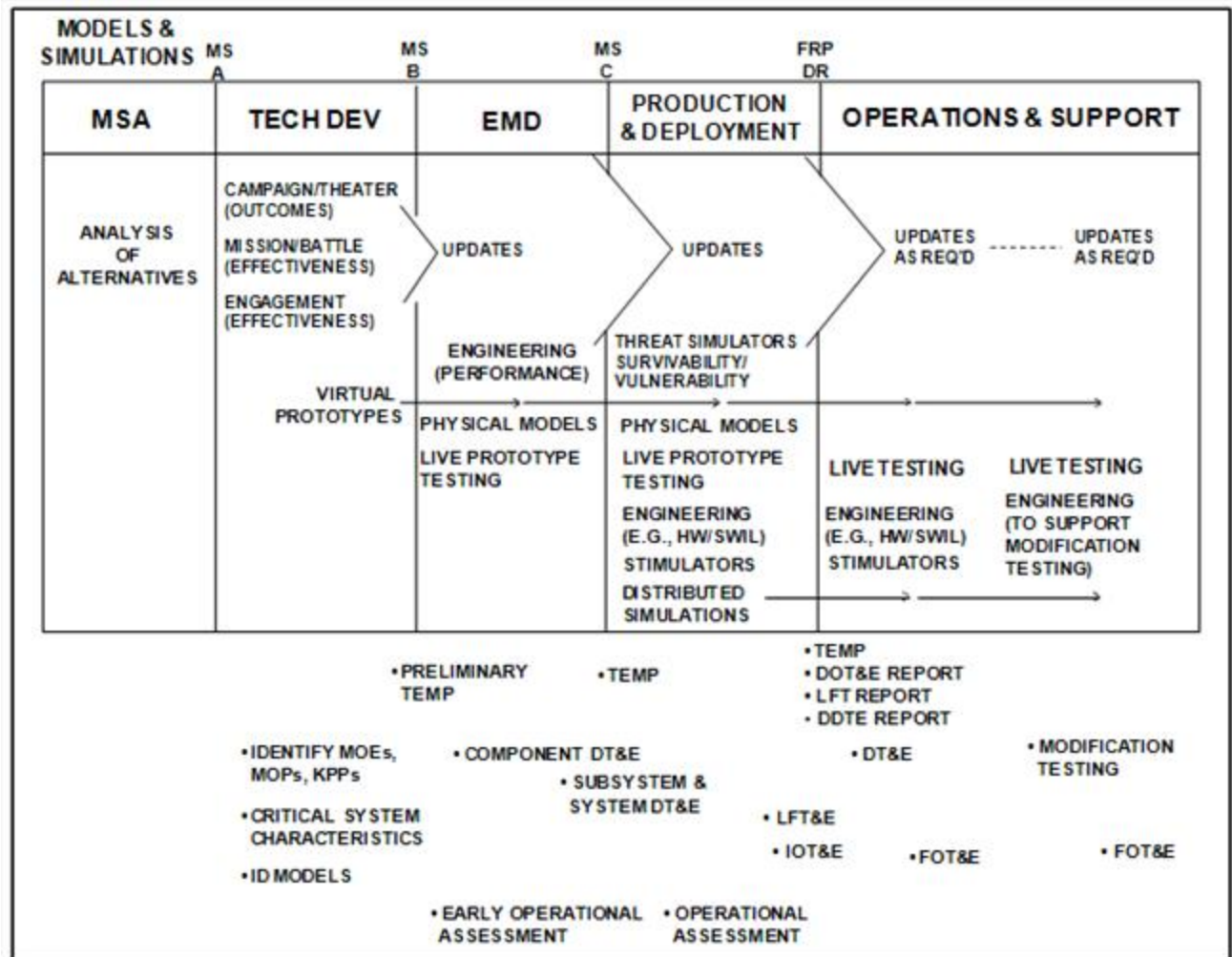


Figure 18-3 Illustrative Uses of M&S in T&E

Use of such a model can also highlight numerous choices available to the threat air defense system in terms of opportunities for engagement and practical applications of doctrine to the specific situations.

### 18.5 Support to Test Execution

Simulations can be useful in test execution and dynamic planning. Funds and other restrictions may limit the number of times a test may be repeated. The test director must exercise close control over the conduct of the test to ensure that the specific types and quantities of data needed to meet the test objectives are being gathered and to ensure adequate safety. The test director must be able to make minor modifications to the test plan and scenario to force achievement of these goals. This need calls for a dynamic (quick-look) analysis capability and a dynamic planning capability. Simulations may contribute to this dynamic planning capability. For example, using the same simulation(s) as used in pre-test planning, the tester could input data gathered during the first day of the exercise to determine the adequacy of the data to fulfill the test objectives. Using this data, the entire test could be simulated.

Projected inadequacies could be isolated, and the test plans could be modified to minimize the deficiencies.

Simulations may also be used to support test control and to ensure safety. For example, during missile test firings at White Sands Missile Range, New Mexico, aerodynamic simulations of the proposed test were run on a computer during actual firings so that real-time missile position data could be compared continuously to the simulated missile position data. If any significant variations occurred and if the range safety officer was too slow (both types of position data were displayed on plotting boards), the computer issued a destruct command.

Simulations can be used to augment tests by simulating non-testable events and scenarios. Although OT should be accomplished in as realistic an operational environment as possible, pragmatically some environments are impossible to simulate for safety or other reasons; for example, the environment of a nuclear battlefield, to include the effects of nuclear bursts on friendly and enemy elements. Other examples include two-sided live firings and adequate representation of other forces to ascertain compatibility and interoperability data. Instrumentation, data collection, and data reduction of large combined armed forces (e.g., Army brigade and larger-sized forces) become extremely difficult and costly. Simulations are not restricted by safety factors and can realistically replicate many environments that are otherwise unachievable in OT&E-nuclear effects, large combined forces, ECM, electronic counter-countermeasures, and many engagements. These effects can be simulated repeatedly with no environmental impacts, costing only for the simulation operations.

Usually, insufficient units are available to simulate the organizational relationships and interaction of the equipment with its operational environment, particularly during the early OT&E conducted using prototype or pilot production-type equipment. Simulations are not constrained by these limitations. Data obtained from a limited test can be plugged into a simulation that is capable of handling many of the types of equipment being tested. The simulation can interface the units with other elements of the blue forces and operate them against large elements of the red forces to obtain interactions.

End-item simulators can be used to evaluate design characteristics of equipment and can be used to augment the results obtained using prototype or pilot production-type equipment that is representative of the final item. The simulator may be used to expand test data to obtain the required iterations or to indicate that the human interface with the prototype equipment will not satisfy the design requirements.

It is often necessary to use substitute or surrogate equipment in testing; for example, American equipment is used to represent threat-force equipment. In some cases, the substitute equipment may have greater capabilities than the real equipment; in other cases, it may have less. Simulations are capable of representing the real characteristics of equipment and, therefore, can be used as a means of modifying raw data collected during the test to reflect real characteristics.

As an example, if the substitute equipment is an anti-aircraft gun with a tracking rate of 30 degrees per second and the unavailable threat equipment for which it is substituted has a tracking rate of 45 degrees per second, the computer simulation could be used to augment the collected, measured data by

determining how many rounds could have been fired against each target, or whether targets that were missed because the tracking rate was too slow could have been engaged by the actual equipment. Consideration of other differing factors simultaneously could have a positive or negative synergistic effect on test results and could allow evaluation more quickly through a credible simulation designed with the flexibility to replicate operational variations.

## **18.6 Support to Analysis and Test Reporting**

M&S may be used in post-test analysis to extend and generalize results and to extrapolate to other conditions. The difficulty of instrumentation for controlling large exercises and for collecting and reducing the data and resource costs to some degree limits the size of T&E. This difficulty makes the process of determining the suitability of equipment, including compatibility, interoperability, organization, etc., a difficult one. To a large degree, the limited interactions, interrelationships, and compatibility of large forces may be supplemented by using actual data collected during the test and applying the data in the simulation.

Simulations may be used to extend test results, save considerable energy (fuel and manpower), and save money by reducing the need to repeat data points to improve the statistical sample or to determine overlooked or directly unmeasured parameters. Sensitivity analyses can be run using simulations to evaluate the robustness of the design.

In analyzing the test results, data may be compared to the results predicted by the simulations used early in the planning process. Thus, the simulation is validated by the actual live test results, and the test results are also validated by the simulation.

## **18.7 Simulation Integration**

Simulations have become so capable and widespread in their application, combined with the ability to network dissimilar and/or geographically separate simulators in real time to synergistically simulate more than ever before, that whole new applications are being discovered. Simulations are no longer stove-piped tools in distinct areas but are increasingly crossing disciplines and different uses. The F-35 Joint Strike Fighter program uses more than 200 different models and simulations throughout its many development and testing activities, in both Government centers and contractor facilities. Increasingly, operational issues are being determined through operational analysis simulations, which will subsequently impact OT much later in a program.

OT elements of the T&E community should be involved increasingly earlier in every program to ensure that such results are compatible with the OT objectives and requirements. For example, the F-35 program networked eight different war game simulations together to develop the initial operational requirements that subsequently were documented in the programs requirements document for the many different required Service applications (i.e., Navy, Air Force, Marine Corps, and British Royal Navy). Only through this extensive Virtual Strike Warfare Environment was the broad and concurrent range of operational requirements able to be evaluated and established. New capabilities were achieved, but the



extensive multi-simulation network demanded new techniques for establishing the technical confidence in the results .

### **18.8 Simulation Planning**

With M&S becoming increasingly more complex, more expensive, and more extensive, testers must be thorough in planning their use of M&S and subsequent technical confidence. Testers, including the OTAs, are expected to be involved increasingly earlier if the subsequent T&E results are to be accepted. Simulation support plans (SSPs) are program documents that span the many simulations, their purpose, and their expected credibility. The Services have policies requiring early M&S planning. Usually, this process starts with a program office-level simulation support group of Service M&S experts who advise the program on M&S opportunities, establish the VV&A process, and document these procedures in the SSP, which extends across the life cycle of system development, testing, and employment. It is vital that the SSP be fully coordinated with the TEMP. Without early planning of what each model or simulation is for, its expense, and its impact on system design as well as testing, earlier programs have ended up with a volume of different data for different purposes, which could not be analyzed, was subsequently found not to be credible, or delayed testing or program development.

### **18.9 Summary**

M&S in T&E can be used for concept evaluation, extrapolation, isolation of design effects, efficiency, representation of complex environments, increasing sample size, and overcoming inherent limitations in actual testing. The use of M&S can validate test results, increase confidence levels, reduce test costs, and provide opportunities to shorten the overall acquisition cycle by providing more data earlier for the decision maker. It takes appropriate time and funding to bring models and simulations along to the point that they are useful during an acquisition.

## Test & Evaluation Management Guide

### Chapter 19 - Electromagnetic Environmental Effects (E3) Testing and Spectrum Supportability (SS)

#### 19.1 Introduction

Historically, failure to verify equipment/platform electromagnetic compatibility in the items intended operational electromagnetic environment has caused costly program delays and adversely affected operational safety, suitability, and effectiveness. E3 can affect the performance of all electrical and electronic systems, subsystems, and equipment, including ordnance containing electrically initiated devices. Therefore, any system that has electronic components must be reviewed to determine the extent of E3 issues; this requirement applies to more than just communication and electronics systems. Such systems must be mutually compatible in their intended electromagnetic environment (EME) without causing or suffering unacceptable mission degradation due to E3.

[DoDD 3222.3](#) (Reference (bj)) provides policy and responsibilities for the management and implementation of the DoD E3 Program to ensure mutual electromagnetic compatibility (EMC) and effective E3 control among ground, air, sea, and space-based electronic and electrical systems and subsystems, and with the existing natural and man-made electromagnetic spectrum. [MIL-HDBK 237D](#) (Reference (bk)) states that SS must be given appropriate and timely consideration in acquisition planning, development, procurement, and deployment of spectrum-dependent systems or equipment. Ensuring compliance with national, international, and DoD policies and procedures for the management and use of the electromagnetic spectrum is critical to interoperability. Both E3 and SS must be addressed early in the conceptual phase of system development and be periodically reviewed and updated throughout the system design. Chairman of the Joint Chiefs of Staff Instruction [\(CJCSI\) 6212.01F](#) (Reference (bl)) on Net Ready Key Performance Parameter (NR KPP) is supportive of [Reference \(bj\)](#). [Reference \(bk\)](#) provides definitive guidance for DoD acquisitions. Finally, [MIL-STD-461F](#) (Reference (bm)) and [MIL-STD-464C](#) (Reference (bn)) provide details on technical execution of these requirements, will prove invaluable as references for the E3 representative on design-related IPTs and WIPTs.

#### 19.2 Key Definitions and Concepts

##### 19.2.1 Responsibilities

Responsibilities of the DOT&E and DASD(DT&E), OTAs, PMs, and E3/SS WIPT are delineated in [Reference \(bk\)](#) and are outlined below. For more information, see [Reference \(bk\)](#) and the [DOT&E Guide](#) (Reference (bo)).

##### 19.2.1.1 DOT&E AND DASD (DT&E)

The DOT&E and DASD (DT&E) shall:

- Approve Service TEMPs, operational test plans, early assessments, and test reports on T&E oversight programs (i.e., programs on the OSD T&E oversight list) to assess the adequacy of E3/SS testing.

- Monitor and cite E3/SS issues and resolutions during participation on T&E oversight programs acquisition IPTs.
- Review Services evaluation approaches, including M&S, small-scale tests, and appropriate chamber, field, and laboratory tests.
- Review spectral characteristics data to ensure that sufficient information is available for test scenarios and to support the resolution of E3/SS issues.
- Report the status of E3/SS issues for T&E oversight programs in the DOT&E Annual Report, and report specific program findings as part of BLRIP reports to the SecDef and Congress.
- As E3/SS issues related to fielded systems arise during OT&E or during large-scale training exercises used to complement operational tests, report these issues to the appropriate agencies for resolution.

#### **19.2.1.2 OTAs and DT Organizations**

The OTAs and DT Organizations shall:

- Coordinate E3/SS assessments during field tests with Services E3/SS points of contact and other DoD agencies.
- Conduct early assessments of DoD programs to identify and mitigate potential E3/SS problems, including hazards of electromagnetic radiation to ordnance (HERO).
- Include E3/SS and spectrum availability assessment issues as a standard presentation at OTRRs .

#### **19.2.1.3 PM**

The PM shall:

- Ensure that E3/SS T&E efforts receive adequate funding.
- Ensure that E3/SS is sufficiently addressed in the TEMP because it will receive scrutiny during the TEMP approval process. Ensure that E3/SS requirements are addressed from the outset of the program. Requirements should be addressed in Part I (Introduction), and known or anticipated test issues should be addressed in Part III (Test and Evaluation Strategy). If a need for specialized test resources, such as anechoic chambers, is anticipated, this should be stated in Part IV (Resource Summary).
- Establish the E3/SS WIPT .

#### **19.2.1.4 E3/SS WIPT**

An E3/SS WIPT is an advisory body of SMEs that may be established by the PM to help ensure that the system under development has spectrum support and will be electromagnetically compatible with itself

and with the external EME. The E3/SS WIPT should be organized early in a program so that it can contribute to the trade-off studies of alternate concepts and to assess the impact of design, budgetary, and scheduling decisions related to E3/SS considerations. The E3/SS WIPT is usually composed of Government, Federally Funded Research and Development Center, and development contractor personnel empowered with the authority to make most decisions within their discipline while being held accountable for meeting performance and cost requirements. The team is expected to make decisions in a cooperative manner. The E3/SS WIPT should be co-chaired by a Government representative and a development contractor representative, operating under the authority of the PM.

Responsibilities of an E3/SS WIPT should be defined in a charter and may include the following:

- Establishing E3 performance requirements for the system or equipment, by drawing from and tailoring existing military and commercial standards.
- Defining the flow of E3/SS requirements down to elements of the system.
- Defining and updating the various aspects of the external EME.
- Defining E3/SS requirements, verification methodology, such as analysis, M&S, and T&E.
- Participating in design reviews by providing technical input from test results on system/subsystem design and system integration relative to E3.
- Providing inputs to system specifications on E3.
- Providing inputs on flight clearance requests.
- Preparing and updating the DD Form 1494, Application for Equipment Frequency Allocation, for spectrum-dependent systems and equipment.
- Defining E3/SS budget requirements.
- Providing E3/SS inputs to acquisition documents and reviewing program documentation and contract deliverables.
- Assessing HERO, hazards of electromagnetic radiation to personnel (HERP), and hazards of electromagnetic radiation to fuel (HERF) safety issues.
- Performing E3 analyses and tests to identify potential E3/SS problems and solutions.
- Identifying operational limitations for E3 problems not corrected.
- Evaluating the E3 impact of using Commercial Item/NDI on the overall performance of the end item.

### 19.2.2 Role of Analyses, Simulations, and Predictions

Analyses and predictions are critical in identifying and resolving potential E3/SS problems during development; therefore, they should be employed as early in a program as possible, before there are significant expenditures of time, effort, and money. The analyses provide essential information to guide the selection of appropriate courses of action to correct problems. E3/SS analyses should be conducted and continually refined throughout the items life cycle, as the operational EME is updated and as technical characteristics of the end-item become available. These analyses are typically performed at an increasing level of detail during each stage of the development life cycle. As measured characteristics are determined, earlier analyses may be refined. Available test data for interference interactions should also be fed back into the E3 analysis. Careful application of E3 analysis and prediction techniques at the appropriate phases of an items life cycle should ensure that the required level of E3 control is defined without having the wasteful expense of over-engineering, the uncertainties of under-engineering, or the need for reengineering at an ever more expensive time late in the program.

### 19.2.3 Key Terms

The key E3/SS specific terms used in this chapter are defined in Figure 19-1.

E3	Electromagnetic Environment	The impact of the EME on the operational capability of military forces, equipment, systems, and platforms. It encompasses all electromagnetic disciplines, discharge; hazards of electromagnetic radiation to personnel, ordnance, and volatile including EMC and electromagnetic interference; electromagnetic vulnerability; electromagnetic pulse; electro-static materials; and natural phenomena effects of lightning and precipitation static.
EMC	Electromagnetic Compatibility	EMC is the ability of a system to operate in their operational EME without experiencing or causing unintentional degradation because of EM radiation or response.
EME	Electromagnetic Environment	The EME in which the item is expected to operate should be defined early in the acquisition process, based on geographical operating area, host nation constraints, physical operating environment and expected interactions with friendly and hostile systems.
EMI	Electromagnetic Interference	EMI is any EM disturbance – intentional (as in EW) or unintentional - degrades or limits the effective performance of electronic equipment
EMP	Electromagnetic Pulse	EMP is the non-ionizing EM radiation (EMR) from a nuclear explosion.
EMV	Electromagnetic Vulnerability	EMV is the characteristic of an item that causes it to suffer degraded performance, or the inability to perform its specified task, as a result of the operational EME. An item is said to be vulnerable its performance is degraded below a satisfactory.
ESD	Electrostatic Discharge	ESD can cause intermittent or upset (transient) failures as well as permanent damage to electronics equipment. ESD can also cause hazardous conditions in fuels and ordnance, as well as presenting a shock hazard to personnel.
HERF	Hazards of Electromagnetic Radiation to Fuels	The potential for electromagnetic radiation to cause ignition or detonation of volatile combustibles is referred to as HERF and/or analyses.
HERO	Hazards of Electromagnetic Radiation to Ordnance	Hazards that result from adverse interactions among radio frequency emitters and electrically initiated devices or initiating systems contained within ordnance systems (e.g., fuses).
HERP	Hazards of Electromagnetic Radiation to Personnel	The potential for electromagnetic radiation (EMR) to produce harmful biological effects in humans is referred to as HERP.
Lightning	Lightning	Lightning effects are divided into direct (physical damage) and indirect (EM-induced electronics damage) effects; both effects may occur to the same component.
P-Static	Precipitation Static	P-static is an EM disturbance caused by a random electrostatic charge buildup as a result of the flow of air, moisture, or airborne particles over the structure or components of a vehicle moving in the atmosphere, such as an aircraft or spacecraft.
SC	Spectrum Certification	The statement(s) of adequacy received from authorities of sovereign nations after their review of the technical characteristics of a spectrum-dependent equipment or system regarding compliance with their national spectrum management policy, allocations, regulations, and technical standards.
SM	Spectrum Management	Planning, coordinating, and managing the use of the electromagnetic spectrum through operational, engineering, and administrative procedures with the objective of enabling electronic systems to perform their functions in the intended environment without causing or suffering unacceptable interference.
SS	Spectrum Supportability	The assessment as to whether the electromagnetic spectrum necessary to support the operation of a spectrum-dependent equipment or system during its expected life cycle is, or will be, available.

**Figure 19-1 Key E3/SS Terms and Definitions**

## 19.3 E3/SS Planning, Analysis, SE, and T&E For the Systems Acquisition Process

### 19.3.1 Planning for T&E Considerations throughout the Acquisition Processes

To ensure that E3/SS concerns are given due consideration, it is essential to include E3/SS in the acquisition process from the very beginning. The following sections address the planning, documentation, and actions in which E3/SS must be taken into account to ensure that issues have been effectively controlled, and that limitations and vulnerabilities have been identified and documented. These evaluations should be initiated at the earliest practical point (preferably prior to MS A) in the items life cycle so that deficiencies can be identified early and corrected. General test requirements and guidelines for [EMC](#) are contained in Reference (bm). The overarching standard is [Reference \(bn\)](#). The S-Diagram in Figure 19-1 provides gives a graphical depiction of the major inputs and decision points in the acquisition process from an E3/SS perspective. This depiction shows decision points that are driven by the need to demonstrate that no operational E3 problems will exist during IOT&E. Thus, if the consensus of experts in the E3 field is that there is no possibility of E3 and spectrum issues going forward, then from that point, the issue is no longer considered. Detailed guidance is available in [section 6](#) of Reference (bk). The following sections provide a brief chronological summary of the documentation, technical reviews, and test activities that need E3/SS input. The checklists for each milestone are provided at the end of this chapter.

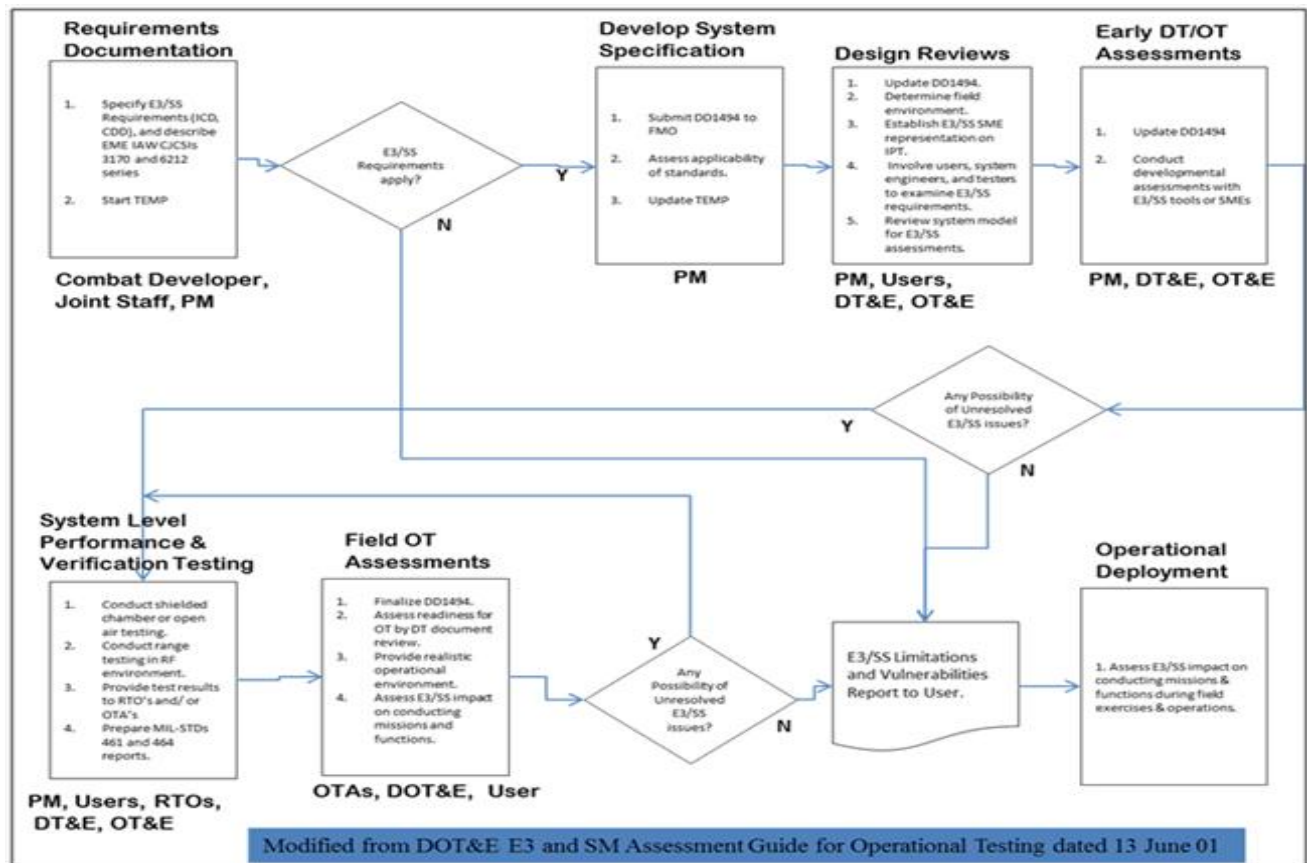


Figure 19-2 S-Diagram



### 19.3.2 Requirements Documentation

Requirements for developmental systems are often determined during pre-acquisition technology development, such as the warfighting experiments conducted by the Military Services and the U.S. Joint Forces Command; Advanced Technology Demonstrations (ATDs); and ACTDs. An AoA is conducted to demonstrate preferred concepts that will go forward to the TD phase if the solution requires new development rather than new TTPs. As the concept for the technology matures, so should the understanding of the EME in which the system is expected to operate. Correctly defining the EME early in the program will have a significant impact on success. The EME includes intra-platform system interactions, interaction with other known friendly and adversary systems, and the natural and man-made environment in the expected area of operations.

As early as practical, a determination should be made as to whether the project has E3/SS concerns or safety issues regarding hazards of electromagnetic radiation that should be addressed. The E3/SS related tasks include refining cost estimates and ensuring that all of the needed analysis and design work is planned. Initial analysis needs to be conducted to provide assessments sufficient to ensure that E3/SS requirements are adequately addressed in the appropriate requirements documents in accordance with Reference [\(ad\)](#) , [\(bl\)](#) , [\(bm\)](#) and [\(bn\)](#) .

The PM must ensure that E3/SS requirements are addressed from the outset of the program. This includes both performance specifications and development standards. Detailed guidance is provided by MIL-HDBK 237 Series, Reference [\(bm\)](#) and [\(bn\)](#) . The ICD should define authoritative, measurable, and testable capabilities and define KPPs. The information support plan (ISP) documents the programs interoperability requirements and interface requirements and must include consideration of E3/SS control. The ITR should support the development and clarification of these requirements. For more details, see of [Reference \(bk\)](#) .

It is highly recommended that the RFP contain language that clearly makes the contractor responsible for ensuring compliance with E3/SS requirements. It is important to realize that any design change will require reevaluation of the E3 considerations. Something that may seem trivial, like rerouting a cable or moving a connector 6 inches, can cause intra-system electromagnetic interference (EMI) problems. EMI is a complex problem in which it is difficult to model everything, and it is not to be taken lightly. Therefore, the contractor is best able to monitor this level of detail by analyzing, testing, and verifying components and systems throughout development. For example, the RFP may state the following:

- The contractor shall design, develop, integrate, and qualify the system such that it meets the E3/SS performance requirements of the system specification.
- The contractor shall perform analyses, studies, and testing to establish E3/SS controls and features to be implemented in the design of the item.
- The contractor shall perform inspections, analyses, and tests, as necessary, to verify that the system meets its E3/SS performance requirements.



- The contractor shall prepare and update the DD Form 1494 throughout the development of the system for spectrum-dependent equipment and shall perform analysis and testing to characterize the equipment, where necessary.
- The contractor shall establish and support an E3/SS WIPT to accomplish these tasks.
- MIL-HDBK-237D may be used for guidance.

The SRR is a system-level review conducted to ensure that the EME, E3/SS performance requirements, test requirements, and plans for all E3/SS analyses and predictions are clearly understood by both the Government and the contractor and are spelled out in the SOW, CDRLs, the specification, and the TEMP as needed.

### **19.3.3 Develop Systems Specification**

#### **19.3.3.1 Spectrum Support**

[OMB Circular No. A-11](#) (Reference (bp)) requires that spectrum support be obtained before submitting funding estimates for the development or procurement of systems or equipment. In addition, certification is required before funds are obligated for spectrum-dependent systems or equipment. To accomplish this certification, a DD Form 1494 must be submitted to the appropriate Service frequency management office (FMO) in accordance with policies and procedures of [DoDI 4650.01](#) (Reference (bq)), [Reference \(d\)](#), and the form itself. The data required and provided on the DD Form 1494 are maintained at the Joint Spectrum Center and benefit that portion of the DoD spectrum management (SM) community involved in mission planning and training operations. The DD Form 1494 must be updated at each design review to ensure that the data are current and accurate. These data enable the following:

- Frequency assignments for DoD operations, exercises, and training, including coordination with foreign (host) nations for use of DoD systems overseas.
- Mitigation or resolution of EMI problems.
- Siting of new DoD or commercial systems on ships, on aircraft, in space, and at shore sites.
- Integration of CI into the intense EME found on military platforms and installations.
- Establishment of mutually beneficial parameters for spectrum sharing with industry.

The PM must also develop a justification and a proposed plan to obtain SS authorization from the National Telecommunications and Information Administration or the Military Communications-Electronics Board (MCEB) to proceed into the EMD phase.

#### **19.3.3.2 Establishing IPTs**

Before MS B, the PM must establish working IPTs as needed to ensure that appropriate SMEs are involved to represent the relevant technical areas well enough to assess program risks and costs related to performance trade-offs. The IPT should include members with sufficient expertise in electrical and

electronics engineering, SM, and SE to address E3/SS issues knowledgeably. Later, once a prime contractor is selected, the design IPTs (commonly one IPT per subsystem and one overall system IPT) must each include members with E3 expertise to guide the designers, ensuring compatibility from the earliest design stages through system integration. This requirement must be dictated in the contract.

### 19.3.3.3 TEMP

The TEMP must ensure that all necessary E3/SS evaluations are conducted during DT&E so that the assessments performed during OT&E will not find new unmitigated E3 issues such as performance and operational limitations and vulnerabilities. Testing is a shared responsibility of the contractor and the Government, with the Government bearing the responsibility but delegating lower level testing such as unit tests and most integration tests to the contractor and holding the contractor accountable to document the test methodology and results. In many cases, systems will include both DoD-developed and COTS electronic equipment. The inclusion of CIs and NDIs eases the design work but, at the same time, increases the importance of effectively testing for E3 concerns and managing spectrum usage. Testing validates the readiness of systems to be fielded into the environment.

Content requirements for the TEMP are defined in [Reference \(j\)](#) , and details are found in References [\(bl\)](#) , [\(bn\)](#) and [\(bo\)](#). The TEMP is organized into four parts that should address the following issues:

- **Introduction**
  - Are MOEs and MOSs established for E3/SS requirements that are addressed in the CDD or CPD?
  - Is E3 identified as a critical operational effectiveness and suitability parameter?
  - Are MOEs and MOPs stated and evaluation criteria and data requirements defined to include E3/SS considerations?
- **Test Program Management and Schedule**
  - Is the schedule for E3 verification events identified?
  - Is T&E responsibility for E3 verification established by organization?
- **T&E Strategy**
  - Has emission and susceptibility testing been planned for the subsystems or equipment in accordance with [Reference \(bm\)](#) or commercial EMI standards, as appropriate?
  - Are E3 tests planned for Commercial Item/NDI?
  - Have platform/system E3 verifications been planned in accordance with [Reference \(bn\)](#) ? (Note that EMI, EMC, and electromagnetic vulnerability (EMV) testing should be required for all platforms or systems, whereas special E3 T&E efforts such as HERO,

HERF, HERP, EMP, lightning, and precipitation static (p-static) may be required on a case-by-case basis, as noted in the CDD, CPD, TEMP, or contract documents.)

- Are E3/SS issues addressed in operational test plans?
- Have intra- and inter-subsystem and equipment E3 verifications been planned for an operational environment?
- Have intra- and inter-platform and system E3 verifications been planned for an operational environment?
- Are special E3 verifications required, depending on the results of DT&E?
- **Resource Summary**
  - Have adequate resources, including M&S, been identified for the following efforts?
    - Subsystem and equipment emission and susceptibility testing.
    - Testing of CI/NDI.
    - [Reference \(bn\)](#) verifications.
    - Operational intra-platform and system EMI evaluations.

#### **19.3.4 Design Reviews**

##### **19.3.4.1 SFR**

The SFR is a review of the conceptual design and technical description of the system to establish its capability to satisfy mission requirements. Both developmental (includes contractor) and operational testers should be reviewers to ensure that the top-level specifications are written in a verifiable manner and that the test program is sufficiently robust to discover and mitigate E3 issues.

##### **19.3.4.2 PDR**

The PDR confirms that the preliminary design logically follows the SFR findings and meets the requirements, and results in approval to begin detailed design. E3/SS documentation and test plans must be updated and E3/SS analysis and predictions are initiated. Both developmental (includes contractor) and operational testers should be reviewers to ensure that the mid-level specifications are written in a verifiable manner and that the test program is sufficiently robust to discover and mitigate E3 issues.

##### **19.3.4.3 CDR**

The CDR evaluates the completeness of the design, its interfaces, and its suitability to start initial manufacturing. E3/SS inputs, documentation, and test plans need to be brought up-to-date. At this

point, it is necessary to ensure that the design has taken into account any limitations or restrictions on its use contained in the approved MCEB DD Form 1494 guidance recommendations.

#### **19.3.4.4 TRR**

The TRR provides the assurance that the system has undergone a thorough test process and is ready for turnover to the next test phase. Ensure that the inputs to the TRR, the E3/SS analysis, and predictions have been completed and that the results inform the criteria for the TRR.

#### **19.3.4.5 E3/SS Analyses and Predictions**

It is essential that E3/SS analyses and predictions be employed in support of the testing and evaluation of electronic platforms, systems, subsystems, and equipment. E3/SS analyses are critical in identifying and resolving potential problems during development and ensuring compatibility in the developmental and operational test phases of the program. The analyses provide essential information to guide the selection of appropriate courses of action to correct problems and should be updated and presented at each design review.

#### **19.3.5 Early DT/OT Assessments**

In general, much of the testing of subsystems and initial integration testing will be performed by the contractor's system developers and system integrators and reported to and reviewed by the PM and the IPTs. A further means of simplifying the DT&E process is to leverage Commercial Item/NDI, often referred to as COTS. The process for incorporating these items is discussed in [section 6.7](#) of Reference (bk). However, blindly using Commercial Item /NDI carries a risk of E3/SS problems within the platform, system, subsystem, or equipment. Commercial Item /NDI should meet the operational performance requirements for that equipment in the proposed installation. In other words, a Commercial Item /NDI may indeed be certified for its original intended use but when integrated into a new system, onto a new platform, and/or fielded to a new EME, the original certification assumptions need to be revisited to determine whether a new evaluation is required.

##### **19.3.5.1 Subsystems and Equipment**

[Reference \(bm\)](#) and [section 6.6.3.2.2](#) of Reference (bj) define the EMI requirements for subsystems and equipment in general; that is, conducted and radiated emission and susceptibility (immunity). [Reference \(bm\)](#) also describes how to tailor and perform tests that can be used for verification of these requirements.

##### **19.3.5.2 Platforms and Systems**

[Reference \(bn\)](#) and [section 6.6.3.2.3](#) of Reference (bj) define the developmental E3/SS requirements for airborne, sea, space, and ground platforms and systems (both new and modified), including associated ordnance. Section 19.3.5.3 provides an overview of the tests needed to verify these requirements. In general, the nature of these tests is to check two at a time paired sub-elements to see whether they interfere, and then add ever increasing elements for more combinations. This testing is sometimes

referred to as source/victim testing. The limits specified in [Reference \(bm\)](#) for subsystems and equipment is empirically derived to cover most configurations and environments. The limits have a proven record of success demonstrated by the relatively low incidence of problems at the platform/system level.

### **19.3.5.3 EMI Testing**

#### **19.3.5.3.1 Intra-platform EMI**

EMI requirements are a risk-reduction initiative, and adherence to them will afford a higher degree of confidence that the platform or system and its associated subsystems and equipment will operate compatibly upon integration. It is essential within a platform or system that the subsystems and equipment be capable of providing full performance along with other subsystems and equipment that are operating concurrently. EMI generated by a subsystem or equipment must not degrade the overall platform or system effectiveness. Intra-platform/system EMI is one of the basic elements of concern and is addressed in detail in [Reference \(o\)](#).

#### **19.3.5.3.2 Inter-platform EMI**

The adverse effects of electromagnetic energy from one system on another or from radio frequency emitters in the operating environment are well documented. [Reference \(bn\)](#) describes airborne, land-based, ship-based, air, and battlespace EME levels and addresses the requirement for inter-platform/system EMI in detail. In addition, [MIL-HDBK-235-1C](#) (Reference (br)) contains friendly and hostile EME levels, as well as emitter characteristics.

#### **19.3.5.4 EMV**

Reference (bq) states that some inter-platform/system EMI testing may be performed under laboratory conditions, in which the item under test and the simulated EME are controlled. Detection of undesired responses during routine EMI testing might necessitate an EMV analysis to determine the impact of the laboratory-observed susceptibility on operational performance. OT in the actual EME rarely is effective in the investigation or verification of susceptibilities because there is much less control on variable conditions, fewer functions can generally be exercised, and expenses can be high.

#### **19.3.5.5 Verification of Special Requirements**

Systems must demonstrate that they meet required protection against environmental threats to systems, specifically, p-static, lightning, EMP, and electromagnetic radiation hazards (HERO, HERP, HERF) IAW References [\(bl\)](#), [\(bn\)](#) and [\(bo\)](#).

### **19.3.6 Developmental Performance and Verification Testing**

DT&E and OT&E are to be conducted at each successive build of a system: the EDM, the first article acceptance test, the LRIP decision point, and at any other points as required.

To understand the role of DT&E and OT&E in the overall acquisition process, it is worth pointing out that a properly executed DT&E program will verify that system design and integration has been done according to design and will prepare the system for operational evaluation. Per [Reference \(bk\)](#), the OT&E program will in turn do the following:

- Estimate the equipment or system E3/SS operational effectiveness and operational suitability, based on analyses and test results to date.
- Test in the operational EME.
- Identify needed E3/SS modifications.
- Provide information about the equipment or system E3/SS operational performance, including tactics, doctrine, organizational, and personnel requirements.
- Verify the adequacy of supporting E3/SS documentation, such as manuals, handbooks, support plans, etc.
- Correct and retest all significant E3/SS deficiencies.

After MS C, system changes must be monitored to determine their impact on requirements for SS and E3 control and to update appropriate requirements documents as necessary. Changes to operational parameters (e.g., tuning range, emission characteristics, antenna gain and height, bandwidth, or output power) or to EME, such as proposed operational locations, may require additional actions through an updated DD Form 1494 or additional E3 analyses or tests.

### **19.3.7 Field Assessments (DT&E in the field in preparation for IOT&E)**

#### **19.3.7.1 Preparation for OT&E**

As the system enters development and operational testing cycles, each series of tests must be preceded by TRRs; a TRR is a review of the programs readiness to begin testing at any level, either by the contractor or by the Government. See Chapter 7 for a more complete description of the TRR. There are several types of readiness reviews that may apply. Not all readiness reviews will apply to each system. In general, each review will require a thorough reevaluation of the E3/SS concerns, with updates to requirements documents as appropriate. Also, the assignment of a frequency will be required to conduct DT and/or OT in open-air ranges. Testers should coordinate with range managers to obtain frequency assignment well in advance of testing .

The reviews should generate specific test guidance to ensure that all relevant E3/SS system issues are adequately tested and reported. Detailed guidance can be found in References [\(bk\)](#), [\(bm\)](#), and [\(bn\)](#).

The TRR is a review to determine readiness for system-level testing, both DT and OT, in an EME with the greater realism during OT. Recommended E3/SS actions and focus areas are as follows:

- Request requisite frequency assignment(s).

- Verify the E3/SS operational test plan and test scenarios.
- Review the E3/SS operational effectiveness and suitability thresholds in the operational requirements section (Part I) of the TEMP.
- Validate all corrections to E3/SS deficiencies discovered during previous testing.
- For airborne platforms or weapon flight tests and for any item requiring interaction with naval systems, additional flight and fleet readiness reviews will likely be required.

As further preparation for testing, ensure that adequate organic support is in place for technical evaluation; the tests should be planned in such a manner that they can:

- Verify attainment of E3/SS performance specifications and objectives.
- Demonstrate that E3/SS risks have been minimized.
- Evaluate compatibility and interoperability with existing or planned equipment and systems.
- Provide assurance that the equipment or system is ready for testing in the operational EME.

It is possible that testing at this stage may reveal problems that require operational rather than materiel changes; for example, prohibiting use of certain frequencies or modes of operation in some circumstances. Any such work-arounds or changes in TTPs must be part of the ensuing OT.

### **19.3.8 Operational Deployment**

#### **19.3.8.1 Reviews in Support of Production Decision**

- SVR and PRR. Once OT&E is complete, the SVR is conducted to verify that the production configuration complies with the performance specification. The PRR is conducted prior to any production decision to validate design readiness, resolution of production engineering problems, and accomplishment of production phase planning. Recommended E3/SS actions are as follows:
  - Validate all corrections to E3/SS deficiencies discovered during previous testing.
  - Review and approve E3/SS test reports.
  - Ensure that subsequent procurements and replacement parts meet original E3/SS program requirements.
  - Physical Configuration Review (PCR). The PCR formalizes the product baseline, including specifications and the technical data package, so that future changes can be made only through full configuration management procedures.

### 19.3.8.2 OT&E

The Services OTAs perform E3/SS OT&E to evaluate operational performance in the presence of other operating items and compliance with KPPs described in Part I of the TEMP and to identify any resulting limitations and vulnerabilities. OT&E should be accomplished in as realistic an operational EME as possible. It is important that resources and assets required for verification of E3 requirements be identified early in the program to ensure their availability when needed. The EME and conduct of tests should be addressed at a high level in Part III of the TEMP. The following guidance applies to operational E3 testing:

- Items used for verification should be in the up-to-date production configuration, preferably the first article.
- EMI qualification testing to either References [\(bm\)](#) or [\(bn\)](#) , as applicable, should be performed before OT.
- All items should be placed in modes of operation that will maximize potential indications of interference or susceptibility, consistent with overall operational performance requirements.
- If it has been determined during DT or field tests that work-arounds or changes in TTPs are needed, the OT personnel need to demonstrate that they can adapt to the changes and the changes must be deemed to be operationally satisfactory.

#### 19.3.8.2.1 Intra-Platform/System EMI Testing

Subsystems and equipment should be designed and integrated to coexist and to provide the operational performance required by the user. The following issues should be addressed during operational intra-platform/system EMI testing:

- Potential EMI source vs. victim pairs should be identified and systematically evaluated by exercising the subsystem and equipment onboard the platform or system through the various modes and functions while monitoring the remaining items for degradation. Both one source vs. one victim and multiple sources vs. one victim conditions should be evaluated.
- Evaluation of transmitters and receivers should be conducted across their entire operating frequency ranges.
- Testing should be conducted in an area in which the ambient, or background, EME does not affect the validity of the test results.
- Testing should include all relevant external hardware such as weapons, stores, provisioned items (i.e., those installed in the platform/system by the user) and support equipment.



### 19.3.8.2.2 Additional Intra-Ship Concerns

#### 19.3.8.2.2.1 Intermodulation Interference

The large number of high-frequency transmitters, their high output power, and the construction techniques and materials used on modern ships make the presence of intermodulation interference a reality. On surface ships, various currents from the different transmitters mix in non-linearities within the hull to produce signals at sums and differences of the fundamental and harmonic frequencies of the incident signals. [Reference \(bn\)](#) specifies the tests and analyses necessary to verify compliance with the applicable internal EME requirements.

#### 19.3.8.2.2.2 Shipboard HERO and EME Surveys

Procedures are implemented onboard Navy ships to protect ordnance from the effects of the EME generated by high-power shipboard transmitters. These procedures include creating a ship-specific HERO emission control instruction. A survey should be performed to identify transmitters, antennas, and ordnance handling and loading areas throughout the ship. After the susceptibility characteristics of the ordnance are ascertained, the ships operational worst-case EME should be determined to ensure that potentially hazardous EME levels are not present in areas in which ordnance may be stored, handled, or used. Emissions from transmitters capable of producing potentially hazardous EMEs should then be measured in worst-case conditions at all ordnance locations.

#### 19.3.8.2.3 Inter-Platform/System E3 Evaluations

As with intra-system testing, interactions between known systems raise issues that should be addressed during operational inter-platform/system E3 evaluations, both testing and analyses. Consider the following:

- Potential EMI source vs. victim pairs from friendly, hostile (if known), joint, and combined forces should be identified and systematically evaluated by exercising the subsystems and equipment on each platform and system through their various modes and functions while monitoring the remaining items for degradation. Both one source vs. one victim and multiple sources vs. one victim conditions should be evaluated.
- A frequency selection or emission control plan should be developed for evaluation of transmitters and receivers across their entire operating frequency range.
- Operational evaluation of responses identified by M&S should be performed.
- Testing should be conducted in an area and at a time in which the ambient, or background, EME does not affect the validity of the test results.
- Testing should include all relevant external hardware such as weapons, stores, provisioned equipment (i.e., items installed in the platform or system by the user), and support items.

#### **19.3.8.2.4 Additional Ordnance Concerns**

Inter-platform/system E3 testing involving ordnance should include preflight, captive-carry, and free-flight configurations of the ordnance. Free-flight testing of ordnance may be simulated utilizing an inert, instrumented, ordnance device suspended in a quiet, EM-free environment, such as an anechoic chamber. Use of the anechoic chamber is recommended to determine the radio frequency (RF) points and aspect angles associated with specific susceptibilities. The free-flight test program consists of evaluating weapon performance during the launch, cruise, and terminal phases of flight, while exposed to friendly and hostile EME.

#### **19.3.8.2.5 Additional Aircraft Concerns**

The EME that may be encountered by an aircraft must be reviewed and the status of the aircraft with regard to the environment must be evaluated prior to flight. EMI testing of the subsystems/equipment can be used as a baseline of hardness. However, limited, inter-platform/system testing involving specific emitters may be necessary. If such tests are not performed, operational restrictions on flight paths may need to be imposed.

### **19.4 Summary**

E3 and spectrum concerns are challenges of the modern system. Proper SE, informed by thorough M&S and even more thorough T&E, is required for successful system deployment and utilization. The key points in the system development life cycle that specifically require E3/SS input are summarized in the checklists below.

#### **CHECKLIST FOR T&E ASSESSMENTS FOR E3 and SS**

Objective: To identify to the best extent possible the E3 and SS limitations and vulnerabilities of the subject system.

#### **PM Responsibilities:**

1. DD Form 1494 submitted to the Service FMO.
2. Status of host-nation frequency supportability description of operational EME (e.g., operational environment, theater, mission in the operations plan).
3. Latest program documentation (e.g., ICD, CDD, CPD, APB, C4 ISP, specification).
4. TEMP that contains:
  - a. E3 within the scope of a COI (TEMP, Part I).
  - b. List of tests and analyses used to determine the equipment effectiveness/ suitability/survivability performance in the operational EME (TEMP, Part III).
5. Copy of the following analyses and/or T&E data:

a. Intra-platform/system analyses:

- (1) Antenna coupling and blockage analyses and/or test data.
- (2) Subsystem/equipment EMC analyses and/or test data.
- (3) CI/NDI/GFE EMC analyses and/or test data.

b. Inter-platform/systems EMC analyses and/or test data for spectrum-dependent (Joint E3 Evaluation Tool (JEET) model) and non-spectrum-dependent equipment.

6. Special E3 analyses and/or test data (i.e., HERO, HERP, HERF, EMP, lightning, and p-static), if required by the CDD, CPD, or TEMP.
7. E3 and SM impact assessments that identify and define operational limitations and vulnerabilities (i.e., lessons learned).
8. DT&E test plans and results/reports.

**Lead DT and OTA Responsibilities:**

1. Develop and execute DT&E test plans and evaluate results in advance of OT&E.
2. Develop and execute OT&E test plan and evaluate results.
3. Evaluate spectrum certification documents and comply with requirements as appropriate.

**ACQUISITION DATA REQUIREMENTS CHECKLISTS FOR E3 and SS**

**Milestone A Checklist**

**Objective:** To ensure that E3 and SS are addressed in requirements documents, ACTDs/ATDs, joint warfighting experiments, concept refinements, and technology developments.

**Required Information:**

1. DD Form 1494 submitted to Service FMO indicating intent to comply with applicable DoD, national, and international SM policies and regulations.
2. Requirements documents, demonstrations, and experiments that address the following:
  - a. Does the project address E3?
  - b. Does the project address the requirement for SS?
  - c. Does the project address the safety issues regarding HERO, if applicable?

**Milestone B Checklist**

**Objective:** To ensure that E3 and SS issues are identified and adequately addressed.

**Required Information:**

1. DD Form 1494 submitted to Service FMO.
2. Status of host-nation approval (HNA) efforts.
3. CDD/CPD that addresses the following:
  - a. Description of operational EME (the operational environment, theater, mission in the operations plan, etc.
  - b. Compliance with applicable DoD, national, and international SM policies and regulations.
  - c. Intra- and inter-platform/system EMC.
  - d. E3 specialty issues (HERO, HERP, HERF, EMP, lightning, electrostatic discharge (ESD), and p-static, as appropriate).
4. TEMP, with a set of KPPs (TEMP, Part I), a list of verification efforts that addresses effectiveness/suitability/ survivability of the platform, system, subsystem, or equipment in the intended operational EME and provisions for testing CI/NDI (TEMP, Part III).
5. E3 and SS potential risks identified and tests and analyses performed to date that identify and define operational limitations and vulnerabilities.

NOTE: All acquisition documents should contain requirements for E3 and SS tests and analyses.

**Milestone C Checklist**

**Objective:** To identify to the best extent possible E3/SS limitations and vulnerabilities of the subject system, subsystem, or equipment.

**Required Information, as appropriate :**

1. DD Form 1494 submitted to Service FMO.
2. Status of HNA effort.
3. Description of operational EME (i.e., the operational environment, theater, mission in the operations plan, etc).
4. Latest program documentation (mission area ICD, CDD, CPD, ISP, performance specification, and SOW).
5. TEMP that contains:
  - a. KPPs (TEMP, Part I).

b. A list of tests and analyses used to determine the items effectiveness/ suitability/survivability in the operational EME (TEMP, Part III).

6. Copies of the following verification results, including T&E data:

a. Intra-platform/system data, including:

(1) Antenna coupling and blockage analyses and test data.

(2) Subsystem/equipment EMC analyses and test data.

(3) CI/NDI EMC analyses and test data.

b. Inter-platform/system EMC verification results and test data for spectrum-dependent (JEET model) and non-spectrum-dependent equipment).

c. Special E3 analyses and test data (HERO, HERP, HERF, EMP, lightning, ESD, and p-static) if required by the CDD, CPD, TEMP, or contractual documents.

7. E3 and SM impact assessments that identify and define operational limitations and vulnerabilities, including lessons learned.

8. DT&E test plans and results/reports.

9. Initial OT&E test plans and results/reports.

10. User-initiated test results.

## Test & Evaluation Management Guide

### Chapter 20 - Special Topics: Interoperability and Cyber Security

#### 20.1 Policy

The interoperability and cyber security requirements for information systems and national security systems are described in several DoD policy documents including the following:

- [DoDI 4630.8](#) (Reference (bs)).
- [Reference \(bq\)](#).
- [DoDD 8500.01E](#) (Reference (bt)).
- [DoDI 8500.2](#) (Reference (bu)).
- DOT&E Memorandums (Reference [\(bv\)](#) and [\(bw\)](#) ).

The Joint Staff also addresses interoperability and cyber security in Reference [\(ad\)](#), [\(bl\)](#), CJCSI 6212 Series Interoperability and Supportability of Information Technology and National Security Systems, and [CJCSI 6510.01F](#) (Reference (bx)). DoD policy documents pertaining to cyber security and the DoD Risk Management Framework are being drafted. These new documents as well as updates to existing documents will impact T&E support.. The latest version of the referenced document should be referenced when considering interoperability and cyber security. The above references are mutually supportive and collectively can be used to understand and shape T&E to support interoperability and cyber security. Additional T&E guidance, provided by DOT&E, related to cyber security and interoperability is provided in References [\(bw\)](#) and [\(bx\)](#).

Early involvement by the T&E community with the PM, security certification and accreditation agents, and the JITC is essential. This involvement may include collaborative test planning and execution conducted to integrate T&E activities such that test data can be shared and reused to support multiple stakeholders.

#### 20.2 Interoperability Testing

##### 20.2.1 NR KPP

Interoperability is measured by the NR KPP, which is used to assess information needs, information timeliness, cyber security, joint interoperability and supportability, and attributes required for technical exchange of information. The NR-KPP is described in both DoD issuances and Chairman of the Joint Chiefs of Staff directives. [Reference \(bl\)](#) is used to assess information needs, information timeliness, cyber security, and net-ready attributes required for both the technical exchange of information and the end-to-end operational effectiveness of that exchange. The NR KPP consists of verifiable performance measures and metrics required to evaluate the timely and accurate exchange and utility of information to satisfy information needs for a given capability.

The underlying concept driving the inception of the NR-KPP is the DoDs move to a net-centric environment (NCE). The NCE is a framework for full human and technical connectivity and interoperability that allows DoD users and mission partners to share the information they need, when they need it, in a form they can understand and act on with confidence, and protects information from those who should not have it. The NCE supports user requirements for seamless information sharing, ubiquitous application reach, and a fully collaborative environment across organizations and domains. The NR-KPP focuses on the information sharing and security capability of the NCE. The strategy for achieving net readiness should be documented in the TEMP.

The inclusion of the NR-KPP in CDDs, CPDs, and ISPs is mandatory for all acquisition programs and post-acquisition programs for systems used to enter, process, store, display, or transmit DoD information, regardless of classification or sensitivity.

Throughout the program life cycle, the NR KPP is used for analyzing, identifying, and describing system interoperability requirements and developing test strategies to assess them. The test strategy should be specified to a level of detail that allows verification of interoperability.

Final NR-KPP certification is routinely assessed in conjunction with IOT&E but is documented separately through the JITC.

## 20.2.2 NR-KPP Compliance

[Reference \(bl\)](#) calls for the identification of the NR KPP via a three-step process of mission analysis, information analysis, and SE. The specific elements of NR-KPP compliance are no longer specified in [Reference \(bl\)](#); however, common elements are defined in [Reference \(j\)](#).

NR KPP compliance encompasses five elements that should be included for NR-KPP certification. Simplified summaries of these elements are provided below:

**Element 1 Required Documentation** . Having the required documentation means that means that selected aspects of the systems architectural products are compliant as documented via the [DoD Architecture Framework \(DoDAF\)](#) (Reference (cb)) with mandated technical interface standards, that required interface and data-sharing standards are being implemented, that cyber security requirements to include system accreditation are being considered, and that applicable SS documentation requirements are being met. From a T&E perspective, interoperability requirements are confirmed in the approved capabilities document, and ISP/tailored ISP. The cyber security requirements are generally described in the capabilities document, but definitive cyber security requirements can be confirmed in the cyber security acquisition strategy and/or RMF package and provide the basis for cyber security RMF certification and accreditation. Spectrum certification is documented in the DD Form 1494/JF-12 and/or Note to Holder. Notes to Holders of DD Form 1494s provide a process to update existing DD Form 1494 forms as operational systems undergo modifications which change the operating parameters of a spectrum-dependent device.

**Element 2 Supporting Integrated Architecture Products** . This element ensures that the products exist and are developed in accordance with DoDAF standards and that they sufficiently describe a net-centric environment consistent with the capability needs of the program. From a T&E perspective, the key integrated architecture viewpoints include the Technical Standards, Systems Viewpoint (SV)-1 Systems Interface Description, SV-6 Systems Resource Flow Matrix, and Operational Viewpoint (OV)-6c Event-Trace Description.

**Element 3 Global Information Grid (GIG) Technical Guidance Compliance** . This element describes the activities required to establish, use, operate, and manage the DoD net-centric enterprise information environment to include the generic user interface, intelligent-assistant capabilities, net-centric service capabilities (core services, community-of-interest services, and environment control services), and enterprise management components. It also describes a selected set of key standards.

The GIG is the globally interconnected, end-to-end set of information capabilities, associated processes, and personnel for collecting, processing, storing, disseminating, and managing information on demand to Warfighters, policy makers, and support personnel. The GIG includes all of the DoDs owned and leased communications and computing systems and services, software (including applications), data, security services, and other associated services necessary to achieve information superiority.

The GIG Technical Guidance defines the objective end-state for the GIG, which provides a wide variety of on-demand services to users and is the centerpiece of the DoDs move to an NCE. From a T&E perspective, compliance with this requirement is based upon the approved capabilities document and ISP. Additional T&E is not required.

**Element 4 Compliance with DoD Cyber Security Requirements** . Cyber security, formerly identified as IA, includes measures that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation. Key components of the DoD Cyber Security Program include the following:

- Risk Management . Management of IT risks to protect U.S. interests; the Departments ability to conduct operations; and DoD individuals, organizations, and assets in accordance with the [National Institute of Standards and Technology \(NIST\) Special Publication \(SP\)](#) (Reference (by)).
- Operational Resilience . Developing and fielding systems that are flexible, adaptable, and successful in the face of cyber degradation, loss, or attack.
- Integration and Interoperability
  - Semantic Interoperability. The ability of each sending party to communicate data and have receiving parties understand the message in the sense intended by the sending party.
  - Technical Interoperability. The ability for different technologies to communicate and exchange data based upon well-defined and widely adopted interface standards.



- Policy Interoperability. The common business processes related to the transmission, receipt, and acceptance of data among participants.
- Cyber Defense . Ensuring that systems have the capability to take actions to protect, monitor, analyze, detect, and respond to unauthorized activity within DoD information networks.

From a T&E perspective, minimum cyber security RMF requirements are dependent upon the mission assurance category (MAC) and confidentiality level (CL) as defined in the References [\(bt\)](#) and [\(bu\)](#) and as documented in the IA acquisition strategy and RMF package. Some IA controls will be required by the system under test and some will be inherited from the hosting enclave and the computer network defense service provider. References [\(bv\)](#) and [\(bw\)](#) describe a six-step process that is heavily dependent upon IA controls verification activities executed prior to OT&E. Early T&E stakeholder involvement including the DT agent, security certification and authorization agent, and OT agent to execute integrated test planning and execution will facilitate test data sharing and streamline certification, DT, and promote successful IA OT. IA controls implemented by the system and supporting enclave must be in place to enable valid interoperability testing. IA and cyber security requirements are described in section 20.6 of this guide.

**Element 5 Compliance with SS** . This element involves compliance with national, international, and DoD policies and procedures for the management and use of the electromagnetic spectrum. From a T&E perspective, the spectrum certification is confirmed by inspecting the DD Form 1494/JF-12 and/or Note to Holder. As described in [Reference \(bq\)](#) the spectrum certification process begins prior to MS A. A Stage 3 DD Form 1494 is typically required in advance of MS B. A Stage 4 DD Form 1494 is typically required in advance of MS C .

### 20.3 "Operationalizing" the NR KPP

The goal for the OT&E community is to design a test plan for the NR KPP that is operationally meaningful; that is, a test plan that evaluates whether the system/service/capability enables a typical operator to do the following, in support of the mission without significantly increasing the burden on the operator, system administrator, or maintainer:

- Enter and manage data in the network (can be configured and managed as a network entity).
- Exchange data (preserves the meaning and relationships of the information exchanged, given the network constraints, within performance thresholds, in a secure manner (meets IA attributes)) with appropriate spectrum considerations.
- Continue to have access to critical mission functions when under attack (exhibiting operational resilience for critical mission operations).

A test design must focus on the mission contribution of the system or service to mission accomplishment. Various methodologies can be used to assist the test design including mission threads, functional decomposition, and mission execution.

A mission thread focuses the exchange of information for sensor to shooter (i.e., from source through fusion to end user). Functional decomposition and data collection directly assess the contribution of the new capability in terms of task performance, collaboration, and overall mission performance.

Data collection occurs at key interfaces (i.e., collaboration, work-arounds, and/or bottleneck), using instrumentation where available, in conjunction with SME observations. Use of mission threads to trace information exchange and functional decomposition to identify the tasks performed along the thread assesses the contribution of the system in terms of task performance, collaboration, and overall mission performance.

In designing a test plan, consider the following:

- Look for a high degree of organization-to-organization interaction and information exchange/sharing (collaboration).
- Look for broad coverage spanning multiple echelons (depth) and multiple mission/functional areas (breadth).
- Look for high concentration of information systems (integration).
- Look for dependency on information systems.

## 20.4 Role of JITC

For all systems, JITC is responsible to the Joint Staff Directorate for Force Structure, Resource, and Assessment (J-8) to provide interoperability test certification. JITC interoperability evaluations will assess the degree to which the NR-KPP requirements are met and the expected operational impact of any observed discrepancies. JITC may function as the lead testing agency or use test data from other sources to evaluate interoperability. Validation of interoperability cannot be accomplished in conjunction with the systems operational assessment alone; as with other testing and certification agencies, JITC must be engaged early and requires adequate funding from the PM.

The JITC NR-KPP evaluation will leverage all available test activities to achieve an interoperability certification in an efficient and effective manner. JITC may use test data provided by the contractor to evaluate standards conformance, data from DT agents to verify Systems/Service Data Exchanges demonstrated in DT, and/or data from the OT agent to validate Operational Information Exchanges demonstrated during OT. Generally, a special test will be conducted by the JTIC only if other test data are not available. Therefore, it is important to involve the JITC as a key participant in test planning efforts. It is critical that test organizations establish an early framework and test methodology as a foundation for coordinating their activities with the JITC to ensure that each of the elements described in section 20.2.2 is properly assessed.

## 20.5 Supporting Integrated Architecture Products

The supporting integrated architecture products (Element 2 cited in section 20.2.2) are a documented collection of different architectural perspectives or viewpoints. Per [Reference \(cb\)](#), there are eight viewpoints that are in turn composed of more than 50 various supporting products, subsets of which are selected based on program needs. The eight DoDAF viewpoints are summarized below:

- **All Viewpoint (AV)** . This viewpoint provides information pertinent to the entire Architectural Description, such as the scope and context of the Architectural Description. These conditions include doctrine, TTPs, relevant goals and vision statements, CONOPS, scenarios, and environmental conditions.
- **Capability Viewpoint (CV)** . This viewpoint captures the enterprise goals associated with the overall vision for executing a specified course of action. The CV models are high level and describe capabilities using terminology that is easily understood by decision makers and used for communicating a strategic vision regarding capability evolution.
- **Data and Information Viewpoint (DIV)** . This viewpoint captures the business information requirements and structural business process rules for the Architectural Description. It describes the information that is associated with the information exchanges in the Architectural Description, such as attributes, characteristics, and interrelationships.
- **Operational Viewpoint (OV)** . This viewpoint captures the organizations, tasks, or activities performed and the information that must be exchanged between them to accomplish DoD missions. It conveys the types of information exchanged, the frequency of exchange, which tasks and activities are supported by the information exchanges, and the nature of information exchanges.
- **Project Viewpoint (PV)** . This viewpoint captures how programs are grouped in organizational terms as a coherent portfolio of acquisition programs. It provides a way of describing the organizational relationships between multiple acquisition programs, each of which is responsible for delivering individual systems or capabilities.
- **Services Viewpoint (SvcV)** . This viewpoint captures system, service, and interconnection functionality providing for, or supporting, operational activities. DoD processes include warfighting, business, intelligence, and infrastructure functions. These system functions and service resources support the operational activities and facilitate the exchange of information.
- **Standards Viewpoint (StdV)** . This viewpoint is the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements. The StdV provides the technical systems implementation guidelines upon which engineering specifications are based, common building blocks are established, and product lines are developed. It includes a collection of the technical standards, implementation conventions, standards options, rules, and

criteria that can be organized into profile(s) that govern systems and system or service elements in a given Architectural Description.

- **Systems Viewpoint (SV)** . This viewpoint captures the information on supporting automated systems, interconnectivity, and other systems functionality in support of operating activities .

The DoDAF StdV, SV, SvcV, DIV, and OV are of particular importance from an interoperability testing perspective.

Information exchanges identified in architecture products are first evaluated for standards conformance during system development and DT, and then later evaluated during OT for end-to-end operational effectiveness and suitability. Standards conformance testing is addressed in a manner such that risks to achieving full interoperability are mitigated. Standards conformance is confirmed during the capabilities development process and again through structured testing during system development and in DT. The evaluation of the level of testing necessary should be based on the following factors: maturity of the standard, availability of existing standards conformance testing capabilities, and risk associated with system conformance to a specified standard or standards profile.

Standards conformance testing can be costly and time-consuming unless automated tools are available to assist in the process. Wherever possible, contracts should require that the developer conduct standards conformance testing with adequate Government oversight to avoid the need to have the Government repeat that testing after the article has been delivered. Early tester involvement in the RFP and contract can help ensure that the developer is responsible for conducting that testing and delivering appropriate documentation. Options for addressing standards conformance are typically discussed between the acquisition program office and DISA JITC to determine the most cost-effective method of ensuring compliance. Standards conformance testing may be based on several factors include the following:

- Accepting letters of compliance from vendors for mature standards (e.g., commercial voice switches or routers).
- Testing only military-unique features that are implemented over commercial standards (e.g., Defense Switched Network).
- Testing entire MIL-STDs (e.g., tactical data links).

Whenever possible, integrated T&E should be executed to maximize the reuse of interoperability test data. For example, DISA JITC assesses the sufficiency of the data submitted by the program office, developer CDRLs, and DT agent. The DT agent should verify SV-6 requirements in advance of OT. OTAs should leverage data provided from the PM, developer, and DT as entrance criteria for OT. OT should be focused on validating the threshold requirements for the NR-KPP as documented in the critical operational mission threads depicted in the OVs.

In preparation for DT and OT, the test agencies should collaborate with JITC as well as the security certification and accreditation agent to verify that the test and security architecture is representative of

the operational and system views as documented via the integrated architectures and security documentation to identify any discrepancies between the test architecture and the documented views. The DT agency should verify MOPs such as timeliness, accuracy, and completeness of the information exchanges. These data should be shared with DISA JITC and the OTA to ensure that sufficient data are collected to satisfy JITC interoperability certification requirements. Because of the large number of potential information exchanges during OT, evaluations should be scoped to select critical operational activities based upon approved OV and SVs. During the OT, the OTA evaluates end-to-end operational effectiveness of the systems information exchanges to accomplish the mission or task.

## 20.6 Cyber Security and IA Requirements

Cyber security and IA are an integral part of the net-centric concept and T&E. The implementation of cyber security and IA is defined by References [\(bu\)](#) and [\(bw\)](#). A set of security controls are implemented, which are the safeguards or countermeasures prescribed for an information system or platform IT system to protect the confidentiality, integrity, and availability of the system and its information.

Currently, minimum IA security controls are dependent upon the MAC and CL as defined in [Reference \(bu\)](#) and as documented in the IA acquisition strategy and RMF package. IA controls that must be applied are defined in References [\(bt\)](#) and [\(bv\)](#).

References [\(bt\)](#) and [\(bv\)](#) are currently being revised, with publication expected to be in FY 2013, including a definition of transition procedures. The revised policy will describe the scheme for identifying the MAC and CL and the IA security controls defined in the NIST SP (Reference (by)) that comprehensively covers cyber security and IA and will be used instead of the DoD IA controls specified in References [\(bt\)](#) and [\(bv\)](#). DoD-specific assignment values, implementation guidance, and validation procedures for the NIST security controls will be published in the DoD Information Assurance Certification and Accreditation Process (DIACAP) Knowledge Service.

IA controls must be implemented and evaluated in conjunction with interoperability to ensure that those controls do not adversely impact critical operational information exchanges. Questions that should be considered include the following:

- Have applicable IA requirements of References [\(bt\)](#) and [\(bv\)](#) and Director of Central Intelligence Directives (DCIDs) and Intelligence Community Directives (ICDs) been identified?
- Is the system-level IA design (to include the use of enterprise services) in alignment with the IA component of the GIG integrated architecture?
- Has the applicable capability (system) received an authority to operate (ATO) from the appropriate designated accrediting authority?

IA encompasses activities that protect and defend information and systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation. Compliance with References [\(bt\)](#), [\(bv\)](#) and [\(bx\)](#) instructions, regulations, and manuals is the responsibility of the materiel developer and the DT

agent and is confirmed during the capabilities development process. Two aspects that are key to IA requirements from the tester's viewpoint are formal certification and accreditation (C&A) and the role of IA controls.

The checklist for T&E assessments of interoperability and cyber security and the acquisition date requirements checklists for interoperability and cyber security are provided at the end of Chapter 20.

### **20.6.1 C&A**

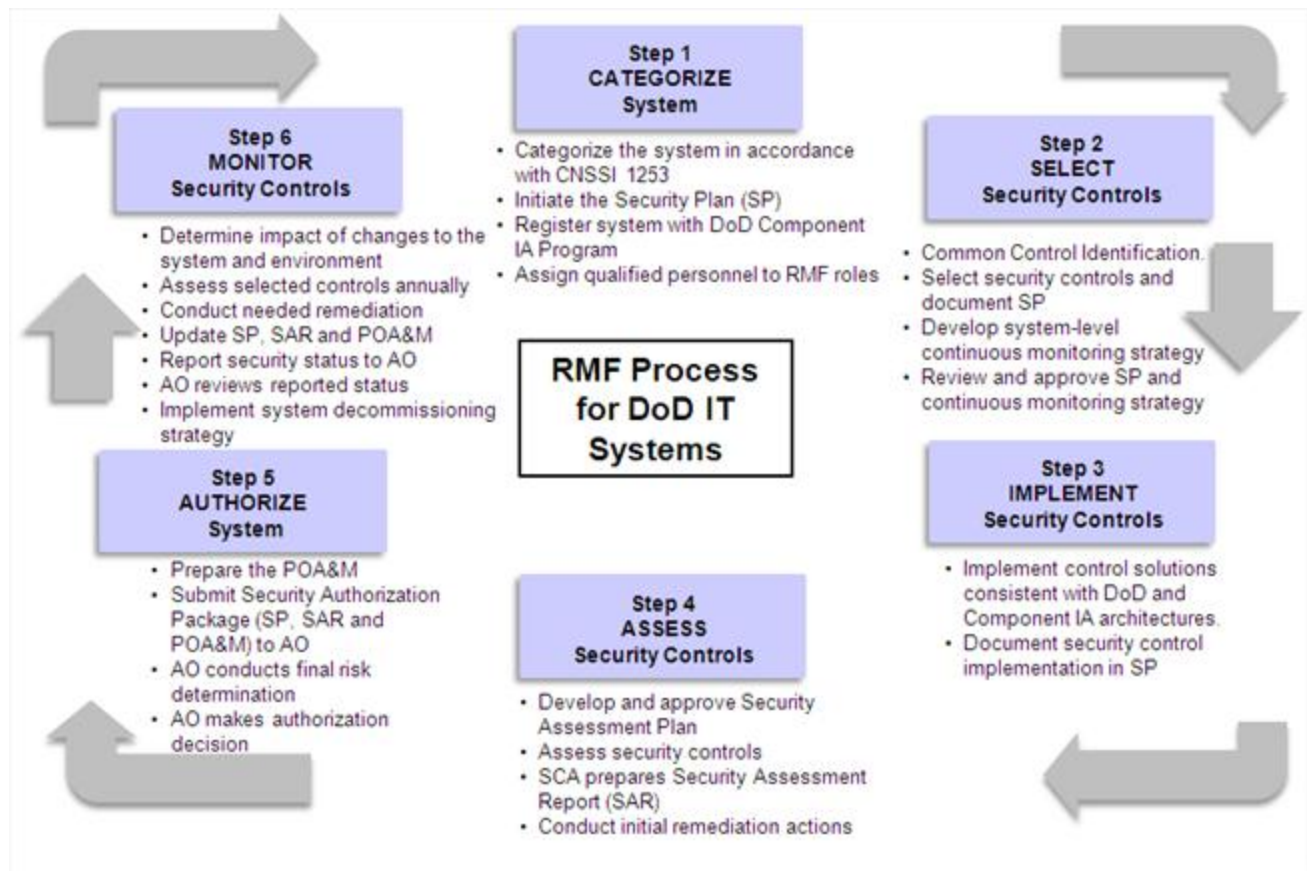
In accordance with subchapter III of chapter 35 of Title 44, U.S.C., all information systems must be certified and accredited. Within the DoD, that process is performed via the DoD RMF process.

RMF details will be specified in the updates to [DoDI 8510.01](#) (Reference (ca)). The RMF and C&A effort is typically a long-lead item and is of interest in TEMP reviews. Most importantly, systems must receive an ATO or at least an interim authority to operate prior to conducting OT and an interim authority to test prior to conducting any IA/network testing.

The RMF process replaces the DoD IA C&A (DIACAP) process and is expected to be implemented in FY 2013.

### **20.6.2 IA Controls**

All sources of IA requirements must be considered in testing. For all DoD systems, under current policy, a set of derived baseline IA controls is developed based on assessment of the systems MAC and CL as identified in the capabilities document and other related documentation such as the system security authorization agreement, SSP, and ATO. The RMF process is described at a high level in Figure 20-1. The detailed process for assessing the system and controls is described in [Reference \(ca\)](#).

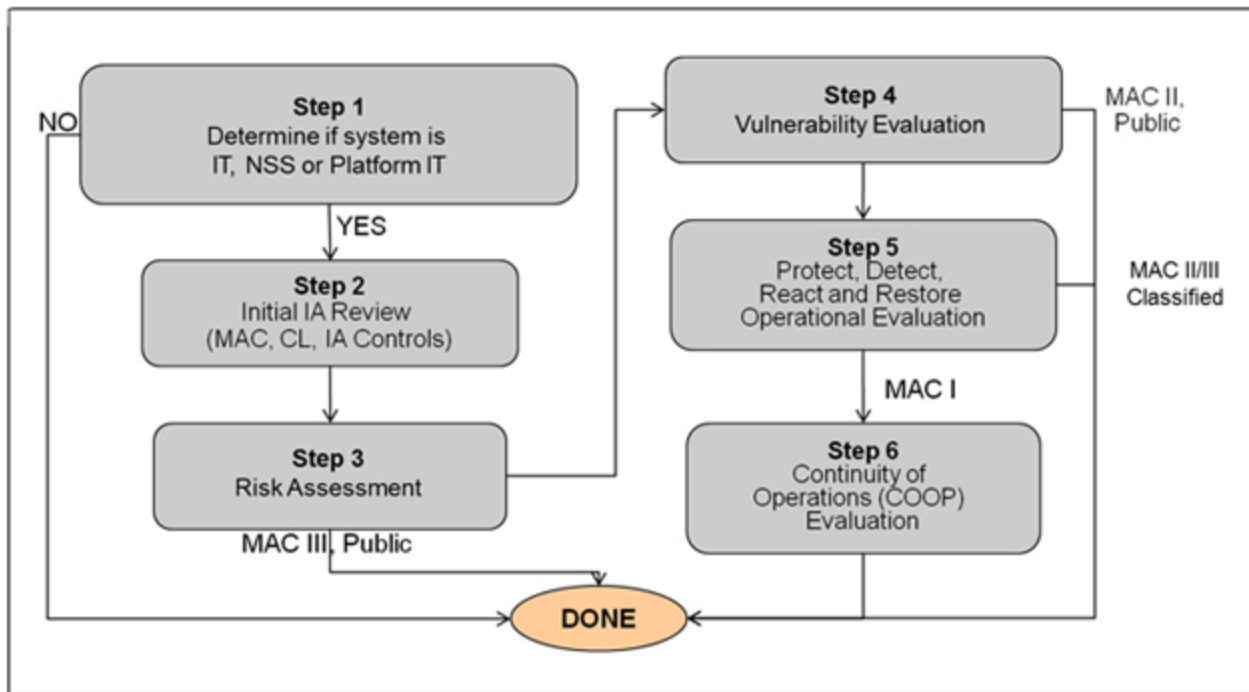


**Figure 20-1 RMF Process**

Appropriate IA controls (which may be technical, procedural, or a combination of both) are integrated into the system as part of its development. Depending on the MAC and CL requirements, these IA controls can add substantial requirements to the system that must be evaluated as part of compliance.

References [\(bw\)](#) and [\(bx\)](#) can be used by all programs to shape IA evaluations. The general process is generally depicted in Figure 20-2. The focus of Steps 1 through 4 of the DOT&E process is the allocation of controls to the system under test and supporting enclave/computer network defense service provider (CNDSP), the verification of those controls through RMF and DT, and the identification and closure of vulnerabilities in advance of OT&E. OTAs execute Steps 5 and 6 with a focus on validation of IA requirements as part of the OT. The status and results of each of the RMF phases should be used to guide development and DT and as exit criteria for DT and entrance criteria for OT.

OTAs may conduct additional IA validation activities including red teaming and continuity of operations (COOP) evaluation activities in support of OT using guidelines provided by DOT&E. Using such teams during an OT, the OT can demonstrate the ability to protect, detect, respond, and restore systems in an operational environment and determine overall vulnerabilities with operations security (OPSEC) processes and procedures.



**Figure 20-2. Procedures for OT&E of IA in Acquisition Programs**

### 20.6.3 IA Security Controls Testing Recommendations

IA testing is a complex area with many moving parts. Several studies have addressed ways to improve the process. One recent review of this area recommended the following:

- Establish an Integrated T&E IPT prior to RFP/contracting, which should include interoperability, security C&A agent, DT&E, OT&E, PM, and computer network defense (CND) representatives.
- Address IA during early system acquisition and engineering activities to ensure that IA controls are being considered in the design.
- Integrated Test Teams (ITTs) should collaborate to identify meaningful and measurable IA test criteria that address IA MOEs and MOPs to include end-to-end IA MOEs that address system operation in a network context.

### 20.6.4 Anti-Tamper Considerations

A topic sometimes considered as part of an overall IA strategy or part of program protection planning/critical program protection is anti-tamper (AT). For AT testing, the program office develops an AT validation plan, typically classified, and provides the necessary funding for the AT V&V on actual or representative system components. This plan is reviewed and approved by the DoD AT Executive Agent. The AT Executive Agent witnesses these V&V activities and verifies that the AT plan is implemented into the system and works according to the AT plan.



### 20.6.5 Supplier Risk Management

T&E supports identification of and countering risks related to suppliers. Due diligence analysis for items of supply is performed to counter unintentional vulnerabilities, intentional vulnerabilities (e.g., malicious wares and processes), and counterfeits. Testing activities may include software static analysis, dynamic analysis (including the use of simulation, white and black box testing), penetration testing, and testing to ensure that the component or service is genuine (e.g., through tag, digital signature, or cryptographic hash verification).

### 20.6.6 Cyber Security and Operational Resilience

Operational resilience (being flexible, adaptable, and successful in the face of cyber degradation, loss, or attack) has three conditions: (1) Information resources are trustworthy, (2) Missions are prepared for information resources degradation or loss, and (3) Network operations have the means to prevail in the face of adverse events. T&E supports the implementation of operational resilience by performing OT&E of IA capabilities to include the ability to detect and react to penetrations and exploitations and to protect and restore data and information, in order to inform acquisition and fielding decisions. Testing should include exercising under realistic cyber conditions and testing procedures and tactics for work-arounds and fallbacks in the face of hostility. This process may include conducting periodic exercises or evaluations of the ability to operate during loss of all information resources and connectivity. This also includes being able to dynamically allocate information resources as needed to sustain mission operations while addressing cyber failures, no matter the cause, and being able to rapidly restore information resources to a trusted state while maintaining support to ongoing missions.

### 20.7 Agile Development and T&E

A current trend in DoD acquisition is the use of the agile development model, allowing acquisition and delivery of IT functionality in a relatively short timeframe. The agile development model relies on a closely knit development and test team that performs iterative and incremental development, with requirements and solutions evolving in a highly collaborative environment. Implementing the agile development model into the standard DoD acquisition life cycle, with existing documentation and test requirements levied on a DoD major acquisition program, is a challenge.

Agile integrates software testing into the development process. Agile-designated programs have incremental and closely integrated development and testing cycles, evolving functionality requirements, and intermittent releases of Warfighter-required functional components or capabilities. In this environment, software testing in particular is integrated in the development process and formal documents, such as the TEMP, and test events may be significantly modified or replaced by other more applicable documentation and events. These modified documentation requirements and events are currently being defined.

Integrated testing is a key feature of agile development. The agile model advocates creating an ITT to facilitate test planning, test script development, test conduct, and data collection during the development and testing cycles. As the DoD joint interoperability test certification authority, JITC is

developing guidance for agile-designated programs to support integrated testing in order to evaluate joint interoperability.

Additional guidance on agile development and agile-designated programs is in development and will be included or referenced, as appropriate, when it becomes available.

## 20.8 Summary

The NR-KPP components include interoperability and cyber security. These components are interdependent and have historically been tested and evaluated by stakeholders throughout the acquisition process. The challenges for each stakeholder are to determine what is essential and to develop an integrated T&E methodology that tests essential elements and creates an environment in which data can be shared by the PM, interoperability, security C&A, DT, and OT.

DISA JITC, as the DoD interoperability certifier, has the primary responsibility for assessing compliance of the NR-KPP. As with other parts of a systems evaluation, the NR-KPP evaluation leverages and uses data from DT and OT. IA is an integral part of interoperability testing. New development methods such as agile present new challenges for interoperability testing and require close coordination with JITC and the developer to leverage testing performed during agile development for use during interoperability certification. As the underlying components of the NR-KPP continue to evolve, the data required for each test will likewise evolve. Close coordination between the user community, materiel developer, security C&A agent, DT and OT test agencies, and JITC to ensure that the proper collected data support the data requirements of all stakeholders is crucial to fielding effective, suitable, survivable, and secure systems to the Warfighter.

## CHECKLIST FOR T&E ASSESSMENTS OF INTEROPERABILITY AND CYBER SECURITY

**Objective:** To ensure that interoperability and cyber security requirements are addressed.

Information as appropriate to program development responsibility

### PM Responsibilities:

1. Latest program documentation (e.g., ICD, CDD, CPD, ISP).
2. TEMP.
3. DT&E test plans and results/reports.

### Lead DT and OTA Responsibilities:

1. Develop and execute DT&E test plans and evaluate results in advance of OT&E.
2. Develop and execute OT&E test plan and evaluate results.

## ACQUISITION DATA REQUIREMENTS CHECKLISTS FOR INTEROPERABILITY AND CYBER SECURITY

### Milestone A Checklist

**Objective:** To ensure that interoperability and cyber security/IA are addressed in requirements documents, concept refinements, and technology developments.

#### Required Information:

1. ICD that addresses the following:
  - a. IA requirements.
  - b. CND architecture.
  - c. Interoperability requirements.
  - d. Threat environment.
2. T&E strategy that includes NR KPP elements.

### Milestone B Checklist

**Objective:** To ensure that interoperability and cyber security/IA are addressed in requirements documents, concept refinements, and technology developments.

#### Required Information:

1. CDD and ISP that address the following:
  - a. Description of operational environment.
  - b. Intra- and inter-platform/systems, CNDSPs.
2. TEMP with the following:
  - a. NR-KPP, a list of verification efforts that addresses effectiveness/suitability/ survivability of the platform, system, subsystem, or equipment in the intended operational environment.
  - b. Identification of IA testing roles and test strategy.

### Milestone C Checklist

**Objective:** To identify the limitations and vulnerabilities of the subject system, subsystem, or equipment and its interoperability and cyber security/IA considerations.

**Required Information:**

1. Latest program documentation (ICD, CDD, CPD, ISP, performance specification, and SOW).
2. TEMP that contains:
  - a. System Description:
    1. MOEs and MOSs established for NR KPP and IA in the CDD or CPD.
    2. Critical operational effectiveness and suitability parameters identified for NR KPP and IA.
    3. MOEs and MOPs stated and evaluation criteria and data requirements defined to include NR KPP and IA.
  - b. System Introduction:
    1. Schedule identifying NR KPP and IA events.
    2. T&E responsibility identified for NR KPP and IA.
  - c. DT&E Outline:
    1. Coordination with JITC identified.
    2. Description of interoperability test plans.
  - d. OT&E Outline:
    1. Coordination with OT&E identified.
    2. Identification of completion of critical DT events as entrance criteria for OT.
    3. A list of tests and analyses used to determine the items effectiveness/suitability/survivability in the operational environment.
3. Copies of the following verification results, including T&E data:
  - a. DT&E test plans and results/reports.
  - b. Initial OT&E test plans and results/reports.

## **Test & Evaluation Management Guide**

### **Chapter 21 - Multi-Service and Joint Testing**

#### **21.1 Introduction**

This chapter discusses the planning and management of a multi-Service test program. A multi-Service test program is conducted when a system is to be acquired for use by more than one Service or when a system must interface with equipment of another Service. A multi-Service test program should not be confused with an OSD-sponsored JT&E program. JT&E is discussed section 21.8 of this guide.

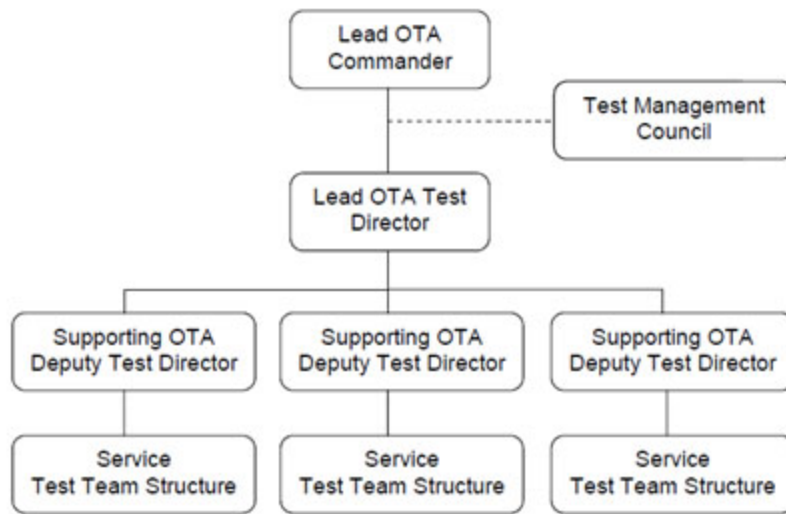
#### **21.2 Background**

Multi-Service T&E is conducted by two or more DoD Components to address acquisition or interface equities across each organization. All affected Services and their respective OTAs participate in planning, conducting, reporting, and evaluating the multi-Service test program. One Service is designated as the lead Service and is responsible for management of the program. The lead Service is charged with the preparation and coordination of a single report that reflects the systems operational effectiveness and suitability across all participating Services.

The management challenge in a joint acquisition program conducting multi-Service T&E stems from the fact that the items undergoing testing will not necessarily be used by each of the Services for identical purposes. Differences among the Services usually exist in performance criteria, tactics, doctrine, configuration of armament or electronics, and the operating environment. As a result, a deficiency or discrepancy considered disqualifying by one Service is not necessarily disqualifying for all Services. It is incumbent upon the lead Service to establish a discrepancy reporting system permitting each participating Service to document all discrepancies consistently within the policies and criteria used by each participating Service. At the conclusion of a multi-Service T&E, each participating OTA may prepare an IER in its own format and submit that report through its normal Service channels. The lead Service OTA may prepare the documentation that goes forward to the MDA. This documentation is coordinated with all participating OTAs.

Formulation of a multi-Service T&E program designates the participants in the program and gives a lead Service responsibility for preparing a single report concerning a systems operational effectiveness and suitability. (The lead Service is the Service responsible for the overall management of a joint acquisition program. A supporting Service is a Service designated as a participant in the system acquisition.)

A multi-Service T&E program may include DT&E or OT&E or both. The OTAs periodically execute a formal MOA on MOT&E that provides a framework for the conduct of a multi-Service OT program. Figure 21-1 illustrates the MOT&E team composition.



**Figure 21-1 MOT&E Team Composition**

The MOA includes such topics as duties and responsibilities of participants, resourcing agreements, DR criteria, and a glossary of common terms and Service-peculiar terms. Resource requirements are documented in the TEMP. Generally, the process can be summarized as follows:

- In a multi-Service acquisition program, T&E is planned and conducted according to the lead Service regulations. The designated lead Service will have the overall responsibility for management of the multi-Service program and will ensure that supporting Service requirements are included. If another Service has certain unique T&E requirements, testing for these unique requirements may be planned, funded, and conducted according to that Services regulations.
- Participating Services will prepare reports in accordance with their respective regulations. The lead Service will prepare and coordinate a single DT&E report and a single OT&E report, which will summarize the conclusions and recommendations of each Services reports. Rationale will be provided to explain any significant differences. The individual Service reports may be attached to this single report.
- Deviations from the lead Service T&E regulations may be accommodated by mutual agreement among the Services involved

### 21.3 Test Program Responsibilities

Each multi-Service T&E program should establish a WIPT. Its membership consists of one senior representative from each participating Service or agency headquarters. The T&E WIPT works closely with the PMO and is responsible for arbitrating all disagreements among the Services that cannot be resolved at the working level.

Resource requirements are documented in the TEMP. Each participating Service is directed to budget for the testing necessary to accomplish its assigned test objectives and for the participation of its personnel and equipment in the entire test program. Separate annexes may be used to address each Services test requirements. Funding will be in accordance with public law and [Reference \(ao\)](#).

#### 21.4 Test Team Structure

A sample test team structure, taken from [Annex C](#) of the Memorandum of Agreement (MOA) on Multi-Service Operational Test and Evaluation (MOT&E) and Operational Suitability Terminology and Definitions (Reference (cc)), is shown in Figure 21-1. As shown in the figure, Service test teams work through a Service deputy test director or senior representative. The lead Service OTA test director exercises test management authority but not operational control over other Service test teams. The responsibilities include integration of test requirements and efficient scheduling of test events. The deputy test directors exercise operational control or test management authority over their Service test teams in accordance with their Service directives. Additionally, they act as advisers to the test director; represent their Services interests; and are responsible, at least administratively, for resources and personnel provided by their Service.

#### 21.5 Test Planning

Test planning for multi-Service T&E is accomplished in the manner prescribed by lead Service directions and overarching MOA. The process generally follows procedures similar to those outlined below:

- The lead Service T&E agency begins the planning process by issuing a call to the supporting Service T&E agencies for critical issues and test objectives.
- The lead Service T&E agency consolidates the objectives into a list and coordinates the list with the supporting Service T&E agencies.
- The lead Service T&E agency accommodates supporting Service T&E requirements and input in the formal coordination action of the TEMP.
- Participating T&E agency project officers assign responsibility for the accomplishment of test objectives (from the consolidated list) to each T&E agency. These assignments are made in a mutually agreeable manner. Each agency is then responsible for resource identification and accomplishment of its assigned test objectives under the direction of the lead Service T&E agency.
- Each participating agency prepares the portion of the overall test plan(s) for its assigned objectives, in the lead Service test plan(s) format, and identifies its data needs.
- The lead Service T&E agency prepares the multi-Service T&E test plan(s), consolidating the input from all participating agencies.

## 21.6 Deficiency Reporting

In a multi-Service T&E program, a deficiency report is a report of any condition that reflects adversely on the item being tested and that must be reported outside the test team for corrective action. The deficiency reporting system of the lead Service is normally used. All members of the multi-Service test team will report deficiencies through their Services system.

Items undergoing test will not necessarily be used by each of the Services for identical purposes. As a result, a deficiency considered disqualifying by one Service is not necessarily disqualifying for all Services. Deficiency reports of a disqualifying nature must include a statement by the concerned Service as to why the deficiency has been so classified. The deficiency report also includes statements by the other Services as to whether the deficiency affects them significantly.

If one of the participating Services identifies a deficiency that it considers as warranting termination of the test, the circumstances are reported immediately to the test director.

Deficiency reporting is a key part in any multi-Service T&E MOA. Figure 21-2 shows a sample deficiency report summary, as found in [Annex D](#) of Reference (ca).

Sample Deficiency Report Summary										Current Date		
Equip Nomen	Report ID	Report Date	Type of Deficiency	Deficiency Description	Cog. Agency	Closure Code	Action Ref	Remarks	Status	Date Information		
										Action AC CLO Date	Test for CLO Date	Last Update
	A		B		C	D						
AN/TCY-18 CNGE, ETC.	EPR 101-41.11-21001-VC-20-RFT, ETC.			SHORT TITLE, PART NO, SUBASSEMBLY, ETC. PLUS PROGRAM EXAMPLES 1. ON-34 INVERTERS FAILED 2. SOFTWARE FLT-8 (DETRID) (DIAG) TRAINING PROBLEM WHEN TTY ON LINE 3. YDU 8 CARD FAILURE INFO. MINOR, OPERATIONAL, ETC.	GTE, ESO, RCA, ETC.	NEEDHAM FORT HUACIACA, ETC.	FMAMS-404, ESD LTR 18 MAR 79	DEPOT REPAIR/REPLACE. TAPE PATCH DUE BY 24 AUG 79. SEE ECP AK-009, ETC.				

A. SERVICE UNIQUE REPORT NUMBER, i.e., EPR KH-41  
B. TERMS LIKE "MAJOR," "MINOR," ETC.  
C. WHERE THE CORRECTIVE ACTIONS WILL TAKE PLACE  
D. PROBLEM REPORT #, DATE OF LETTER SENT TO AGENCY, ETC.

Figure 21-2 Deficiency Report Summary Format



## 21.7 Test Reporting

The following test-reporting policy applies to multi-Service IOT&E:

- The lead OTA will prepare and coordinate the test report reflecting the systems operational effectiveness and suitability for each Service. Interim reports will not normally be prepared.
- The test report will synergize the different operational requirements and operational environments of the involved Services.
- The test report will state findings, put those findings into perspective, and present rationale why there is or is not consensus on the utility of the system.
- All participating OTAs will sign the test report.
- Each participating OTA may prepare an IER or final test report, as required, in its own format and process that report through normal Service channels.
- The lead OTA will ensure that all separate participating Service IERs/test reports are appended to the overall final test report prepared by the lead OTA for submission to the MDA.
- The lead OTA will submit a single integrated multi-Service report to the MDA 90 calendar days after the official end of test is declared but not later than 45 days prior to a milestone decision.

## 21.8 JT&E

JT&E is not the same as multi-Service T&E. JT&E is a specific program activity sponsored by the DOT&E. JT&E is a means of examining joint-Service tactics and doctrine. Details of formulating a JT&E program are set forth in [DoDI 5010.41](#) (Reference (cd)). Figure 21-3 shows the formal process used to identify

JT&E candidates and establish testing priorities.

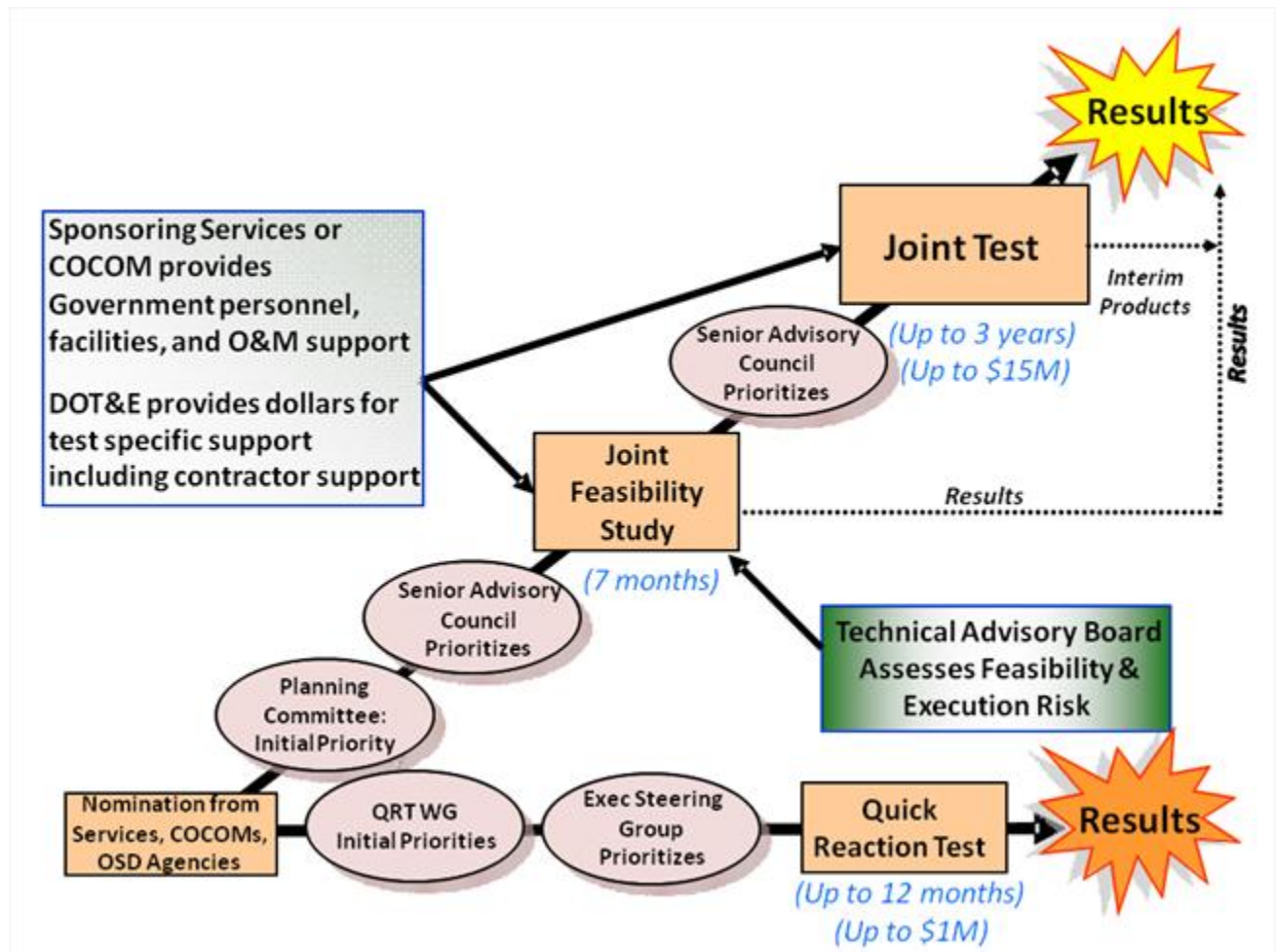


Figure 21-3 JT&E Process

JT&E program objectives include the following: evaluate joint technical and operational concepts and recommend improvements; validate testing methodologies that have joint applications; improve M&S validity with field exercise data; increase joint mission capability, using quantitative data for analysis; provide feedback to the acquisition and joint operations communities; and improve joint TTPs.

JT&E is a conduit for Warfighters to solve joint operational issues. Although the DOT&E manages the program, partnerships with the Services and combatant commands are critical. JT&E does not assess system performance and is not a hardware acquisition program.

The goal of JT&E is to provide the following:

- Non-materiel solutions to Warfighter issues.
- Process improvements so that fielded equipment is used more effectively in a joint operational environment.

Test products that are:

- Improved TTPs, architectures, and training packages.
- New test and evaluation methodologies

## 21.9 Summary

Multi-Service weapon system acquisition test programs are conducted by two or more Services when a system is to be acquired for employment by more than one Service or when a system must interface with equipment of another Service. Test procedures for multi-Service T&E follow those of the designated lead Service, with mutual agreements resolving areas in which deviations are necessary. The MOA on OT&E procedures provides guidance to the OTA. Care must be exercised when integrating test results and reporting discrepancies because items undergoing testing may be used for different purposes in different Services. Close coordination is required to ensure that an accurate summary of the developing systems capabilities is provided to Service and DoD decision authorities. Joint T&E programs involving interested Services are normally short-term TTP-oriented analytical efforts funded and managed by the Office of the DOT&E.

## Test & Evaluation Management Guide

### Chapter 22 - International T&E Programs

#### 22.1 Introduction

This chapter discusses T&E from an international perspective. It describes the OSD-sponsored FCT Program and the international test operations procedures (ITOPs). Factors that bear on the T&E of multinational acquisition programs are also summarized.

#### 22.2 FCT Program

The Comparative Technology Office (CTO) is administered under the Deputy Assistant Secretary of Defense for Rapid Fielding (DASD(RF)). CTO has responsibility over the Defense Acquisition Challenge (DAC) Program and the FCT Program.

The purpose of the FCT Program is to test items and technologies of our allies and other friendly nations that have a high TRL in order to satisfy valid defense requirements more quickly and economically. Since 1980, the FCT Program has helped foster the two-way street in defense spending between the United States and its allies. The purpose of the DAC Program is to provide opportunities for the increased introduction of innovative and cost-saving technology or products into existing DoD acquisition programs.

Each Military Department (Army, Navy, and Air Force) and the U.S. Special Operations Command (USSOCOM) have one or more offices that manage their respective DAC and FCT programs and receive funding and guidance from the OSD CTO. Each Military Department and USSOCOM have acquisition authority for equipping their Warfighters. Because the goal of the DAC and FCT programs is to find and test the best equipment for our Warfighters, the Services and USSOCOM are integral partners.

##### 22.2.1 Program Objectives

CTO provides oversight direction to the FCT Program, the DAC Program, and other projects as assigned by OSD. The FCT Program is designed to support the evaluation of a foreign nation's weapons system, equipment, or technology in terms of its potential to meet a valid requirement of one or more of the Military Services.

The CTO mission is to find, demonstrate, transition, and rapidly transfer the best operational concepts and technology solutions for use by the United States. Some of these solutions may be existing foreign systems. The FCT Program helps ensure that these systems are properly evaluated and that they will satisfy U.S. needs.

CTO objectives are to improve the U.S. Warfighters capabilities and reduce expenditures through the following:

- Rapidly fielding quality military equipment 12 to 18 months after start (funding) of project.
- Eliminating unnecessary duplication of RDT&E.

- Reducing life cycle or procurement costs.
- Enhancing standardization and interoperability.
- Promoting competition by qualifying alternative sources.
- Improving the U.S. military industrial base.
- Promoting international technology exchanges.

The program is managed in accordance with [section 2350\(a\)](#) of Reference (b) and funded centrally by the USD(AT&L).

## 22.2.2 Program Administration

Foreign weapons evaluation (FWE) activities and responsibilities are assigned to the CTO. Each year, sponsoring military Services nominate systems to be evaluated under the FCT Program to the CTO. The Services are encouraged to make submissions whenever a promising candidate that appears to satisfy a current or potential Service requirement is found. Procedures for nominating a system are outlined in the [OSD\(CTO\) Handbook](#) (Reference (ce)).

The fundamental criterion for FCT Program selection is the candidate systems potential to satisfy U.S. operational or training requirements that exist or are projected or the systems possible contribution to the U.S. technology base. Additional factors influencing candidate selection include candidate maturity, available test data, multi-Service interest, existence of a statement of operational need, potential for subsequent procurement, sponsorship by U.S.-based licensee, realistic evaluation schedule cost, DoD Component OSD evaluation cost-sharing proposal, and preprogrammed procurement funds. For technology evaluation programs within the FCT Program, the candidate nomination proposal must address the specific arrangements under which the United States and foreign participants (governments, armed forces, and corporations) will operate. These arrangements may include government-to-government MOAs, private industry licensing agreements, data exchange agreements, and/or cooperative technology exchange programs.

FWE activities are funded by OSD and executed by the Service with the potential need for the system. Points of contact at the HQ level in each Service monitor the conduct of the programs. Work is performed in laboratories and test centers throughout the country.

## 22.2.3 FCT Test Plans

An ideal FCT T&E plan will use all available/acceptable existing test data. Similarly, the plan should seek to validate pass/fail criteria in a phased approach where possible. This approach reduces the DoD financial risk by identifying insurmountable problems early in the T&E process. Testing of items must be such as to ensure performance, operational effectiveness, and operational suitability of an item for military application. A test approach leveraging previous test and operational data of an NDI will save costs.

OSD CTO staff, as part of the project review process, will review FCT test plans, and an approved coordinated test plan must be in place before commencing testing.

[Subpart 225.872 of the Defense Federal Acquisition Regulation Supplement](#) (Reference (cf)) waives the Buy American Act for NATO and other qualifying countries when using the FCT Program.

## **22.3 NATO Comparative Test (NCT) Program**

The NCT Program has been integrated with the FCT Program. The [NCT Program](#) was created per Reference (az). The program supports the evaluation of NATO nations' weapons systems, equipment, and technology and assesses their suitability for use by U.S. forces. NCT program selection criteria are essentially the same as for the FCT Program. The exceptions are that the equipment must be NATO member-nation produced and be considered as an alternative to a system in a late stage of development in the U.S. or offer a cost, schedule, or performance advantage over U.S. equipment. In addition, the NCT Program must notify the Armed Services and Appropriations Committees of the House of Representatives and Senate before funds are obligated. With this exception, the NCT Program follows the same nomination process and administrative procedures as the FCT Program.

Problems associated with testing foreign weapons normally stem from politics, national pride, and a lack of previous test data. The test community must be careful not to allow national pride to be a driving force in the evaluation. U.S. testers must make every effort to obtain all available test data on foreign systems. These data can be used to help validate the evolving test data and additional test data during the evaluation.

## **22.4 T&E Management in Multinational Programs**

### **22.4.1 Compatibility With Allies**

Rationalization, standardization, and interoperability have become increasingly important elements in the materiel acquisition process. [CJCSI 2700.01E](#) (Reference (cg)) requires that equipment for use by personnel of the U.S. Armed Forces stationed in Europe under the terms of the North Atlantic Treaty be standardized or at least interoperable with equipment of other NATO members. Therefore, PMs and TMs must be fully aware of any potential international applications of the systems for which they are responsible.

Representatives of the United States and other NATO countries have executed MOAs concerning the mutual acceptability of each country's T&E data. Such MOAs seek to avoid redundant testing by documenting the extent of understanding among involved governments concerning mutual acceptability of respective T&E procedures for systems that are developed in one country and are candidates for procurement by one or more of the other countries. Focal points for DT and OT in each of the countries are identified, and procedures governing generation and release of T&E data are described in the MOU. The European concept of OT&E is significantly different from that used by the U.S. DoD.

Early and thorough planning is an important element of any successful T&E program but is even more critical in a multinational program. Agreement must be reached concerning T&E procedures, data requirements, and methodology. Differences in tactics, battlefield representations, and military

organizations may make it difficult for one nation to accept another's test data. Therefore, agreement must be reached in advance concerning the OT scenario and battlefield representation that will be used.

#### **22.4.2 ITOPs**

ITOPs are documents containing standardized state-of-the-art test procedures prepared by the cooperative efforts of France, Germany, the United Kingdom, and the United States. Their use ensures high quality, efficient, accurate, and cost-effective testing. Per [Reference \(c\)](#) the DOT&E is the OSD sponsor for providing basic guidance and direction to the ITOP processes. The ITOPs program is intended to shorten and reduce costs of the materiel development and acquisition cycle, minimize duplicate testing, improve interoperability of U.S. and allied equipment, promote the cooperative development and exchange of advanced test technology, and expand the customer base. Each Service has designated an ITOPs point of contact. The Army is the lead Service. Completed documents are submitted to DTIC for official distribution.

#### **22.5 U.S. and NATO Acquisition Programs**

Some test programs involve combined development and test of new weapon systems for U.S. and other NATO countries. In these programs, some differences from the regular normal methodologies occur. An international agreement is concluded with one or more foreign governments including their agencies, instrumentalities, or political subdivisions or with an international organization. [DoDD 5530.3](#) (Reference (ch)), is the principal directive that governs international agreements. However, for cooperative R&D international agreements, References [\(d\)](#) and [\(j\)](#) and the [Office of the USD\(AT&L\) International Armaments Cooperation Handbook](#) (Reference (ci)), delineate streamlined procedures that may be used in lieu of the lengthy requirements mandated by [Reference \(ch\)](#). The definition of an international agreement contains important aspects. It can be concluded by any DoD Component, or in certain situations by the Department of State, with a foreign government or international organization. The United States insists that any international agreement must signify the intention of its parties to be bound in international law. Although [Reference \(ch\)](#) lists many possible denominations for an international agreement, the most common are MOUs or MOAs. Usually, a multinational MOU or MOA is created concerning test program and production funding, test resources, test team composition, use of national assets for testing, etc. Nations are encouraged to use the data that another nation has gathered on similar test programs to avoid duplication of effort.

#### **22.6 Summary**

The procurement of weapon systems from foreign nations for use by U.S. Armed Forces can provide the following advantages: reduced R&D costs, faster IOC, improved interoperability with friendly nations, and lower procurement costs because of economies of scale. This procurement is normally a preferred solution to user requirements before attempting to start a new development. Testing such systems presents specific challenges to accommodate the needs of all users. OT&E conducted by allied and friendly nations may not follow U.S. public law and DoD acquisition regulations. Such testing requires careful advance planning and systematic execution. Expectations and understandings must be well documented at an early stage to ensure that the test results have utility for all concerned.

## Test & Evaluation Management Guide

### Chapter 23 - Commercial Off-The-Shelf and Non-Developmental Items

#### Considerations

##### 23.1 Introduction

Many options are available when an acquisition strategy calls for a materiel solution before electing to develop a new system. They range from the preferred solution of using commercially available products from domestic or international sources to ultimately the least preferred option of a traditional, single-Service new development program. Between these two extremes are other acquisition strategies that can call for using modified systems at different component levels and unmodified or ruggedized cooperative developments to various extents. Figure 23-1 illustrates the spectrum of approaches that can be taken. Complex DoD systems typically use a variety of such approaches. No matter what combination of approaches is used, T&E must be performed. This chapter discusses some key COTS and NDI testing considerations. Additionally, software COTS testing considerations are discussed in Chapter 15 of this guide.

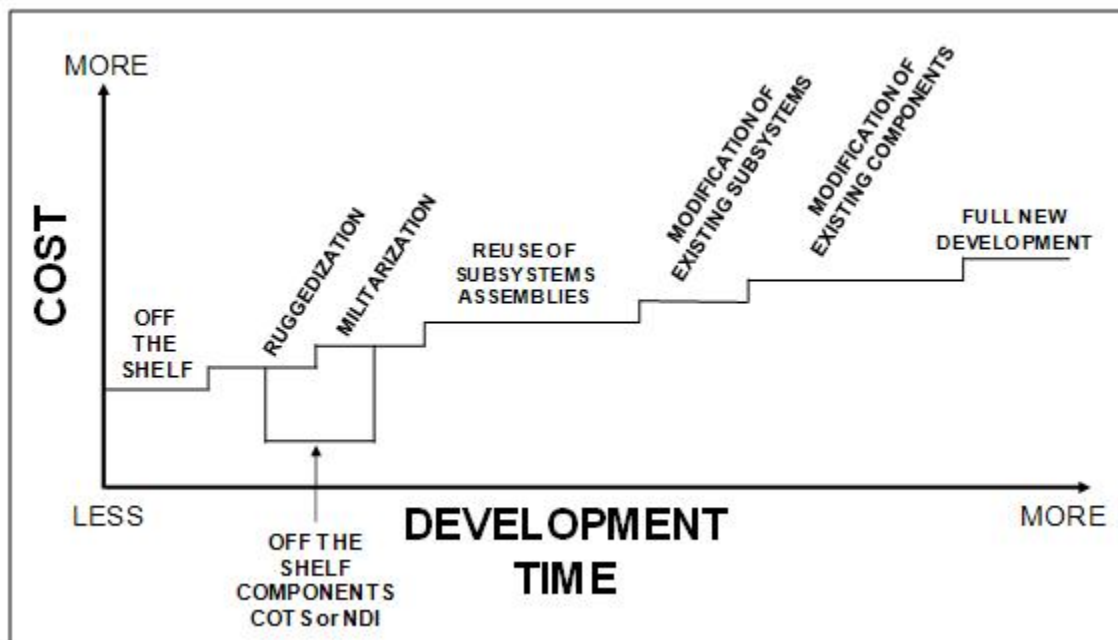


Figure 23-1 Spectrum of COTS/NDI Applicability (not to scale)

##### 23.1.1 Definitions

[Section 2.101](#) of Reference (a) formally defines CI. Generally, a CI is defined as follows:



Any item, other than real property, that is of a type customarily used for nongovernmental purposes and:

- Has been sold, leased, or licensed to the general public; or
- Has been offered for sale, lease, or license to the general public.

Any item that evolved through advances in technology or performance and that is not yet available in the commercial marketplace but will be available in the commercial marketplace in time to satisfy the delivery requirements under a Government solicitation.

Also included in [section 2.101](#) of Reference (a) are services in support of a CI or services of a type offered and sold competitively in substantial quantities in the commercial marketplace based on established catalog or market prices for specific tasks performed under standard commercial terms and conditions; this does not include services that are sold based on hourly rates without an established catalog or market price for a specific service performed.

Per [section 2.101](#) of Reference (a) an NDI is defined as follows:

- (1) Any previously developed item of supply used exclusively for governmental purposes by a Federal agency, a State or local government, or a foreign government with which the United States has a mutual defense cooperation agreement;
- (2) Any item described in paragraph (1) of this definition that requires only minor modification or modifications of a type customarily available in the commercial marketplace in order to meet the requirements of the procuring department or agency; or
- (3) Any item described in paragraphs (1) or (2) solely because the item is not yet in use.

All NDI systems are required to undergo technical and OT&E before the procurement decision, unless the decision authority determines that previous testing or other data (such as user/market investigations) provide sufficient evidence of acceptability.

### **23.1.2 Advantages and Disadvantages of Commercial and NDI Approaches**

The advantages of using CIs and NDIs include the following:

- The time to field a system can be greatly reduced, providing a quicker response to the user's needs.
- R&D costs or TOCs may be reduced.
- State-of-the-art technology may be available sooner.

The disadvantages of using CIs and NDIs include the following:

- Commercial and NDI acquisitions can create logistics support difficulties.
- Commercial and NDI acquisitions may not have comparable competition; therefore, fewer second sources may be available.

- With commercial and NDI acquisitions, engineering and test data often are not available.
- With commercial and NDI acquisitions, it is often difficult to reach agreement among the product provider, developer, and user on the level of modification required for military utility.
- Commercial and NDI acquisitions data rights and software updates.

### 23.1.3 COTS and NDI Operating Environments

Ideally, CIs or NDIs will be used in the same environment and operating conditions and with the same user skill base for which the items were originally designed. Such items normally do not require DT prior to PQT except in those cases in which a contract may be awarded to a contractor that has not previously produced an acceptable finished product and the item is assessed as high risk. In that case, preproduction qualification testing would be required. Also, an OA or some more rigorous level of OT&E might be appropriate.

In the DoD, however, COTS or NDIs can be used in an environment other than that for which the items were originally designed. This is a potential (and frequently overlooked) significant risk area. Such items may require DoD-unique modifications in their hardware and/or software that add complexity to development, support, and T&E. Such items require testing in an operational environment, preproduction qualification testing (if previous testing or modifications for DoD needs resulted in item redesign), and PQT.

Integration of CIs or NDIs into a newly developed system may require some degree of regression testing. These efforts require more extensive RDT&E achieve effective operation of the desired system configuration, which is frequently complicated by the lack of availability of COTS/NDI engineering and test data or by proprietary considerations relating to release of such data. Required testing includes feasibility testing in a military environment, preproduction qualification testing, hardware/software integration testing, OT, and PQT. Additional certification testing may be required, such as transportability (shipboard and airlift) or IA testing.

Given the variety of approaches that may be employed, it is imperative that the acquisition strategy clearly specify, with the agreement of the testing authority, the following:

- The level of testing that will be performed on CIs and NDI systems.
- Access to requisite technical data.
- Understanding how the COTS/NDI environment differs from the envisioned DoD usage.

## 23.2 Market Investigation and Procurement

A market investigation is the central activity leading to the program initiation decision regarding the use of a CI or NDI acquisition strategy. The purpose of the market investigation is to determine the nature of available products and the number of potential vendors. Market investigations may vary from informal telephone inquiries to comprehensive industry-wide reviews. During the market investigation, sufficient data must be gathered to support a definitive decision, to finalize the requirements, and to develop an acquisition strategy that is responsive to these requirements. The search would include dual-use

technologies that meet military needs, yet have sufficient commercial application to support a viable production base.

During the market investigation, a formal request for information process may be followed wherein a brief narrative description of the requirement is published and interested vendors are invited to respond. Test samples or test items may be leased or purchased at this time to support the conduct of operational suitability tests, to evaluate the ability of the equipment to satisfy the requirements, and to help build the functional purchase description or system specification. This type of preliminary testing should not be used to select or eliminate any particular vendor or product unless it is preceded by competitive contracting procedures.

It is imperative that technical and operational evaluators become involved during this early stage of any CI or NDI procurement and that they perform an early assessment of the initial issues. The evaluators must also relate these issues to T&E criteria and provide their independent evaluation plans and reports to the decision authorities in a timely manner.

### **23.3 COTS and NDI Testing**

#### **23.3.1 General Considerations**

T&E must be considered throughout the acquisition of a system that involves CIs and NDIs. Test planning for COTS and NDIs should recognize prior commercial experience and testing performed on the products. Nonetheless, the appropriate levels of DT&E, OT&E, and LFT&E are needed to ensure effective performance in the intended operational environment. The program office should develop an appropriate T&E strategy for CIs. This strategy should include evaluating CIs in a system test bed, when appropriate; focusing such test beds on high-risk items; and testing CI upgrades for unanticipated side effects in areas such as security, safety, reliability, and performance.

The amount and level of testing required depends on the nature of the CI or NDI and its anticipated use; testing should be planned to support the design and decision process. At a minimum, T&E will be conducted to verify integration and interoperability with other system elements. All CI and NDI modifications necessary to adapt the items to the weapon system environment will also be subject to T&E. Available test results from all commercial and Government sources may help determine the actual extent of testing necessary. In medical programs, preliminary test results may be used for down-selecting items for further T&E.

For example, a CI or NDI usually encompasses a mature design. The availability of this mature design contributes to the rapid development of the logistics support system that will be needed. In addition, there are more production items available for use in a test program. These systems also require activity in areas associated with traditional development and acquisition programs. For example, training and maintenance programs and manuals must be developed, and sufficient time should be allowed for their preparation.

When the solicitation package for a CI or NDI acquisition is assembled, it should include the following T&E-related items:

- Approved T&E issues and criteria.
- A requirement that the contractor provide a description of the testing previously performed on the system, including test procedures followed, data, and results achieved.
- PQT and quality conformance requirements.
- Acceptance test plans for the system and its components.

### **23.3.2 Testing Before Program Initiation**

Because reduced acquisition time is an important advantage of using a CI or NDI acquisition strategy, it is important that testing not be redundant and that it be limited to the minimum effort necessary to obtain the required data. Testing can be minimized by:

- Obtaining and assessing contractor test results.
- Obtaining usage/failure data from other customers.
- Observing contractor testing.
- Obtaining T&E results from independent test organizations (e.g., Underwriters Laboratories.)
- Verifying selected contractor test data.

If it is determined that more information is needed after the initial data collection from the above activities, CIs or NDI candidates may be bought or leased, and technical and operational tests may be conducted.

### **23.3.3 Testing After Program Initiation**

All testing conducted after the program initiation milestone decision to proceed with the CI or NDI acquisition solution should be described in the Acquisition Strategy and the TEMP. DT is conducted only if specific information that cannot be satisfied by contractor or other test data sources is needed. OT is conducted as needed, based on the risk assessment provided by the test agency.

T&E continues even after the system has been fielded. This testing takes the form of a follow-on evaluation to validate and refine operating and support cost data; RAM characteristics; logistics support plans; and training requirements, doctrine, and tactics.

### **23.3.4 Special Considerations**

Medical programs, by their nature of almost exclusively consisting of GOTS and COTS items and NDIs, and with the inclusion of other Government agencies participation (i.e., the Food and Drug Administration (FDA)), have special circumstances surrounding their testing.

Medical materiel is governed as a program with significant oversight by the PM and with performance-based requirements composed by an IPT or a high-performance team (HPT). The Defense Medical Materiel Program Office (DMMPO), PMs, joint and Service procurement agencies, Service T&E activities,

and other governmental organizations assist in the development of performance criteria for T&E, for both developmental and non-developmental medical materiel, as stipulated in [DoDI 6430.02](#) (Reference (cj)). Efficacy is based on the products clearance for use by the FDA, if applicable, and compliance with the FDAs rules governing manufacture (i.e., Good Manufacturing Practices). The FDA classifies medical devices into three categories, each more rigorously examined than the last, but no testing is performed by the FDA on these items.

DT of military medical devices is normally limited to airworthiness certification and environmental testing to ensure that the device does not fail due to the austere or harsh environments imposed by the operational environment or interfere with the aircraft where it may be utilized. This testing can often be integrated into or performed alongside the requisite OT. Like items of medical devices and equipment can be difficult to distinguish in terms of overall construction or capability; therefore, effectiveness and suitability (aspects of OT) become the primary delineating factors for selection. This performance under pressure, whether environmental or the stresses of the user, distinguishes the medical devices that will fit the unique needs of military operations from those that are better used in controlled hospital conditions.

### **23.4 Resources and Funding**

Programming and budgeting for a CI or NDI acquisition present a special challenge. Because of the shorter duration of the acquisition process, the standard lead times required in the normal budgeting cycle may be unduly restrictive. This situation can be minimized through careful, advance planning and, in the case of urgent requirements, reprogramming/supplemental funding techniques.

RDT&E funds are normally used to support the conduct of the MSA phase and the purchase or lease of candidate systems/components required for T&E purposes. The RDT&E funds are also used to support T&E activities such as modification of the test article; purchase of specifications, manufacturers publications, repair parts, and special tools and equipment; transportation of the test article to and from the test site; and training, salaries, and temporary duty costs of T&E personnel. Procurement, operations, and maintenance funds are usually used to support P&D costs.

One reason for using a CI or NDI acquisition strategy is the potential for reduced overall TOC. Additional cost savings can be achieved after a contract has been awarded if the PM ensures that incentives are provided to contractors to submit value engineering change proposals to the Government when unnecessary costs are identified.

### **23.5 Summary**

The use of CIs and NDIs in a system acquisition can provide considerable time and cost savings. The testing approach used must be carefully tailored to the type of system, levels of modifications, technology risk areas, and the amount of test data already available. The T&E community must get involved early in the process so that all test issues are adequately addressed and timely comprehensive evaluations are provided to decision authorities.

## Test & Evaluation Management Guide

### Chapter 24 - Testing the Special Cases

#### 24.1 Introduction

This chapter covers the special factors and alternative test strategies that the tester should consider in testing dangerous or lethal weapons, one-of-a-kind or limited production systems, joint capability technology demonstrations, and systems with high-cost and/or special security considerations. Examples include chemical, biological, and medical (CBM) defensive systems; laser weapons; and space and missile systems.

#### 24.2 Testing with Limitations

Certain types of systems cannot be tested using relatively standard T&E for reasons such as a nonstandard acquisition strategy, resource limitations, cost, safety, environmental conditions, or security constraints. In such cases, the TEMP should contain a statement that identifies those factors that will preclude a full and completely realistic OT (IOT&E and FOT&E). The impact of these limitations on the tests COIs must also be addressed.

Nonstandard acquisition strategies are often used for one-of-a-kind or limited production systems. Examples of these include space systems, missiles, and ships. For one-of-a-kind systems, the production decision is often made prior to system design; therefore, testing does not support the traditional decision process. In limited production systems, there are often no prototypes available for test; consequently, the tester must develop innovative test strategies.

Medical programs, by their nature of almost exclusively consisting of GOTS and COTS items and NDIs, and with the inclusion of other Government agencies participation (i.e., the FDA), have special circumstances surrounding their testing. Medical materiel are governed as programs with significant oversight by the PM and with performance-based requirements composed by an IPT or an HPT. The DMMPO, PMs, joint and Service procurement agencies, Service T&E activities, and other governmental organizations assist in the development of OT and performance evaluation criteria for T&E, for both developmental and nondevelopmental medical materiel (As stipulated in [Reference \(cj\)](#)). Efficacy has already been shown, based on the products clearance for use by the FDA, if applicable, and compliance with the FDAs rules governing manufacture (i.e., Good Manufacturing Practices). The FDA classifies medical devices into three categories, each more rigorously examined than the last, but no testing is performed by the FDA on these items.

Testing of military medical devices, because of the reliance on COTS items cleared for use by the FDA, does not typically involve the rigorous DT imposed on other systems. Unless the item is developed specifically for military use, DT is normally limited to airworthiness certification and environmental testing to ensure that the device does not fail due to the austere or harsh environments imposed by the operational scenario. This testing can often be integrated into or performed alongside the requisite OT. Like items of medical materiel can be difficult to distinguish in terms of overall construction or capability; therefore, effectiveness and suitability (aspects of OT) become the primary delineating

factors for selection. This performance under pressure, whether environmental or the stresses of the user, distinguishes the medical devices that will fit the unique needs of military operations from those that are better used in controlled hospital conditions.

Medical devices must also comply with the SEP in terms of [Public Law 104-191](#) (Reference (ck)) and DIACAP information protection procedures and measures. Most medical devices will require Information Management/IT testing and validation of information security protocols. The Army and Air Force have dedicated medical OT agencies, separate from their Service OTAs. These medical OT agencies are empowered by their respective OTAs to conduct OT for medical materiel, and both have sites in place to accommodate Information Management/IT testing. Depending on structure, these responsible medical test agencies work with the PM and the IPT/HPT to evaluate risk, address COIs, and conduct OT events. Each medical test agency evaluates what type of testing will be required and how best to mitigate risks incumbent to fielding the system or device. Service guidelines provide additional information about these structures and processes.

The tester of dangerous or lethal systems, like chemical and laser weapons, must consider various safety, health, and medical factors in developing test plans, such as:

- Provision of medical facilities for pre- and post-test checkups and emergency treatment.
- Need for protective gear for participating/observer personnel.
- Approval of the test plan by the Surgeon General.
- Restrictions in selection of test participants (e.g., medical criteria, use of only volunteers).
- Restricted test locations.
- Safety approvals involving range needs such as flight termination systems and large hazard footprints.
- EISs and compliance with ESOH legal and regulatory requirements.

Also, the tester must allow for additional planning time, test funds, and test resources to accommodate such factors.

#### **24.2.1 CBM Testing**

The testing of chemical and biological defense equipment and medical countermeasures systems (such as chemical and biological detection and reconnaissance systems, individual and collective protection systems, decontamination systems, information management systems, medical devices, drugs and vaccines, and installation and force protection systems) poses unique problems because the tester cannot perform actual open-air field testing. In addition to obvious health and safety factors, test issues that the CBM system tester must address include the following:

- All possible chemical reactions due to variations such as moisture, temperature, pressure, and contamination.
- Physical behavior of the chemical; i.e., droplet size, dispersion density, and ground contamination pattern when used operationally.
- Toxicity of the chemical; i.e., lethality and duration of contamination when used operationally.
- Safety of the chemical weapon during storage, handling, and delivery.

- Decontamination processes.

Addressing all of these issues requires a combination of laboratory chamber tests and open-air field testing. The latter must be performed using simulants, which are substances that replicate the physical and chemical properties of the tested agent but with no toxicity.

The development and use of simulants for testing will require increased attention as more chemical weapons are developed. Chemical and biological agents can demonstrate a wide variety of effects depending on such factors as moisture, temperature, and contamination. Consequently, the simulants must be able to replicate all possible agent reactions; it is likely that several simulants would have to be used in a test to produce all predicted agent behaviors. In developing and selecting simulants, the tester must thoroughly understand all chemical and physical properties and possible reactions of the agent.

Studies of the anticipated reactions can be performed in toxic-chamber tests using the real agent. Here, factors such as changes in moisture, temperature, pressure, and levels of impurity can be controlled to assess the agent's behavior. The tester must think through all possible environmental conditions in which the system could operate so all cases can be tested in the laboratory chamber with the real agent.

Tests to confirm toxicity must be conducted using simulants in the actual environment. Since the agent's toxicity is dependent on factors such as droplet size, dispersion density, ground contamination pattern, and degradation rate, a simulant that behaves as the agent does must be used in actual field testing. Agent toxicity is determined in the lab.

#### **24.2.2 Laser Weapons Testing**

Many new weapon systems are being designed with embedded laser range finders and laser designators. Because of the danger to the human eye posed by lasers, the tester must adhere to special safety requirements and utilize specially configured geographic locations during T&E. For instance, the program seeking to free-play non-eye-safe airborne or ground lasers during tests involves significant precautions, such as the airspace must be restricted from overflight during active testing and guards must be posted to prevent anyone (hikers, bikers, off-road vehicles, equestrians) from accidentally venturing into the area. A potential solution to the safety issue is to develop and use proper procedures to ensure a non-tactical system operation that allows the actual design hardware/software to be part of the unit under test. The tester must ensure that eye-safe lasers produce the same laser energy as the real laser system. Another concern of the laser/directed-energy weapons tester is the accurate determination of energy levels and location on the target. Measurements of the energy on the target are usually conducted in the laboratory. In the field, video cameras are often used to verify that a laser designator did indeed illuminate the target. Such determinations are important when the tester is trying to attribute weapon performance to behavior of the directed-energy weapon, behavior of the guidance system, or some other factor.



### 24.3 Space System Testing

From a historical perspective, space system acquisition has posed several unique problems to the test process, especially the OT process. The root causes generally fall into four categories: limited quantities/high cost, incremental upgrade approach to acquisition, operating environment (peacetime and wartime), and test environment. These root causes are summarized below.

**Limited Quantities/High Cost** . Space systems have traditionally involved the acquisition of relatively few (historically, less than 20) systems at extremely high per-unit costs (in comparison with more traditional military systems). The high per-unit costs are driven by a combination of high transportation costs (launch to orbit), high life-cycle reliability requirements and associated costs because of the lack of an on-orbit maintenance capability, and the high costs associated with leading edge technologies that tend to be a part of spacecraft design. From a test perspective, this situation serves to drive space system acquisition strategy into a nonstandard approach addressed below. The problem is compounded by the incremental upgrade approach to acquisition.

**Incremental Upgrade Approach to Acquisition** . Due to the limited buy and high per-unit cost nature of spacecraft acquisition, these systems tend to be procured using an individual increment acquisition strategy. Under this concept, the decision to deploy is often made at the front end of the acquisition cycle, and the first prototype to be placed in orbit becomes the first operational asset. As early and follow-on systems undergo ground and on-orbit testing (either DT&E or OT&E), discrepancies are corrected by increment changes to the next system in the pipeline. This approach to acquisition can perturb the test process as the tester may have no formal milestone decisions to test toward. The focus must change toward being able to influence the design of (and block changes to) systems further downstream in the pipeline. Because the first on-orbit asset usually becomes the first operational asset, pressure is created from the operational community to expedite (and sometimes limit) testing so a limited operational capability can be declared and the system can begin fulfilling mission requirements. Once the asset goes operational, any use of it for testing must compete with operational mission needs—a situation potentially placing the tester in a position of relatively low priority. Recognition of these realities and careful early-on test planning can overcome many of these problems, but the tester needs to be involved and ready early in the life cycle.

**Operating Environment (Peacetime and Wartime)** . Most currently deployed space systems and near-term future space systems operate in the military support arena such as tactical warning/attack assessment, communications, navigation, weather, and intelligence, and their day-to-day peacetime operating environment is not much different from the wartime operating environment except for activity level (i.e., message throughput, more objects to track/see, etc.). Historically, space has been a relatively benign battlefield environment because of technology limitations in the capability of potential adversaries to reach into space with weapons. But this is no longer valid. This combination of support-type missions and a battlefield environment that is not much different from the peacetime environment has played a definite role in allowing systems to reach limited operational capability without as much dedicated prototype system-level testing as seen on other systems. This situation is changing with the advent of organizations like the Missile Defense Agency, in which actual weapons systems (impact

antisatellite and laser) may be in operation, and day-to-day peacetime operations will not mirror the anticipated battlefield environment as closely. Likewise, the elevation of the battlefield into space and the advancing technologies that allow potential adversaries to reach into space are changing the thrust of how space systems need to be tested in space.

**Test Environment** . The location of space assets in remote orbits also compounds the test problem. Space systems do not have the ready access (as with ground or aircraft systems) to correct deficiencies identified during testing. This situation has driven the main thrust of testing into the prelaunch critical component testing and ground simulation (such as altitude chamber) test environment in which discrepancies can be corrected before the system becomes inaccessible. However, as mentioned previously, when space system missions change from a peacetime focus to a warfighting focus and the number of systems required to do the mission increases from the high reliability/limited number mode to a more traditional fairly large number buy mode, future space system testing could be expected to become more like the testing associated with current ground, sea, and air systems. From a test perspective, this change could also create unique test technology requirements; i.e., with these systems, it will be necessary to bring the test range to the operating system as opposed to bringing the system to the range. Also, because the space environment tends to be visible to the world (others can observe our tests as readily as we can), unique test operations security methodologies may be required to achieve test realism without giving away system vulnerabilities.

In summary, current and near-term future space systems have unique test methodologies. However, in the future, space operations might entail development/deployment of weapon platforms on orbit with lower design-life reliability (because of cost), and day-to-day peacetime operations will not mirror the wartime environment. Thus, space system testing requirements may begin to more closely parallel those of traditional weapon systems.

## 24.4 Cyber Warfare

### 24.4.1 Introduction

Cyber warfare refers to politically motivated hacking to conduct sabotage and espionage. It is a form of information warfare sometimes seen as analogous to conventional warfare although this analogy is controversial for both its accuracy and its political motivation.

Cyber warfare poses a significant threat to U.S. military capabilities: Determined cyber foes can threaten our global logistics network, steal our operational plans, blind our intelligence capabilities, or hinder our ability to deliver weapons on target. The frequency and sophistication of intrusions into U.S. military computers, information systems, and communications networks have increased significantly. Dominance across the full spectrum of operations within the cyberspace warfighting domain is essential if U.S. forces are to maintain a strategic advantage. The following are examples of cyber warfare:

On October 6, 2011, it was announced that the Creech Air Force Base drone and Predator fleets C2 data stream was keylogged and resisted all attempts to reverse the exploitation.

In September 2010, Iran was attacked by the Stuxnet worm, thought to specifically target its Natanz nuclear enrichment facility. The worm was said to be the most advanced piece of malicious software (i.e., malware) ever discovered and significantly increased the profile of cyber warfare.

In April 2007, Estonia came under cyber attack in the wake of relocation of the Bronze Soldier of Tallinn. The largest part of the attacks came from Russia and from official servers of the authorities of Russia. In the attack, ministries, banks, and media were targeted.

The 2008 cyber attack on the United States was to date the worst breach of U.S. military computers in history. It led to the creation of U.S. Cyber Command (USCYBERCOM). It started when a universal serial bus (USB) flash drive infected by a foreign intelligence agency was left in the parking lot of a DoD facility at a base in the Middle East. The drive contained malicious code and was put into a USB port from a laptop computer that was attached to U.S. Central Command. The Pentagon spent nearly 14 months cleaning the worm from military networks. The worm had the ability to scan computers for data, open backdoors, and send through those backdoors to a remote command and control server.

Critical to achieving cyber warfare dominance is mission assurance-the ability to ensure the successful completion of military objectives while operating in a contested cyber environment with sophisticated adversaries. The original information infrastructure, despite security enhancements, was designed for a benign environment.

Cyber and IT security should be considered across the life cycle. The Acquisition Strategy should address design and programmatic measures/countermeasures to protect the programs technologies and capabilities. It should also describe the processes planned to be used to identify critical program information (CPI) and, if applicable, measures for the protection of CPI, including protection of critical functionality from supply chain risk in accordance with [DoDI 5200.39](#) (Reference (cl)) and [DTM 09-016](#) (Reference (cm)). The Acquisition Strategy should identify the technical, schedule, cost, and funding issues associated with protecting critical program information and technologies and the plans to resolve the issues.

[MACs and CLs](#) called out in Reference (bu) set the security level for any particular system. The security level of the system determines what types of IA controls must be put into place for the system; this is the DIACAP. Although the DIACAP requires IA controls to be put into place, it is a compliance program and not a test program. In today's perilous cyber environment, PMs should be going beyond the DIACAP and subjecting their systems to more thorough cyber testing.

The following subsections discuss the concepts of computer network operations (CNO) including CND, computer network exploitation (CNE), and computer network attack (CNA), as well as [section 933 of Public Law 111-383](#) (Reference (cn)), the DoD strategy for rapid acquisition of tools, applications, and other capabilities for cyber warfare.

## 24.4.2 CNO

CNO have become vital in today's interconnected world. Protecting our information networks allows our forces to operate effectively, and frequently with advantages, in today's battlefield. At the same time, offensive cyber operations can be utilized to deny our adversaries that same benefit. Additionally, offensive cyber operations may be used to inflict actual damage on adversary systems or to gather information from their networks. The following sections cover some special concerns that arise when testing CNO capabilities..

### 24.4.2.1 CND

Definition - As defined in [Joint Publication 3-13](#) (Reference (co)), actions taken through the use of computer networks to protect, monitor, analyze, detect, and respond to unauthorized activity within DoD information systems and computer networks.

CND testing is used to ensure that CND tools will protect our networks and systems from outside threats. Additional considerations to address in CND testing include the following:

**Threat.** An appropriate threat assessment must be utilized to determine adversary capabilities and how those capabilities can exploit system vulnerabilities.

**Red Team.** Threat information should be used by a team of red attackers to fully exercise system and network defenses.

**Operationally Realistic Ranges .** CND testing should involve operationally realistic ranges. Blue, adversary, and neutral networks should be simulated or brought in to the test environment via a live, virtual, and constructive setup. The environment should also include realistic network traffic generators to simulate loads on bandwidth and server throughput.

**CND Service Providers.** CND testing of a system should also include the CND service provider that provides umbrella defense to the system under test. This inclusion will allow the system to be tested in an environment closer to that under which it will actually operate-part of the operationally realistic range.

**Instrumentation .** Currently, it is difficult to know what is taking place within our systems (from a cyber defense view) because systems do not contain instrumentation and measures that allow for insight into their inner workings. Future developments should include data monitoring and instrumentation to utilize during CND testing.

### 24.4.2.2 CNE

Definition As defined in [Reference \(co\)](#) , enabling operations and intelligence collection capabilities conducted through the use of computer networks to gather data from target or adversary or networks.

Utilizing CNE, an entity may collect data from an adversary (and sometimes a friend) for an extended period of time. The data gathering helps the entity at the strategic, operational, and tactical levels and

may lead to compromise of sensitive information and introduction of vulnerabilities into the target system(s). CNE tools typically consist of Trojan horse programs and other associated malware. In addition, CNE tools may be designed to take full control of infected computers and the associated domains.

Due to the potentially destructive nature of CNE, testing of CNE tools should ensure that the tools are able to operate effectively without having undesired side effects. In addition, CNE testing should include tests to ensure extended data-gathering capabilities (going undetected) as well as tests measuring full control of infected computers and domains.

#### **24.4.2.3 CNA**

**Definition** - As defined in Reference (co), actions taken through the use of computer networks to disrupt, deny, degrade, or destroy information resident in computers and computer networks, or the computers and networks themselves.

CNA testing is used to ensure that CNA tools will have the desired effect. Additional considerations to address in CNA testing include the following:

**Collateral Effects** . If tools built to carry out CNA operations are not designed and built carefully, they can have unintended collateral effects when employed. Even when carefully constructed, these tools may have some level of collateral effects that must be tolerated. Thus before CNA tools can be employed, they must be thoroughly tested so that their collateral effects are understood.

**Detection** . CNA tool testing needs to examine the likelihood of detection by adversaries. Detection can lead to an adversary shutting down an avenue of attack. Potentially worse, if an adversary is able to detect and trace an attack back to its source, its attribution could lead to unwanted political consequences.

**Closed and Operationally Realistic Ranges** . Testing for CNA tools and capabilities should take place on closed ranges where the potential spread of adverse effects can be contained. In addition to being isolated, these ranges should provide operationally realistic environments that simulate blue, adversary, and neutral networks. Unfortunately, although fairly accurate models of adversary networks can be constructed, the models will never be perfect. Therefore, a full and complete CNA OT will likely not be possible, as some details of the adversaries systems will become known only during an operational effort.

**DoD Instruction O-3600.03 (Reference (cp))** . Technical Assurance Standard (TAS) for Computer Network Attack (CNA) Capabilities establishes guidelines and standards for CNA tools.

#### **24.4.3 Rapid Acquisition of Tools, Applications, and Other Capabilities**

[Section 933](#) of Reference (cn) directs the DoD to provide a strategy for the rapid acquisition of tools, applications, and other capabilities for cyber warfare for USCYBERCOM and the cyber operations components of the Military Departments. The USD(AT&L) worked with the DoD cyber community to

develop a common framework for the Services and Defense Agencies to acquire cyberspace operations capabilities.

The framework addresses requirements, acquisition, testing, and governance. To execute this new framework, the traditional defense acquisition framework will be aggressively streamlined to accommodate cyberspace operations quick reaction timelines, while at the same time managing risk. There are four cyber capability need timelines: A less than 30 days; B 30 days to 9 months; C 9 to 18 months; D greater than 18 months (likely to follow traditional acquisition processes).

An evaluation of operational risk to mission success is central to testing in all four cyberspace operations acquisition processes and will be the primary driver in determining the degree of testing appropriate for each capability. Whichever of the four processes is followed, an integrated team of testers, certifiers, and users must help develop the requirements, identify the significant operational risks, and work to address those risks through T&E. T&E of cyberspace operations capabilities must support risk management in any of the four acquisition paths by providing decision makers with credible, relevant, and efficient estimates of system and operational performance. T&E processes and products must be tailored to program need, risk, and risk tolerance; be fully integrated into capability development processes; leverage testing as a service; and efficiently synthesize developmental, operational, and specialty T&E perspectives to generate data for independent evaluation.

#### **24.4.4 Cyber Warfare in the United States**

The DoD sees the use of computers and the Internet to conduct warfare in cyberspace as a threat to national security. According to the U.S. Joint Forces Command, cyberspace technology is emerging as an instrument of power in societies, and is becoming more available to a country's opponents, who may use it to attack, degrade, and disrupt communications and the flow of information. With low barriers to entry, coupled with the anonymous nature of activities in cyberspace, the list of potential adversaries is broad. Furthermore, the globe-spanning range of cyberspace and its disregard for national borders will challenge legal systems and complicate a nation's ability to deter threats and respond to contingencies.

#### **24.5 Operations Security and T&E**

OPSEC issues must be considered in all test planning. Security regulations and contracting documents require the protection of sensitive design information and test data throughout the acquisition cycle by:

- Protecting sensitive technology.
- Eliminating non-secure transmittal data on and from test ranges.
- Providing secure communications linking DoD agencies to each other and to their contractors.

Such protection is obviously costly and will require additional planning time, test resources, and test constraints. The test planner must determine all possible ways in which the system could be susceptible to hostile exploitation during testing. For example, announcement of test schedule and location could allow monitoring by unauthorized persons. Knowledge of the locations of systems and instrumentation or test concepts could reveal classified system capabilities or military concepts. Compilations of

unclassified data could, as a whole, reveal classified information as could surveillance (electronic or photographic) of test activities or interception of unencrypted transmissions.

Routine reviews of the system under test security classification guide should be standard practice of the test team. Specific issues of interest should be identified before each test event that has potential exposure risk. Some new acquisitions may not have complete classification guidance, requiring test teams to be proactive in seeking guidance for new technologies and unexplored CONOPS.

## **24.6 Joint Capability Technology Demonstrations**

Systems with potential utility for the user and having relatively mature technology may be evaluated by a user in an operational field environment. These programs are not an acquisition program and therefore are not subject to the normal acquisition T&E processes. A favorable evaluation may result in the decision to acquire additional systems for Service use, bypassing a number of the normal acquisition phases. The Services have been using their OTAs to assist the field commanders in structuring an evaluation process that would provide the documented data necessary for an informed acquisition decision.

## **24.7 Chemical and Biological Agent Testing**

The Chemical and Biological Defense Program uses chemical and biological agents in controlled amounts (and in compliance with the relevant treaties) to test the efficacy of protection, decontamination, detection, medical, modeling, and warning systems. The testing of chemical and biological defense equipment and medical countermeasures systems poses unique problems because the tester cannot perform actual open-air field testing. In addition to obvious health and safety factors, test issues that the chemical and biological system tester must address include the following:

- All possible chemical reactions due to variations such as moisture, temperature, pressure, and contamination.
- Physical behavior of the chemical; i.e., droplet size, dispersion density, and ground contamination pattern when used operationally.
- Toxicity of the chemical; i.e., lethality and duration of contamination when used operationally.
- Safety of the chemical weapon during storage, handling, and delivery; adherence to chemical and biological surety regulations.
- Decontamination processes.

Addressing all of these issues requires a variety of techniques and test fixtures ranging from small-scale, material-level laboratory tests in which chemical and biological agents are employed, to large chamber and open-air field testing of systems. Cost and safety concerns may require the use of simulants, which are substances that replicate the physical or chemical properties of the tested agent but possess reduced human and environmental toxicity.

It should be noted, however, that simulant-agent correlation is very difficult to establish and results in severe limitations in test results, particularly in determining the efficacy of detection, protection, and decontamination systems. In medical systems, correlation of simulant to agent properties is not a

reliable method for establishing the performance of most medical countermeasures. Studies of agent chemistry are performed in toxic-chamber tests using the agents to establish physical properties, solubility, and interaction with common battlefield contaminants. Factors such as humidity, temperature, pressure, and agent purity must be controlled to assess the agent's behavior.

The ability to predict operational outcomes upon exposure to chemical and biological warfare agents is further complicated by the limited available human toxicity data. Chemical surety in U.S. laboratories and test ranges is governed by [AR 50-6](#) (Reference (cq)), and biological surety is governed by [AR 50-1](#) (Reference (cr)).

## 24.8 Summary

All weapon systems tests are limited to some degree, but certain systems face major limitations that could preclude a comprehensive and realistic evaluation. The test planners of these special systems must allow additional planning time, budget for extra test resources, and devise alternative test strategies to work around testing limitations caused by such factors as security restrictions, resource availability, environmental safety factors, and nonstandard acquisition strategies.



## Appendix A: Acronyms and Abbreviations

### A

A <sub>A</sub>	Achieved Availability
AAE	Army Acquisition Executive
ACAT	Acquisition Category
ACE	Army Corps of Engineers
ACTD	Advanced Concept Technology Demonstration
ADM	Acquisition Decision Memorandum
AEC	Army Evaluation Center
AFMC	Air Force Materiel Command
AFOTEC	Air Force Operational Test and Evaluation Center
AFSPC	Air Force Space Command
AF/TE	Air Force Test and Evaluation
A <sub>I</sub>	Inherent Availability
AIS	Automated Information System
AMC	Army Materiel Command
A <sub>O</sub>	Operational Availability
AoA	Analysis of Alternatives
AOTR	Assessment of Operational Test Readiness
APB	Acquisition Program Baseline
AR	Army Regulation
ARL	Army Research Laboratory
ASA(ALT)	Assistant Secretary of the Army (Acquisition, Logistics and Technology)
ASAF(A)	
ASD(R&E)	Assistant Secretary of Defense for Research and Engineering
ASN(RD&A)	Assistant Secretary of the Navy for Research, Development, and Acquisition
ASR	Alternative Systems Review

AT	Anti-Tamper
ATD	Advanced Technology Development (or Demonstration)
ATE	Automated Test Equipment
ATEC	Army Test and Evaluation Command (Army)
ATO	Authority to Operate (DIACAP)
AV	All Viewpoint
<b>B</b>	
BCD	Business Capability Definition
BCL	Business Capability Lifecycle
BEA	Business Enterprise Architecture
BIT	Built-In Test
BITE	Built-in Test Equipment
BLRIP	Beyond Low Rate Initial Production
<b>C</b>	
C&A	Certification and Accreditation
C2	Command and Control
C4	Command, Control, Communications, and Computers
C4I	Command, Control, Communications, Computers and Intelligence
CAD/CAM	
CAE	Component Acquisition Executive; Computer-Aided Engineering
CARD	Cost Analysis Requirements Description
CBA	Cost-Benefit Analysis
CBM	Chemical, Biological, and Medical
CDD	Capability Development Document
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CEP	Circular Error Probable

CG	Commanding General
CI	Commercial Item; Configuration Item
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
CL	Confidentiality Level
CM	Configuration Management
CNA	Computer Network Attack
CND	Computer Network Defense
CNE	Computer Network Exploitation
CNDSP	Computer Defense Service Provider
CNO	Chief of Naval Operations
CNO	Computer Network Operations
CNSSI	Committee on National Security Systems Instruction
COCOM	Combatant Command
COI	Critical Operational Issues and Criteria
COIC	Computer Network exploitation
COMOPTEVFOR	Commander, Operational Test and Evaluation Force (Navy)
CONOPS	Concept of Operations
COOP	Continuity of Operations
CoP	Community of Practice
COTS	Commercial Off-The-Shelf
CPD	Capability Production Document
CPI	Critical Program Information
CPU	Central Processing Unit
CRTC	Cold Regions Test Center
CSAF	Chief of Staff of the Air Force
CSCI	Computer Software Configuration Item (also called SI (Software Item))
CSI	Critical Safety Item

CTEIP	Central Test and Evaluation Investment Program
CTO	Comparative Technology Office
CTP	Critical Technical Parameter
CV	Capability Viewpoint
CY	Calendar Year
<b>D</b>	
DAB	Defense Acquisition Board
DAG	Defense Acquisition Guidebook
DAE	Defense Acquisition Executive
DAES	Defense Acquisition Executive Summary
DAS	Director of the Army Staff
DASD(DT&E)	Deputy Assistant Secretary of Defense for Developmental Test and Evaluation
DAU	Defense Acquisition University
DBS	Defense Business System
DBSMC	Defense Business Systems Management Committee
DCAPE	Director of Cost Assessment and Program Evaluation
DCMA	Defense Contract Management Agency
DIACAP	DoD Information Assurance Certification and Accreditation Process
DISA	Defense Information Systems Agency
DIV	Data and Information Viewpoint
DLT	Design Limit Test
DMMPO	Defense Medical Materiel Program Office
DoD	Department of Defense
DoDAF	DoD Architecture Framework
DoDD	DoD Directive
DoDI	DoD Instruction
DOE	Design of Experiments

DOT&E	Director of Operational Test and Evaluation
DOTMLPF	(Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities) Change Recommendation
DFARS	Defense Federal Acquisition Regulation Supplement
DIACAP	Department of Defense Information Assurance Certification and Accreditation Process
DID	Data Item Description
DISA	Defense Information Systems Agency
DLT	Design Limit Test
DoDAF	Department of Defense Architecture Framework
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DOE	Design of Experiments
DON	Department of the Navy
DOT&E	Director of Operational Test and Evaluation (Office of the Secretary of Defense)
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DoD)
DR	Deficiency Reporting
DT	Developmental Test; Developmental Testing
DT&E	Developmental Test and Evaluation
DTIC	Defense Technical Information Center
DTM	Directive-Type Memorandum
DTRA	Defense Threat Reduction Agency
DUSA-TE	Deputy Under Secretary of the Army for Test and Evaluation
<b>E</b>	
E3	Electromagnetic Environmental Effects Evolutionary Acquisition; Executive Agent
ECM	Electronic Countermeasures
EDM	Engineering Development Model
EIS	Environmental Impact Statement

EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development (phase of the Defense Acquisition Management System)
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EOA	Early Operational Assessment
EPG	Electronic Proving Ground
ERP	Enterprise Resource Planning
ESOH	Environment, Safety, and Occupational Health
ESS	Environmental Stress Screening
EVM	Earned Value Management
EW	Electronic Warfare

**F**

FAT	First Article Testing
FCA	Functional Configuration Audit
FCT	Foreign Comparative Testing
FDA	Food and Drug Administration
FDD	Full Deployment Decision
FDE	Force Development Evaluation
FDT/E	Force Development Tests and/or Experimentation
FMECA	Failure Mode, Effects, and Criticality Analysis
FMO	Frequency Management Office
FOC	Full Operational Capability
FORSCOM	Follow-on Operational Test and Evaluation
FOT&E	Follow-on Operational Test and Evaluation
FRP	Full-Rate Production
FRPDR	Full-Rate Production Decision Review
FRR	Flight Readiness Review

FUSL	Full-Up System-Level
FWE	Foreign Weapons Evaluation
FY	Fiscal Year
FYDP	Future Years Defense Program
FYTP	Five-Year Test Program

**G**

GFE	Government-Furnished Equipment
GIG	Global Information Grid
GOTS	Government Off-The-Shelf

**H**

HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HI	Hardware Item
HNA	Host-Nation Approval
HPT	High-performance Team
HQ	Headquarters
HQDA	Headquarters, Department of the Army
HSI	Human Systems Integration
HSIPP	Human Systems Integration Program Plan
HWIL	Hardware-in-the-Loop

**I**

IA	Information Assurance
IAW	In Accordance With
IBR	Integrated Baseline Review
ICBM	Intercontinental Ballistic Missile
ICD	Initial Capabilities Document

ID	
IER	Information Evaluation Report
ILS	Integrated Logistics Support
IM	Investment Management
IMO	Instrumentation Management Office
INCOSE	International Council on Systems Engineering
INSCOM	Intelligence and Security Command
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IPS	integrated product support
IPT	Integrated Product Team
IRB	Investment Review Board
IRS	Interface Requirement Specification
ISD	Integrated System Design (effort of the Engineering Manufacturing Development phase)
ISP	Information Support Plan; Internet Service Provider
ISR	In-Service Review
ISTF	Installed System Test Facility
IT	Information Technology
ITOP	International Test Operations Procedures
ITR	Initial Technical Review
ITT	integrated test team
IV&V	Independent Verification and Validation

## J

J-8	Joint Staff Directorate for Force Structure, Resource, and Assessment
JCIDS	Joint Capabilities Integration and Development System
JEET	Joint E3 Evaluation Tool
JITC	Joint Interoperability Test Command



JLF	Joint Live Fire
JROC	Joint Requirements Oversight Council
JT&E	Joint Test and Evaluation
JTCG	Joint Technical Coordinating Group
<b>K</b>	
KLP	Key Leadership Position
KPP	Key Performance Parameter
KSA	Key System Attribute
<b>L</b>	
LCC	Life Cycle Cost
LCSP	Life Cycle Sustainment Plan
LFT	Live-fire Testing
LFT&E	Live Fire Test and Evaluation
LOG Demo	Logistics Demonstration
LOG T&E	Logistics Support Test and Evaluation
LRIP	Low-Rate Initial Production
LSA	Logistics Support Analysis (Obsolete)
<b>M</b>	
MAC	Mission Assurance Category
MAIS	Major Automated Information System
MAJCOM	Major Command
MCEB	Military Communications-Electronics Board
MCOTEA	Marine Corps Operational Test and Evaluation Activity
MCSC	Marine Corps Systems Command
MDA	Milestone Decision Authority; Missile Defense Agency
MDAP	Major Defense Acquisition Program
MDD	Materiel Development Decision (of the Defense Acquisition Management System)

MEDCOM	Medical Command
MF	Measurement facility
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MLDT	Mean Logistics Delay Time
MMT	Manufacturing Methods Technology; Mean Maintenance Time
MOA	Memorandum of Agreement
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOS	Measure of Suitability
MOT&E	Multi-Service Operational Test and Evaluation
MOU	Memorandum of Understanding
MRTFB	Major Range and Test Facility Base
M&S	Modeling and Simulation
MS or M/S	Milestone
MSA	Materiel Solution Analysis (phase of the Defense Acquisition Management System)
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
MTBOMF	Mean Time Between Operational Mission Failures
MTTR	Mean Time to Repair

## N

NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NBC	Nuclear, Biological, and Chemical
NCE	Net-centric Environment

NCT	NATO Comparative Test
NDAA	National Defense Authorization Act
NDI	Non-Developmental Item
NEPA	National Environmental Policy Act
NH&S	Nuclear Hardness and Survivability
NIST	National Institute of Standards and Technology
NR-KPP	Net-Ready Key Performance Parameter
NSS	National Security Strategy; National Security System

## O

OA	Operational Assessment
OAR	Open Air Range
OIPT	Overarching Integrated Product Team
O&M	Operation and Maintenance
OMB	Office of Management and Budget
OPEVAL	Operational Evaluation (Navy)
OPSEC	Operations Security
OPTEVFOR	Operational Test and Evaluation Force (Navy)
O&S	Operations and Support (phase of the Defense Acquisition Management Framework); also a life cycle cost category
OSD	Office of the Secretary of Defense
OT	Operational Testing
OTA	Operational Test Agency
OTC	Operational Test Command
OTD	Operational Test Director
OT&E	Operational Test and Evaluation
OTP	Operational Test Plan
OTRR	Operational Test Readiness Review
OV	Operational Viewpoint

**P**

P3I	Preplanned Product Improvement
PAT&E	Production Acceptance Test and Evaluation
PCA	Physical Configuration Audit
PCDRA	Post-Critical Design Review Assessment
PCO	Primary Contracting Officer
PCR	Physical Configuration Review
P&D	Production and Deployment (phase of the Defense Acquisition Management System)
PDR	Post-Deployment Review; Preliminary Design Review; Program Deviation Report
PE	Program Element
PEO	Program Executive Officer
PEO STRI	Program Executive Office for Simulations, Training, and Instrumentation
PESHE	Programmatic Environment, Safety and Occupational Health Evaluation
PHS&T	Packaging, Handling, Storage, and Transportation
PI	Product Improvement
PM	Product Manager; Program Manager; Project Manager
PMB	Performance Measurement Baseline
PMITTS	Project Manager for Instrumentation, Targets, and Threat Simulators
PMO	Program Management Office
POA&M	Plan of Action and Milestones
PPBE	Planning, Programming, Budgeting, and Execution
PPP	Program Protection Plan
PQT	Production Qualification Test
PRAT	Production Reliability Acceptance Test
PRR	Production Readiness Review
PSM	Product Support Manager
P-Static	Precipitation Static

PV Project Viewpoint

**Q**

QA Quality Assurance

QASP Quality Assurance Surveillance Plan

QOT&E Qualification Operational Test and Evaluation

QRTWG Quick Reaction Test Working Group

**R**

R&D Research and Development

RAM Reliability, Availability, and Maintainability

RDA Research, Development, and Acquisition

RDECOM Research, Development, and Engineering Command

RDT Reliability Development Testing

RDT&E Research, Development, Test, and Evaluation

RF Radio Frequency

RFP Request for Proposal

RGC Reliability Growth Curve

RGT Reliability Growth Testing

R&M Reliability and Maintainability

RM Resource Manager

RTM Requirements Traceability Matrix

RTO Responsible Test Organization

RTS Reagan Test Site

**S**

SAE Service Acquisition Executive

SAF(AQ) Assistant Secretary of the Air Force (Acquisition)

SAR Safety Assessment Report; Selected Acquisition Report; Special Access Required

SCA Security Control Assessor

SCI	Software Configuration Item
SC&MPD	System Capability and Manufacturing Process Demonstration (effort of the Engineering and Manufacturing Development phase)
SE	Support Equipment; Systems Engineering
SecDef	Secretary of Defense
SECNAV	Secretary of the Navy
SECNAVINST	Secretary of the Navy Instruction
SEP	Systems Engineering Plan; System(s) Engineering Process
SEP	System Evaluation Plan
SETR	Systems Evaluation Plan
SFR	System Functional Review
SI	Software Item (also called CSCI (Computer Software Configuration Item)); Special Intelligence
SIL	System Integration Laboratory
SLAD	Survivability/Lethality Analysis Directorate
SM	Spectrum Management
SMDC	Space and Missile Defense Command (Army)
SME	Subject Matter Expert
SOW	Statement of Work
SP	Special Publication
SPAWAR	Space and Naval Warfare Systems Command
SPO	System Program/Project Office (Air Force)
SQT	Software Qualification test
SRR	System Requirements Review
SRS	Software Requirement Specification
SS	Software Specification Review
SSA	Spectrum Supportability Assessment
SSP	Simulation Support Plan

SSR	Software Specification Review
STA	System Threat Assessment
STAR	System Threat Assessment Report
STAT	Scientific Test and Analysis Techniques
StdV	Standards Viewpoint
SVR	System Verification Review
<b>T</b>	
TAAF	Test, Analyze, and Fix
TAFT	Test, Analyze, Fix, and Test
TAP	
TD	Technology Development (phase of the Defense Acquisition Management System)
TDS	Technology Development Strategy
T&E	Test and Evaluation
TECHEVAL	Technical Evaluation (Navy)
TEMG	Test and Evaluation Management Guide
TEMP	Test and Evaluation Master Plan
TES	Test and Evaluation Strategy
TM	Test Manager
TMO	Target Management Office
TOC	Total Ownership Cost
TPM	Technical Performance Measurement
TRA	Technology Readiness Assessment
TRADOC	Training and Doctrine Command (Army)
TREE	Transient Radiation Effects on Electronics
TRIMS	Test Resource Information Management System
TRL	Technology Readiness Level
TRMC	Test Resource Management Center

TRP	Test Resource Plan
TRR	Test Readiness Review
TRTC	Tropical Regions Test Center
TSARC	Test Schedule and Review Committee
TSG	The Surgeon General
TSMO	Threat Systems Management Office
TTP	Tactics, Techniques and Procedures

## U

UAV	Unmanned Aerial Vehicle
USASOC	U.S. Army Special Operations Command
U.S.	United States
USAF	U.S. Air Force
USB	Universal Serial Bus
U.S.C.	United States Code
USCYBERCOM	U.S. Cyber Command
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
USD(C)/CFO	Under Secretary of Defense (Comptroller)/Chief Financial Officer
USSOCOM	U.S. Special Operations Command

## V

VCSA	Vice Chief of Staff (Army)
V&V	Verification and Validation
VV&A	Verification, Validation and Accreditation

## W

WBS	Work Breakdown Structure
WDTC	Western Desert Test Center
WIPT	Working-Level Integrated Product Team



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