Department of the Army
Pamphlet 73–6

Test and Evaluation

Live Fire Test and Evaluation Guidelines

Headquarters
Department of the Army
Washington, DC
30 September 1996

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SUMMARY of CHANGE

DA PAM 73–6
Live Fire Test and Evaluation Guidelines

This new Army pamphlet--

- References and implements the policies and procedures contained in DODD 5000.1, DODI 5000.2, DOD 5000.2-M, AR 73-1, and Live Fire Testing Legislation (chap 1).

- Provides an overview of the Live Fire Test and Evaluation (LFT&E) process (chap 2).

- Provides LFT&E functions (chap 3).

- Provides the general details necessary for the development of an adequate and credible LFT&E strategy (chap 4).

- Details the LFT&E review and approval process pertaining to the strategy, T&E plans, and test reports by senior decision makers within HQDA and OSD (chap 5).

- Provides an overview of the Army’s vulnerability/lethality models and their role in LFT&E (chap 6).

- Describes the parameters and functions which must be considered during test planning and conduct based on Army LFT&E experience to date with armor/anti-armor systems (chap 7).

- Summarizes key lessons learned during the development and conduct of previous LFT&E programs, emphasizing the necessity of wisely incorporating these lessons into the planning and conduct of future LFT&E efforts to ensure that the maximum return is achieved on the Army’s investment in LFT&E (chap 8).

Headquarters
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Washington, DC
30 September 1996

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Test and Evaluation

Live Fire Test and Evaluation Guidelines

By Order of the Secretary of the Army:

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General, United States Army
Chief of Staff

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History. This publication has been reorganized to make it compatible with the Army electronic database. No content has been changed.

Summary. This pamphlet, in support of AR 73–1, provides guidelines for development of Live Fire Test and Evaluation strategies and for detailed planning and execution of full-up, system-level, Live Fire tests required by public law.

Applicability. This pamphlet applies to the Active Army, the Army National Guard, and the U.S. Army Reserve.

Proponent and exception authority. The proponent of this pamphlet is the Deputy Under Secretary of the Army (Operations and Research) (DUSA(OR)). The DUSA(OR) has the authority to approve exceptions to this pamphlet that are consistent with law and controlling regulation. The DUSA(OR) may delegate this approval authority in writing to a division chief under his or her supervision within the proponent agency who holds the grade of colonel or the civilian equivalent.

Interim changes. Interim changes to this pamphlet are not official unless they are authenticated by the Administrative Assistant to the Secretary of the Army. Users will destroy interim changes on their expiration dates unless sooner superseded or rescinded.

Suggested Improvements. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to HQDA, Office of the Chief of Staff of the Army, Test and Evaluation Management Agency (DACS–TE), 200 Army Pentagon, WASH DC 20310–0200.

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Chapter 1
Introduction

1–1. Purpose

Through a series of amendments to Title 10, United States Code, Congress has mandated that major weapon system and munition programs undergo a realistic Live Fire Test and Evaluation (LFT&E) program. This pamphlet attempts to achieve the following:

a. Present the basis for determining whether a LFT&E program is required for a given system.

b. Describe the key steps in developing an adequate and acceptable LFT&E strategy including the role of modeling and testing in the LFT&E process.

c. Provide guidance on the planning, execution, reporting, and review and approval processes for LFT&E programs.

d. Outline the function of key LFT&E activities.

1–2. Scope

Figure 1–1 illustrates the basic elements of the overall LFT&E process from initial strategy definition to the writing of the final test and evaluation reports. While the details of each element of this overall process must be decided on a case-by-case basis, this pamphlet provides the foundation required to develop a credible LFT&E program. It draws upon those general approaches and lessons learned from initial LFTs which have proven successful and which should prove beneficial to those individuals involved in future LFT&E programs.

1–3. References

Required and related publications are listed in appendix A.

1–4. Explanation of abbreviations and terms

Abbreviations and special terms used in this pamphlet are explained in the glossary.

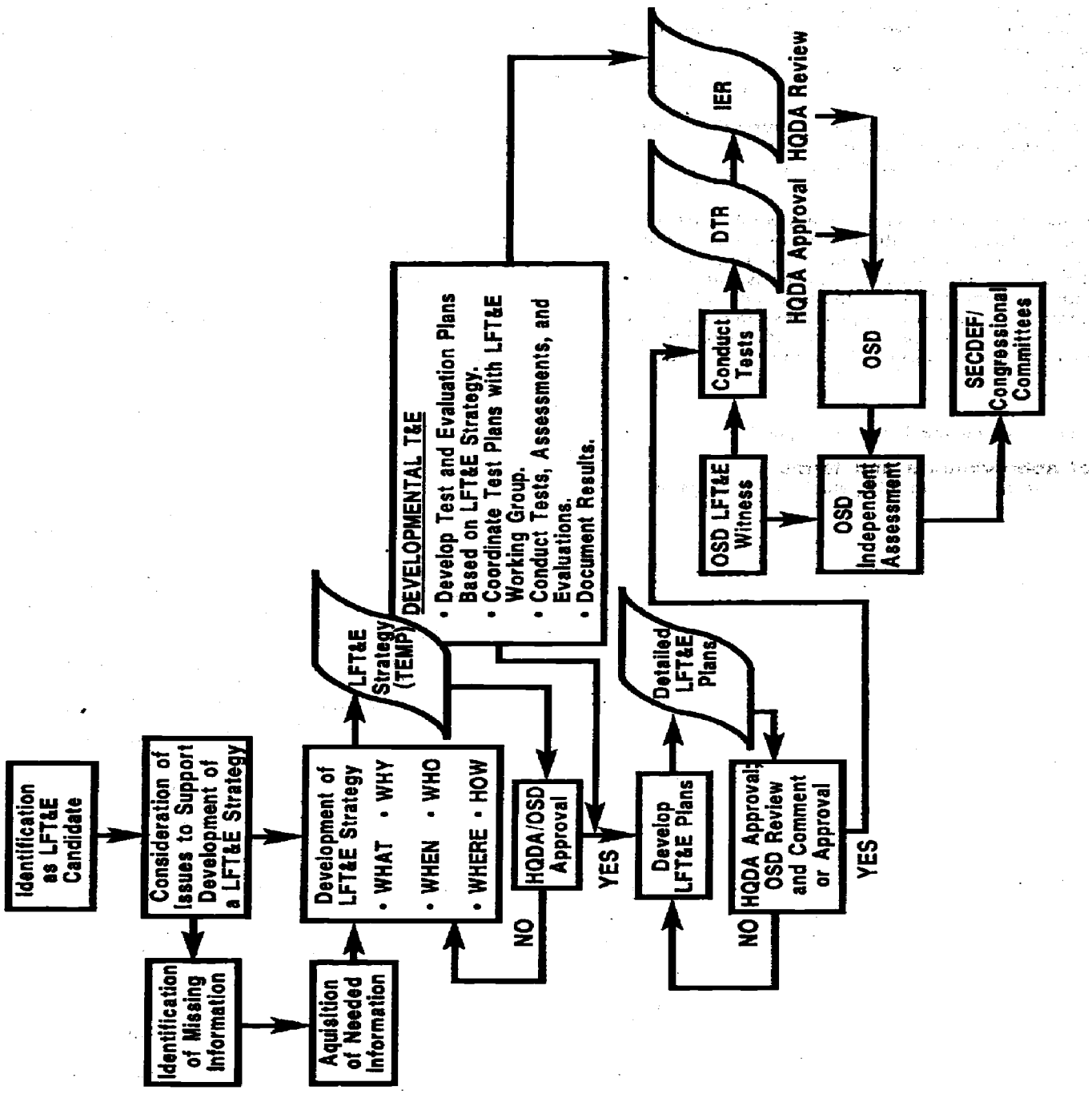


Figure 1-1. Overview of the LFT&E process

Chapter 2
Overview

2–1. Why Live Fire Test and Evaluation (LFT&E)?

a. As stated previously, LFT&E is necessary because it is the law; but, more importantly, because it is cost effective and smart testing (that is, it simply makes sense). A realistic LFT&E program represents the best alternative to "actual" combat in assessing our systems performance and is more cost effective than combat. However, with the lack of actual combat data must come a disciplined and realistic approach to assessing the vulnerability and lethality of our weapon systems. The LFT&E program provides the needed means for assessing the synergistic effects of system component integration and of selected damage mechanisms. A well-planned and well-structured LFT&E program reduces the potential for "surprises" before that system's arrival on the battlefield.

b. Furthermore, an active, well-planned, well-managed, and well-executed LFT&E program is essential to understanding system vulnerability/lethality (V/L) and will be an essential element of the information supporting decisions regarding the acquisition of materiel as well as the development of doctrine and plans for its proper operational employment. When properly structured and scheduled, the LFT&E program will enable design changes resulting from that testing and analysis to be incorporated into the system at the earliest possible date and reduce the need for expensive retrofit programs.

2–2. Objective of LFT&E

a. The objective of LFT&E is to support a timely and thorough assessment of the vulnerability/lethality of a system as it progresses through its development and subsequent production phases. The LFT&E program should demonstrate the ability of the weapon system or munition to provide battle resilient survivability or lethality and provide insights into the principal damage mechanisms and failure modes occurring as a result of the munition/target interaction and into techniques for reducing personnel casualties or enhancing system survivability/lethality. These insights will mature during the course of the LFT&E program. Data will emerge which will identify specific failure and damage mechanisms. With this knowledge, cost effectiveness trade-offs can be conducted to predict the optimal "mix" of vulnerability reduction/lethality enhancement measures.

b. The primary emphasis of LFT&E is on realistic testing as a source of personnel casualty, vulnerability, and lethality information to ensure potential design flaws are identified and corrected before full-rate production. The LFT&E program should assess a system's vulnerability/lethality performance relative to the expected spectrum of battlefield threats; it is not constrained to addressing specific design performance goals or threats. (However, LFT&E, by itself, is not a basis for the decision to transition to full-rate production; many other factors must be considered in arriving at this decision.) Additionally, LFT&E will provide insights into how to enhance the survivability and/or lethality of similar or future systems and provide a mechanism for gaining insights into the adequacy of vulnerability/lethality assessment techniques and supporting databases.

2–3. Background

a. The genesis of LFT began in the early 1980s as the outgrowth of perceived needs by two separate groups. First, the vulnerability/lethality assessment community was concerned that the technological viability of their assessment techniques was becoming increasingly tenuous. They were relying more and more on questionable extrapolation of existing databases (rapid advances in technology over the past two decades had simply made many of these databases outdated and inapplicable). Due to the increasing complexity of foreign and domestic weapon systems and of the munition/target interaction, assessment techniques demand a strong tie to empirical databases including those based on firings against full-up targets. Staff personnel within Congress, the Office of the Secretary of Defense (OSD), and Headquarters, Department of the Army (HQDA) were concerned that testing programs were ignoring the realities of war and were not providing a realistic and rigorous assessment of the likely performance of these systems in combat. They felt that program decisions were too dependent on modeling and component testing and that full-up LFT was needed to judge how well these systems— and the crew who operated them—would survive on the modern battlefield.

b. The need for full-up testing led to the establishment of the Joint Live Fire (JLF) Program in March 1984; the JLF Program was and continues to be sponsored by OSD as a joint test initiative. The JLF Program is chartered to assess the vulnerabilities and lethalities of fielded conventional U.S. ground systems and aircraft. Army systems initially included in the JLF Program were the Bradley Fighting Vehicle System, the Abrams Tank, and the M113 Family of Vehicles. Because of differences in the philosophic approach to LFT between the Army and OSD (the building-block approach versus large scale full-up testing) and the Army's desire to accelerate the testing of these systems, the Army subsequently requested and received permission from OSD to withdraw the Bradley, Abrams, and M113 systems from the JLF Program. The Army agreed to fund the cost of the LFT programs for these systems and to provide OSD open access to test planning, test conduct, and test results. This series of LFTs was known as Army LFT and was completed in 1988.

c. The need for LFT led Congress to mandate such testing for major weapon system and munition programs through a series of amendments to Title 10, United States Code in the FY86 through FY94 Department of Defense (DoD) Authorization Acts, and in the Federal Acquisition Streamlining Act of 1994. Table 2–1 presents a comparison of the primary features and differences among the JLF, the Army Live Fire, and the congressionally legislated LFT&E programs. The remainder of this pamphlet discusses the reguirements and strategies applicable only to congressionally legislated LFT&E programs.

2–4. LFT&E legislation

a. The FY86 and FY87 DOD Authorization Acts amended Chapter 139 of Title 10, United States Code, to require LFT&E before proceeding beyond low-rate initial production (LRIP). Specifically, the FY86 legislation requires side-by-side vulnerability LFT&E if a wheeled or tracked armored vehicle is to replace an existing vehicle; the FY87 legislation requires LFT&E for all covered systems and major munition and missile programs. The FY88–89 DOD Authorization Act amended Title 2010 to include a LFT&E requirement for product improvements to major systems (that is, system changes (modifications or upgrades)); the FY90–91 Act requires DOD to report results of LFT before a system enters full-rate production and also acknowledges that procurement funds can be reprogrammed to support LFT&E programs (such funding shall not exceed one-third of one percent of the total program cost). The FY94 DOD Authorization Act eliminates redundant sections of Chapter 139 of Title 10 including the requirement to conduct comparison testing with existing vehicles being replaced. The Federal Acquisition Streamlining Act of 1994 transfers oversight of Live Fire testing from the Office of the Deputy Director, Defense Research and Engineering (Test and Evaluation) to the Director of Operational Test and Evaluation, OSD.

b. To summarize, the current legislation requires that the Secretary of Defense provide that:

(1) A covered system not proceed beyond LRIP until realistic survivability testing is completed.

(2) A major munition or missile program not proceed beyond LRIP until realistic lethality testing is completed.

(3) A covered product improvement program not proceed beyond LRIP until realistic survivability/lethality testing is completed.

c. The legislation states that the costs of all survivability/lethality testing shall be paid from funds available for the system being tested. The legislation also provides that the Secretary of Defense may waive the requirement for survivability/lethality testing in time of war or if the Secretary certifies to Congress, before the system

enters engineering and manufacturing development (EMD) (formerly full- scale development (FSD)) that LFT of that system would be unreasonably expensive and impractical. A verbatim listing of the amended sections of the United States Code pertinent to LFT&E is provided at appendix B. Per Department of Defense Instruction (DoDI) 5000.2, 23 February 1991, all acquisition programs, excluding highly classified programs, shall be placed into one of four categories, Acquisition Category (ACAT) I, ACAT II, ACAT III, or ACAT IV. ACAT I and ACAT II programs are major defense acquisition programs and major programs, respectively, and, if they are covered systems or a munition/missile system, will have a LFT&E requirement. ACAT III and ACAT IV munition/missile programs may have a LFT&E requirement if they meet the 1,000, 000 round production requirement.

d. Figure 2–1 provides a flow chart to assist in determining a systems LFT&E requirement. This flow chart addresses both new systems and system changes (modifications or upgrades) to existing systems. Specific situations (for example, the LFT&E requirements for "add-ons" to existing systems which have undergone LFT&E) must be addressed on a case-by-case basis. Basically, if a system meets the LFT&E dollar or quantity criteria or if a system change provides a significant V/L effect, the system has a LFT&E requirement. The degree of LFT&E needs to be addressed in a comprehensive LFT&E strategy, incorporated into the appropriate documentation, and provided the Army leadership for guidance and approval. Per DODI 5000.2, a system's proposed acquisition strategy developed during Acquisition Phase 0 (Concept Exploration and Definition) "must include provisions for conducting Live Fire testing on covered systems, major munition programs and missile programs (and covered product improvements programs thereto)"; Army policy requires a system's LFT&E requirement be identified to the U.S. Army Test and Evaluation Management Agency (TEMA) and the initial strategy and resource requirements be included in the Milestone I Test and Evaluation Master Plan (TEMP).

2–5. Keys to success

The LFT&E program has and will continue to be one of the most complex and high-visibility phases of weapon system development. It requires proper planning, resourcing, testing, evaluation, and coordination to ensure that critical vulnerability/ lethality issues are effectively and adequately addressed and that the Congressional mandate is satisfied. Based on the experience gained during previous Army LFT Programs (Bradley and Abrams), a number of "keys to success" have been identified which should be useful for future LFT&E programs. These "keys" include:

a. Integration into the test and evaluation (T&E) process. The requirements of LFT&E are comparable to those of any T&E program: one must identify the critical issues, develop a test strategy, coordinate and obtain approval of that strategy, and execute and report the results of that program. Thus, the existing T&E process not only provides an existing infrastructure and reporting system which can effectively and efficiently accommodate the requirements of LFT&E, but it also avoids the unnecessary step of establishing a separate and unique process simply for LFT&E. As will be discussed in subsequent chapters, the TEMP is ideally suited for articulating the LFT&E strategy and the Test Integration Working Group (TIWG) is an ideal forum for the planning, coordination, and integration of the LFT&E program.

b. Early planning. The resource demands, plus the review and approval process, for LFT&E make early planning absolutely essential. Early identification of the critical vulnerability and/or lethality issues, the LFT&E strategy, the test resource requirements, test limitations, and inclusion in the TEMP are necessary to provide:

(1) The HQDA/OSD with an understanding of the basic strategy and the adequacy of planned testing and resources.

(2) The Project Manager (PM) with an understanding of the system hardware and threat or threat surrogate requirements, many of which require long lead times to procure or develop.

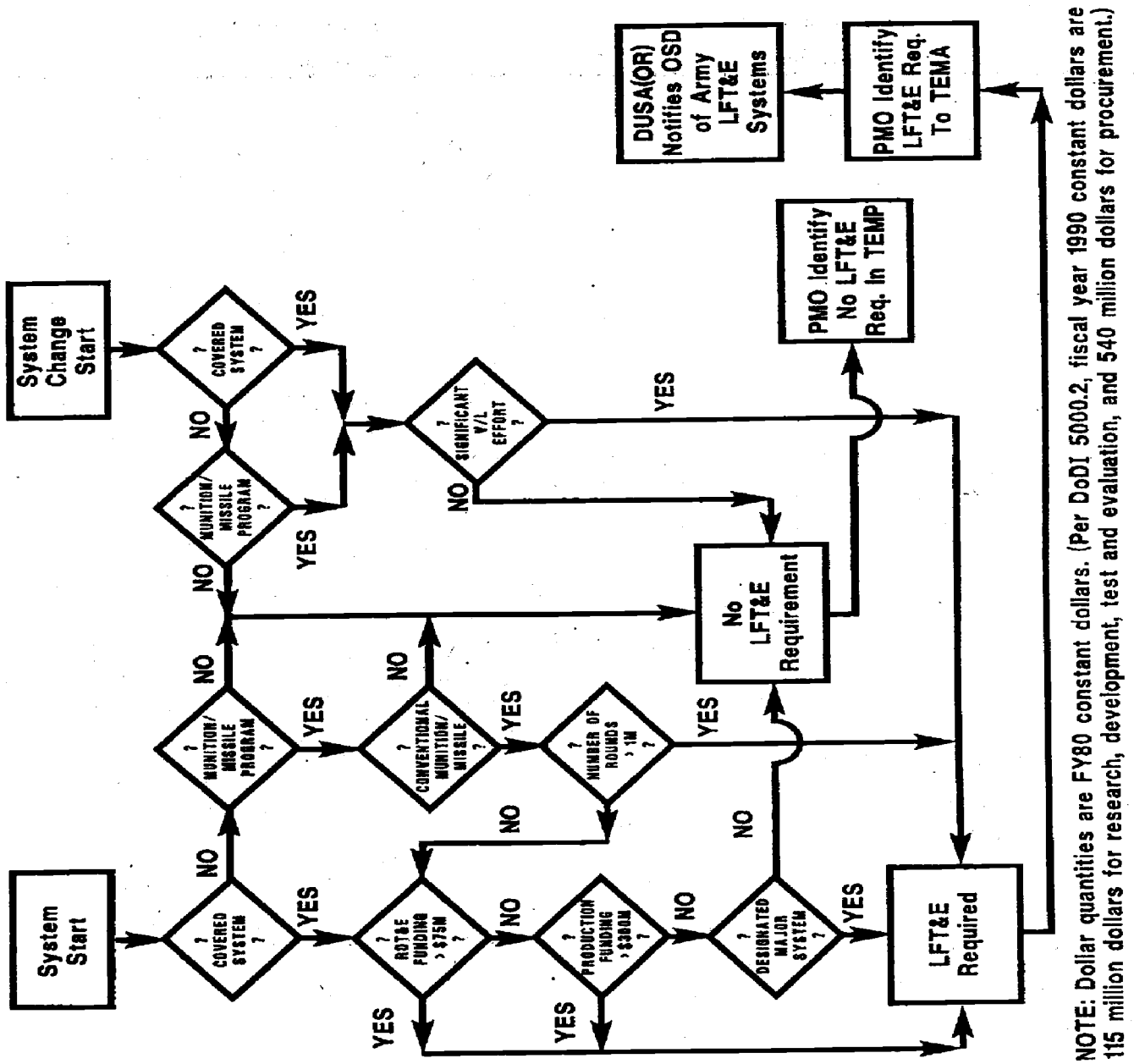
c. Building-block approach. The key to understanding a given munition/target interaction is an understanding of the underlying phenomenology. These insights can often be gained and many critical issues addressed through component and/or sub-system testing. Thus, the most cost effective and efficient approach to LFT is a building-block approach. Using such an approach, a development program would progress from early component testing to sub-system/system testing and culminate in a limited series of full-up firings to address personnel casualty, damage mechanism, and critical system vulnerability/lethality issues which can only be answered through full-up testing. The building-block approach provides the earliest possible understanding of the munition/target interaction phenomena during the development process and enables required fixes to identified problems to be incorporated at the earliest possible date.

d. Matrix team approach. The complexity of LFT&E programs requires that a broad range of technical, programmatic, and management expertise be brought together for the planning, execution, and reporting of that program. A matrix team approach has been found to be the most effective and efficient approach in previous LFT&E efforts for bringing this diverse set of expertise and activities together and ensuring a coordinated and credible LFT&E program. Thus, successful execution of a LFT&E program demands the early recognition of the need for, the solicitation of, the support of, and the continuous involvement of all necessary activities. Principal team members typically include the system developer, combat developer, independent evaluators, vulnerability/lethality analysts, testers, medical community, intelligence community, and system contractor (as required). Generally, this matrix team will remain in existence throughout the LFT&E program and should be organized as a separate working group under the TIWG. Membership may be expanded or modified as required and as the program evolves.

e. Test discipline. Strict discipline is required during the test conduct to ensure validity of results and efficient test execution. This discipline includes strict adherence to the HQDA approved Detailed Test Plan (DTP), approval of DTP changes by HQDA, controlled access to the test item, and early reporting of emerging results. Test discipline is discussed in greater detail in chapter 7, section V.

Table 2–1
Comparison of Joint Live Fire, Army Live Fire, and Congressionally Legislated LFT&E Programs

Joint Live Fire	Army Live Fire	Congressionally Legislated LFT&E
Chartered FY84	Legislated/Chartered	Legislated FY86-FY94
Multiservice	Army only	Individual/Multiservice
OSD funded	Army funded	Service funded
Fielded systems	Bradley, Abrams, M113 Family	Developmental systems/PIPs
Vulnerablility/lethality	Vulnerability	Vulnerability/lethality
Armor/anti-armor, aircraft	Armor	Air, land, sea systems
Test event oriented	Test event oriented	Milestone oriented
OSD oversite	OSD oversite	OSD oversite



NOTE: Dollar quantities are FY80 constant dollars. (Per DoDI 5000.2, fiscal year 1990 constant dollars are 115 million dollars for research, development, test and evaluation, and 540 million dollars for procurement.)

Figure 2-1. LFT&E requirement flow chart

Chapter 3
Functions of the Secretary of Defense and the Army

Section I
Office of the Secretary of Defense and Headquarters, Department of the Army (HQDA) Elements

3–1. Director, Operational Test and Evaluation (DOT&E)

For the Office of the Secretary of Defense, the DOT&E—

a. Serves as the OSD focal point for review, coordination, and approval of LFT&E policy.

b. Approves LFT&E strategies as provided in the TEMP and Service proposed deviations to the approved LFT&E strategies in accordance with DOD 5000.2–M.

c. Approves candidate systems for LFT&E. Annually reviews all potential systems for inclusion or exclusion from the LFT&E oversight list according to DoDI 5000.2, part 8, paragraph 5a(5).

d. Ensures that the Services implement all aspects of the legislation covering LFT&E.

e. Develops, recommends, and supervises DOD LFT&E policy.

f. Reviews and approves Services' detailed LFT&E plans.

g. Reviews Services' LFT&E reports.

h. Monitors the Services' LFT&E program during its conduct.

i. Conducts an independent assessment of individual Services' LFT&E programs and prepares the Secretary of Defense LFT&E assessment report to Congress.

j. Advocates the development of improved instrumentation, methodologies, criteria, and facilities for conducting LFT&E.

k. Provides a focal point to identify requirements for foreign targets and ammunition for LFT.

3–2. Deputy Under Secretary of the Army (Operations Research) (DUSA(OR))

For Headquarters, Department of the Army, the DUSA(OR) will—

a. Serve as the HQDA focal point for review, coordination, and approval of Army LFT&E policy.

b. Identify to OSD Army systems with a LFT requirement.

c. Serve as the Army approval authority of LFT&E strategies as provided in the TEMP and per DOD 5000.2–M.

d. Approve LFT&E Independent Evaluation Plans (IEPs), test design plan (TDPs), DTPs, and Detailed Test Reports (DTRs); review LFT&E Independent Evaluation Reports (IERs).

e. Approve any deviations to approved DTPs and IEPs.

f. Authorize and coordinate the transfer of validated LFT data to the DOT&E or designated representatives on a mutually agreed upon schedule. (Validated data are raw data which have been subjected to a quality control review.)

3–3. Director for Program and Vulnerability Assessment, Office of the Assistant Secretary of the Army (Research, Development, and Acquisition)(ASA(RDA))

The Director for Program and Vulnerability Assessment, ASA(-RDA) will—

a. Provide the Army Acquisition Executive (AAE), Army System Acquisition Review Council (ASARC) members, and Program Executive Officers (PEOs)/Program Managers (PMs) results of independent assessments of analytical, test and evaluation, countermeasures (CM), counter-countermeasures (CCM), and vulnerability (including LFT&E) issues on programs before all milestone decision reviews.

b. Provide guidance, policy, and direction with respect to CM/CCM, vulnerability, and survivability for all AAE programs.

c. Oversee vulnerability programs throughout Army.

3–4. Deputy Chief of Staff for Intelligence (DCSINT)

The DCSINT will—

a. Ensure Defense Intelligence Agency (DIA) approved threat characteristics are provided to support design, development, and validation of threat surrogates.

b. Approve threat surrogates.

3–5. Program Manager

The PM will—

a. Inform DUSA(OR), through TEMA, of system LFT&E requirement. If system does not have LFT&E requirement, PM so identifies in the TEMP.

b. Provide membership to the LFT&E working group.

c. Provide required resources (funding, to include that required for acquisition of targets and threat ammunition, spare parts, and similar items).

d. Recommend during LFT&E vulnerability testing whether shots deemed catastrophic should be conceded.

e. Provide required information on system configuration.

f. Provide system contractor support, as required.

g. Ensure that all user directed design fixes identified during LFT&E are, within program constraints, analyzed (for impact on safety, reliability, availabilty, and maintainability (RAM), and so forth), developed, and implemented.

Section II
United States Army Materiel Command

3–6. Commanding General, United States Army Materiel Command (AMC)

The Commanding General, AMC will—

a. Provide LFT&E oversight and ensure support of AMC activities.

b. Ensure LFT&E guidance is staffed and incorporated in appropriate Army policy and procedural documents.

3–7. Director, United States Army Materiel Systems Analysis Activity (AMSAA)

The Director, AMSAA will—

a. Form and lead the LFT&E working group under the TIWG.

b. Serve as the head of the lead organization for developing the LFT&E strategy and preparing the TEMP section.

c. Identify and define critical vulnerability and/or lethality issues and ensure issues are incorporated in the TEMP and the LFT&E IEP/TDP.

d. Develop the LFT&E IEP/TDP.

e. Develop the LFT&E IER as a separate stand-alone companion document to the DTR. Ensure the IER is completed in a timely manner to meet LFT&E milestone requirements.

f. Define threat surrogate requirements, coordinate these with the LFT&E working group, and provide a list of proposed surrogates to the intelligence community for their approval.

g. For missile systems, ensure that warhead configurations and firing methods used for various test phases are documented in minutes of the LFT&E working group meetings.

h. Ensure that T&E actions to validate non-tactical hardware (simulants) used in missile warhead lethality tests are documented in minutes of the LFT&E working group meetings.

3–8. Director, U.S. Army Research Laboratory (ARL), Survivability/Lethality Analysis Directorate (SLAD)

The Director, ARL/SLAD will—

a. Serve as the principal activity in the Army for determining the survivability/lethality and vulnerability (SLV) of Army systems to the full spectrum of battlefield threats.

b. Act as the Army focal point for technical advice and consultation on vulnerability and lethality matters for decision makers, system managers and developers, users, testers, independent evaluators, and other SLV customers.

c. Provide objective technical judgments on complex technical issues regarding the SLV of Army systems.

d. Serve as the AMC spokesperson on SLV at major milestone decision points.

e. Ensure appropriate AMC support is provided to vulnerability/lethality assessments and LFT&E programs.

f. Provide membership to the LFT&E working group.

g. Assist AMSAA in identifying critical vulnerability/lethality issues and developing the test design and data requirements.

h. Develop and improve vulnerability/lethality assessment techniques to include incorporation of LFT&E lessons learned in assessment techniques and supporting databases.

i. Conduct vulnerability/lethality assessments for decision reviews; provide pre-shot predictions/assessments for LFT&E. Prepare the Pre-Shot Prediction Report.

j. Lead crew casualty and system damage assessments. Prepare the Detailed Damage Assessment Report.

3–9. Commanding General, United States Army Test and Evaluation Command (TECOM)

a. The officials at Headquarters, TECOM, will—

(1) Plan, coordinate, and manage the execution of LFTs assigned to TECOM.

(2) Provide membership to the LFT&E working group.

(3) Assist AMSAA in developing the LFT&E strategy.

(4) Manage preparation of the DTP and the DTR for those LFTs assigned to TECOM for execution.

(5) Review the DTP and DTR for those LFTs assigned to other agencies for execution.

b. Commander, U.S. Army Aberdeen Test Center (ATC) will—

(1) Serve as the TECOM Center of Excellence for LFT.

(2) For assigned tests: plan and conduct all required test efforts including instrumentation, execution, target repair, and maintenance; serve as lead for preparation of the DTP and DTR; and document test results and support the damage assessment process.

(3) Monitor tests conducted at other installations as requested.

3–10. Project Manger for Instrumentation, Targets, and Threat Simulators (PM ITTS)

PM ITTS will—

a. Implement Army and AMC policy for the management, control, and operation and support (O&S) of foreign assets to include those used in support of LFT&E.

b. Interface with other DOD agencies and enter into Memorandum of Agreement/Understanding (MOA/MOU), as necessary, for the O&S of foreign assets to include those used to support LFT&E.

c. Assess requirements for using foreign assets to support LFT&E and forward recommendations and/or requests for destructive testing to the Army Foreign Materiel Review Board.

Section III
Other Army Components

3–11. Commanding General, U.S. Army Training and Doctrine Command (TRADOC) (Centers and Schools)

The Commanding General, TRADOC will—

a. Serve as lead for the Battlefield Damage Assessment and Repair (BDAR) team.

b. Provide membership to the LFT&E working group as required.

c. Participate in preparation of the DTR.

d. In coordination with the PM, identify fixes that result from LFT&E and establish implementation priority.

3–12. Commanding General, U.S. Army Medical Research and Materiel Command (MRMC)

The Commanding General, MRMC will—

a. Assist in developing LFT plans to ensure appropriate data collection for a reliable medical assessment of relevant issues.

b. Assist in identifying critical crew vulnerability issues and in developing the criteria for casualty assessments.

c. Provide membership to the LFT&E working group as required.

d. Develop and improve crew vulnerability assessment techniques to include incorporation of LFT&E lessons learned in assessment techniques and supporting data bases.

e. Assist as required in crew casualty assessments; review, in a timely manner, the final casualty assessments to ensure medically relevant concerns have been adequately addressed.

3–13. Commanding General, U.S. Army Operational Test and Evaluation Command (OPTEC)

The Commanding General, OPTEC will provide membership to the LFT&E working group as required.

Chapter 4
LFT&E Strategy

Section I
Introduction

4–1. Roadmap to testing and evaluation

a. The development and subsequent approval of the LFT&E strategy is the single most important step in the overall LFT&E process. The LFT&E strategy is a documented concept that describes who, what, why, when, where, and how the LFT&E requirements for a given system will be satisfied. Just as a system's acquisition strategy outlines the top level approach for the overall system acquisition, the LFT&E strategy provides the top level description of the LFT&E portion of the system's test and evaluation strategy and is an integral part of the TEMP. Once approved, the LFT&E strategy provides the basic roadmap for what vulnerability/lethality testing and evaluation has to be conducted before transitioning to full-rate production.

b. While the details of the LFT&E strategy will vary from system-to-system, this chapter attempts to provide the general details necessary for the development of an adequate and credible LFT&E strategy. Development of the LFT&E strategy requires an understanding of both the system's acquisition strategy and the overall T&E process. An overview of the T&E process is provided in DA Pam 73–1.

4–2. Events schedule

Figure 4–1 depicts where the elements of the required vulnerability/lethality assessment and the LFT&E program fall within the materiel acquisition process as outlined in DODI 5000.2. Table 4–1 presents an outline schedule of LFT&E events which, if followed, will result in a timely and effectively executed LFT&E program. The schedule for the DTP, DTR, and IER are mandated requirements (see appendix C, OSD LFT&E Guidelines).

Table 4–1
Live Fire Test and Evaluation Event

Schedule	Live Fire Test and Evaluation Event	Lead for Strategy	Lead for Resources
Pre-MS I	Working Group Formation	AMSAA	N/A
MS I	Initial TEMP Input	AMSAA	PM
MS II	Detailed TEMP input	AMSAA	PM
T-180	IEP/TDP	AMSAA	N/A
T-60	Army Approved IEP/TDP, DTP, and Pre-Shot Prediction Report to OSD	DUSA(OR)	N/A
T	Live Fire Test	Tester	N/A
T+60	DTR	Tester	N/A

Table 4–1
Live Fire Test and Evaluation Event—Continued

Schedule	Live Fire Test and Evaluation Event	Lead for Strategy	Lead for Resources
T+110	IER	AMSAA	N/A
T+120	DTR and IER to OSD	DUSA(OR)	N/A
T+180	Detailed damage assessment report	SLAD	N/A

Section II
LFT&E in the T&E Process

4–3. Scope
Live Fire tests are part of developmental tests of system vulnerability and lethality. What has changed from previous developmental tests is that a more comprehensive full-up system test with OSD oversight is required before a program may enter full-rate production. The LFT&E program examines the full spectrum of battlefield threats, to include overmatching threats, as opposed to the design level threats considered in previous developmental tests. The scope of LFT&E should build upon early developmental tests of component and system vulnerability and lethality and modeling. Resource and schedule constraints and the stochastic nature of LFTs limit the scope of these tests to a demonstration of system vulnerability and lethality.

4–4. Elements
System developmental tests and evaluations typically address the following factors: firepower (lethality is an element); survivability (vulnerability is an element); performance; safety; reliability, availability, maintainability, and durability; manpower and personnel integration; integrated logistics support; and software. The LFT&E program addresses elements of firepower and survivability; firepower and survivability are compared/contrasted in table 4–2.

Table 4–2
Elements of Firepower and Survivability

Firepower	Survivability
Ability to acquire targets	Avoid or reduce acquisition
Ability to hit an acquired target	Avoid or reduce being hit given an acquisition
Ability to kill a target given a hit (lethality)	**Avoid or reduce being killed given a hit (vulnerability)**
Ability to perforate or breach target	**Protect against lethal mechanisms**
Ability to do significant damage to the target	**Limit damage to crew and hardware**
Rate of aimed fire	**Design for expedient repair of combat damage**

Notes:
Bold entries are focus of LFT&E.

4–5. Sub-elements
Both lethality and vulnerability LFT&E address system performance given a munition effect. At the sub-element level, lethality LFT&E addresses both the ability to perforate or breach the target and to do significant damage to the target. Vulnerability LFT&E addresses both being protected against lethal mechanisms and minimizing damage to the crew and hardware given an impact or breach by a lethal mechanism. In addition, vulnerability LFT&E addresses repairability of combat damage (another element of survivability).

4–6. Differences between vulnerability and lethality
There are several subtle differences in vulnerability versus lethality LFT&E. Vulnerability LFT&E must address crew, hardware (excluding crew), and system (crew and hardware) vulnerability for threats and impact conditions that the system is designed to protect against and for threats and impact conditions that the system is not designed to protect against, but could encounter on the battlefield. In lethality LFT&E, it is sufficient to address lethality against the threat system for areas that have the greatest protection and/or where differences between competing munitions are expected (not only areas of greatest protection). For example, a new munition may not be able to breach the area of greatest protection on the threat; however, for areas that it can breach, the damaging effects (for example, probability of kill given a hit (Pk/h)) may be significantly greater than the munition being replaced.

Section III
Developing the LFT&E Strategy

4–7. Importance of the strategy
The LFT&E strategy is the most important element of the LFT&E process. It should be prepared and approved as early as possible in the acquisition cycle (see table 4–1). The AMSAA has the lead for preparing and obtaining approval for the strategy in coordination with TIWG members. The DUSA(OR) approves the strategy for the Army before it is sent (via the TEMP) to the DOT&E for OSD approval. If consensus on the scope of the LFT&E cannot be reached, or if program constraints limit compliance with required reporting dates, these issues will be raised to the DUSA(OR) for resolution. The strategy is the foundation of the LFT&E section of the TEMP and all subsequent planning documents (the IEP/TDP prepared by AMSAA, the Pre-Shot Prediction Report prepared by the Survivability\Lethality Analysis Directorate (SLAD), and the DTP whose preparation is managed by TECOM). The strategy should be detailed enough to adequately project resource requirements and trigger long lead time planning, procurement of threats/surrogates, and modeling.

4–8. Background information necessary to develop the strategy
The first step in preparing a strategy is to do the necessary homework to:

a. Understand the technical and operational characteristics of the concepts, technology, and requirements for the system being developed and how they differ from the system being replaced.

b. Develop a rationale for which threats are to be considered in the LFT&E. The rationale should be based upon a review of the System Threat Assessment Report (STAR), the densities of the various classes of threat weapons and countermeasures in organizations likely to be encountered, and the frequency that various threats kill or are killed by the system from force effectiveness analyses supporting program decisions or planning studies. An accepted rationale from an approved vulnerability LFT&E plan was to break threats into major and minor threats. A major threat was either one that killed or reduced the effectiveness of a large percentage of the systems in the force effectiveness evaluation or had a high density in the force; all others were considered minor threats. Most of the shots fired in vulnerability LFT&E should be with major threats. The rationale for lethality LFT&E should be based on the threat that is driving the design (usually the most difficult target to kill given a hit).

c. Review previous LFT or JLF results for the system being replaced. Previous LFT and JLF tests may have identified vulnerability issues that need further exploration or designs that could reduce system vulnerability. This should influence the scope of the vulnerability LFT. For example, during developmental testing of the

M1A1 Abrams tank, damage caused by ballistic shock from nonperforating impacts was identified as a potentially significant vulnerability of the tank. The Vice Chief of Staff of the Army directed a ballistic shock test of the M1 tanks in production. That test identified design fixes that were incorporated into the M1A1 design. The Abrams Vulnerability LFT evaluated how well the design modifications worked.

d. Identify, for lethality LFT&E, threat target requirements and availability. The PMs provide funding for the acquisition of targets for lethality LFT&E. (See Section IV and appendix E for threat target alternatives.) In the past, JLF targets have been made available to support LFT&E testing. Providing developmental rounds to fire in JLF tests may satisfy some or all of the full-up threat target portion of the lethality LFT&E requirement. In addition, it may be possible to infer that the developmental round would be at least as lethal as similar (less capable) rounds fired in the test. This could be used as a justification for firing fewer developmental rounds in LFT&E. An additional potential source of threat targets for use in LFT&E is PM ITTS, the AMC management agent of foreign materiel assets used in support of testing. (See Section IV for procedures for acquiring targets through PM ITTS to support LFT&E.)

4–9. Define the critical issues

Having completed the homework on the developmental system, the next step in developing a strategy is to define the critical issues (test issues). Critical issues are not unique to the LFT&E phase, but are issues which are developed to address overall system vulnerability and/or lethality, (that is, they are vulnerability/lethality critical issues). The LFT&E program will address specific elements of the overall system vulnerability/lethality issues. Testing should provide valuable inputs and a basis for refinement and calibration of vulnerability and Sustainability Predictions for Army Requirements for Combat (SPARC) models. Critical issues vary for vulnerability and lethality and generally should address the following:

a. Vulnerability LFT&E

(1) Crew, hardware, and system vulnerability.

(2) Known vulnerabilities and vulnerability reduction techniques (for example, increased ballistic protection, less sensitive munitions, and redundant components).

(3) Potential vulnerability reduction techniques.

(4) Processes, provisioning, repair times, and training required for BDAR.

b. Lethality LFT&E. Testing should provide valuable inputs and a basis for refinement and calibration of lethality models and databases. It should also demonstrate the following:

(1) Ability to perforate or breach the protection of the threat system.

(2) Ability to significantly degrade the combat/mission functions of threat systems given a breach.

(3) Potential lethality improvements.

4–10. Finalization of the evaluation process

During the examination of the vulnerability/lethality of the system being developed and the defining of the critical issues, the process by which the LFT&E results will be evaluated is formulated. The next step in the strategy development is finalizing the evaluation process and articulating the details of this process in the LFT&E IEP/TDP document. This document will identify procedures to be followed in the evaluation (for example, statistical analyses, criteria, models, system comparisons, shotlines, and so forth) and define data requirements. During development of the LFT&E strategy and the resultant IEP/TDP, the total vulnerability/lethality assessment process must be considered. The evaluation must crosswalk the developmental, component, sub-system, and so forth, vulnerability/lethality testing and assessments with LFT&E requirements. Some aspects of the assessment process which must be examined in the development of the LFT&E strategy are:

a. Early in the system acquisition cycle there is little or no test data and the evaluations are made based upon model estimates. Databases to support the models should reflect the technical and performance characteristics of the system and the threat. The initial models and model inputs will probably be both unrefined and uncertain. The LFT&E strategy should be designed to increase the level of refinement and to reduce the uncertainty.

b. Models for both vulnerability and lethality evaluations require similar inputs. A detailed description of the system is required for a vulnerability assessment. A detailed description of the threat target is required for a lethality assessment. These descriptions must geometrically describe the location of the critical components, crew, and protective systems. In addition, a degraded states criticality analysis to relate component damage to expected loss of system capability, and possibly a damage assessment list (DAL) to relate loss of system capability to degraded combat utility are also required. The DAL is developed by vulnerability analysts and system users. (Unlike the DAL process, degraded states criticality analysis makes no attempt to relate loss of capability to some combat utility, thus avoiding averaging over some spectrum of mission scenarios. Another difference between degraded states and the DAL is that degraded states criticality analysis allows the user to apply his or her own mission profile, rather than using the one implicit in the DAL.) Finally, the ability of the system's protective system to withstand an impact by the threat; the characterization of the damaging capability of the threat that breaches the protective system; and the susceptibility of the components and crew to the threat damage mechanisms are required. Comparable information is required on threat targets for lethality evaluations.

c. Vulnerability developmental tests must be planned to assess the ability of a system's protective system (for example, armor, optics, and so forth) to withstand impacts by threat missiles and projectiles and to examine the ability of critical components (for example, ammunition compartments) to withstand damage from a threat warhead or projectile that breaches the protective system. During the Demonstration and Validation Phase, the developmental tests will focus on components. During EMD and production verification testing (PVT), complete systems should be tested; however, developmental tests should be planned to upgrade and develop the system vulnerability model. The vulnerability LFT is the last vulnerability developmental test and should be conducted against a full-up (combat-loaded) production or production representative system.

d. Lethality developmental tests must be planned to assess the ability of the system to damage critical components and the crew. During the Demonstration and Validation Phase, the tests will usually focus on the warhead's or penetrator's ability to breach the threat target's protective system. During EMD and PVT, impact conditions will be firmly established for the missile or projectile and the ability of the warhead or penetrator to breach the threat target's protective system will be refined. The lethality LFT is again the last developmental test and should be conducted against a full-up (combat-loaded) threat target. However, it is unlikely that the required threat target will be available. (The Army develops munitions/missiles to "defeat" projected threats which in most cases have not been fielded.) Therefore, surrogate targets will have to be developed or JLF and/or available threat targets will have to be used. In either case, the scarcity of lethality LFT targets and their cost may dictate that these targets not be fully combat-loaded to preclude an unexpected catastrophic loss.

e. Vulnerability models are also used to estimate the spare parts and time required to repair combat damaged components. Vulnerability LFTs provide valuable inputs for refining these estimates. In addition, rapidly returning damaged systems to battle requires being able to accurately assess the damage and apply field expedient repairs. Again, vulnerability LFTs provide both valuable training and opportunities to refine and develop field expedient repair methods and to identify tools and materials required to execute these repairs.

Section IV
Threat Targets and Munitions

4–11. Identification of the threat target and munition requirements

An integral part of LFT&E strategy development is the identification of the threat target (lethality LFT) and munition (vulnerability LFT) requirements. These requirements need to be identified early-on in the acquisition cycle to allow for possible long lead times for procurement. It is very unlikely that the required threats will be available for LFT. It is also unlikely that any hard intelligence data will be available on the threat's physical and performance characteristics. Therefore, LFTs will probably be conducted using threats based upon postulated technology options derived from intelligence assessments. This will require surrogates in lieu of "real" threats. The rationale for threat surrogate selection must be detailed in the IEP/TDP.

4–12. Rationale for selecting surrogate threat projectiles

The rationale for selecting surrogate threat projectiles for vulnerability LFTs is to match physical and performance characteristics of the projected threat. For kinetic energy projectiles, penetration into rolled homogeneous armor (RHA); muzzle velocity and impact velocity; and penetrator material, length, and diameter are key parameters. For shaped charge warheads, penetration into RHA; impact velocity; and warhead diameter, explosive type, and material are key parameters. Availability and cost of surrogate projectiles may also drive the selection. Typically, U.S. projectiles and warheads will be selected as surrogates. The U.S. projectiles and warheads selected as threat surrogates must be submitted, along with the supporting rationale, by AMSAA to the DCSINT, HQDA, for approval.

4–13. Rationale for selecting surrogate targets

The rationale for selecting surrogate targets for lethality LFTs is the same as that for selecting surrogate projectiles or warheads. However, selecting and obtaining surrogate targets is much more difficult and expensive than selecting and obtaining surrogate projectiles and warheads. It is the pacing item and probably the most difficult part of executing the lethality LFT and, as such, must be addressed and identified early in the LFT&E planning process. This problem was recognized by OSD and the DUSA(OR). The AMSAA was requested to chair an Army working group (AMSAA, BRL, TECOM, and VLAMO) to develop guidelines for generic classes of threat target surrogates to satisfy long-term requirements. The Army working group prepared two papers that identified and evaluated alternatives for threat tank and helicopter targets for LFT&E. These papers have been approved by the DUSA(OR) and a verbatim listing is provided in appendix E. In the following paragraphs, a brief summary of each paper is provided. Since the publication of these papers, the Army has established PM ITTS under AMC. The PM ITTS function is to act as the AMC management agent of foreign materiel assets used in testing. If PMs require PM ITTS support, they must identify their target requirements (including LFT&E) early in the development cycle (by MS I).

4–14. Tank alternatives

Eight T&E alternatives were identified for anti-tank munitions in terms of the type of target utilized in the lethality LFT, whether the target functions (mobility, firepower, and so forth), what the test addresses (armor perforation, damage mechanisms, components, so forth), and the basis for the overall lethality assessment (test, model). The eight lethality T&E alternatives break logically into three groups:

a. Functioning tanks with an overall lethality assessment based upon test results.

b. Ballistic hull and turret (BH&T) with the crew or crew and components represented by boxes with a limited overall lethality assessment based upon test results.

c. A BH&T only or range targets with no overall lethality assessment based upon test results.

4–15. Recommended tank LFT&E approach

None of the alternatives by themselves are adequate for lethality LFT; however, it is possible to utilize three different targets to adequately demonstrate lethality in LFTs. The three different targets and the types of tests recommended are as follows:

a. Threat tank, range target tests with sufficient sample sizes to establish (with high statistical confidence) the ability of the baseline and developmental anti-armor munitions to perforate the range targets of interest and to characterize the behind-armor debris (BAD) characteristics of both munitions. Several recent Live Fire Lethality tests utilized range targets designed to represent the armor along randomly selected shotlines.

b. A BH&T target constructed to threat armor projections and configured with crew and major component box representations to demonstrate major lethality differences between baseline and developmental anti-armor munitions.

c. An older threat or U.S. tank (without modifications) to provide a limited demonstration of lethality of the baseline and developmental anti-armor munitions against a functioning vehicle. (Note, these tests may not demonstrate significant differences because both munitions may significantly overmatch these targets.)

4–16. Helicopter alternatives

Four T&E alternatives were identified for anti-helicopter munitions. The four alternatives for lethality LFTs are:

a. Flyable, functioning helicopters with an overall lethality assessment based upon observation of test results.

b. Non-flyable, functioning helicopter targets with an overall lethality assessment based upon a combination of modeling (principally to define intercept and fuzing/detonation points) and test results (collection of damage effects data).

c. Non-flyable, non-functioning helicopter targets with an overall lethality assessment based upon a combination of modeling (defining intercept and fuzing/detonation points and damage effects on non-functioning components) and test results (collection of damage effects data).

d. Fuselage or major sub-systems representative of comparable threat helicopter components (engine, rotor system, and so forth) with an overall lethality assessment based primarily upon modeling.

4–17. Recommended helicopter LFT&E approach

Again, the recommended approach for lethality LFT of anti-helicopter munitions is a combination of two target types:

a. Non-flyable/non-functioning helicopters and fuselage or major sub-systems built based upon threat helicopter technical projections.

b. Flyable/functioning and non-flyable/functioning older threat or U.S. helicopters.

Section V
Shot Selection Process

4–18. Engineering versus random shots

In order to provide the appropriate information required to address critical LFT&E issues, the attack conditions and the munition/target impact location (that is, shotline) must be identified for each shot. The shotlines selected and the rationale for their selection must be included in the IEP/TDP. There are two types of shots: engineering and random. Engineering shots provide information and data to address specific vulnerability or lethality issues for a specific threat. Random shots are selected from the combat distribution of impact conditions (direction, location, and range) for the threats of interest. The minimum number of engineering shots should be selected first to address the vulnerability and/or lethality critical issues. Next, the number of random shots required for each threat weapon should be selected. Random shots should be reviewed to determine if any engineering shots are duplicated or if a critical issue is satisfied by a random shot. Those engineering shots duplicated by a random shot should be eliminated.

4–19. Basis for shot selection

In order to select LFT&E shots, the answers to the following questions must be known:

a. What are the characteristics of the system being developed and the system being replaced?

b. What are the differences in system characteristics that could influence vulnerability or lethality?

c. What is the current state of knowledge about system vulnerability or lethality?

d. What are the critical issues?

e. What are the threats?

f. What are the physical and performance characteristics of the threats?

g. If threat systems are not available, then what is the rationale for threat surrogates?

h. What vulnerability or lethality developmental testing has been planned/conducted prior to LFT?

i. Has JLF or vulnerability/lethality testing been done on the system being replaced?

j. What are the program and test constraints?

k. Has any high level guidance been provided?

4–20. Program/test constraints and high level guidance

Questions a through i have been discussed previously; question h is also discussed below to reemphasize its importance. Questions j and k will be discussed briefly before outlining the parameters to be considered in selecting LFT&E shots.

a. Ideally, system program schedules and funding should be developed based upon detailed LFT&E planning; however, early in the acquisition cycle, the level of planning is usually unrefined and decisions are made that lock in schedules and funding levels. The LFT&E program should be planned independent of constraints and then efforts must be made in developing and approving the strategy to obtain relief from schedule and resource constraints. The most likely outcome of this process is compromise and trying to work out strategies that meet the spirit and intent of the law within existing or modified constraints.

b. Test facilities may constrain LFTs. There may be a need for new facilities or instrumentation. Time and money may not be sufficient to develop new facilities. In addition, there may be competing demands for LFT facilities for concurrent system developments.

c. High-level guidance is frequently provided on the number or percentage of random shots, threats to be included in the test, conditions to be fired, test design and statistical tests to use in the evaluation (for example, pairwise comparison using the Sign Test), vulnerability or lethality issues to be assessed, and test methods. This guidance must be taken into account explicitly in developing the strategy. If the guidance cannot be accommodated, then the rationale for not addressing it must be presented.

d. The other major constraints are the availability of threat projectiles for vulnerability tests and threat targets for lethality tests. For developmental systems, it is almost a certainty that threat projectiles and threat targets will not be available or, if they are, that they will be available in very limited quantities. Developing a rationale for surrogates that is practical (in terms of availability and cost) is important, especially for lethality LFT&E.

4–21. Parameter selection and specification

a. For each munition/target combination, the following parameters must be selected and specified: range, angle of attack, and point of impact. For engineering shots, the procedure for selecting these parameters is straightforward; select the threat and the required parameters to address a specific vulnerability/lethality issue. For random shots, the procedure is based on random selections from "battlefield" distributions of the appropriate parameters. The Board on Army Science and Technology (BAST) developed a methodology for selecting random shots for the Bradley Live Fire Vulnerability Test. The BAST methodology was revised for the Abrams Vulnerability LFT to better distribute the random shots over the entire vehicle when the sample size was small. The revised random shot methodology was reviewed and approved by members of the BAST. This methodology should be considered for future LFT&E programs. The random sampling parameters for direct fire threats versus an armored target are:

(1) Posture (attack or defense).

(2) Range (based upon attack or defense posture).

(3) Angle of attack (stratified into equal probability intervals to ensure sampling over all possible attack angles with small sample sizes).

(4) Target side (left or right).

(5) Hull or turret.

(6) Horizontal dispersion.

(7) Direction of horizontal dispersion (left or right).

(8) Vertical dispersion.

(9) Direction of vertical dispersion (up or down).

b. The sampling parameters for random shot selection must be modified as a function of weapon class (direct fire weapons, indirect fire and top attack weapons, mines, and so forth.). For example, none of the preceding parameters apply for pressure activated mines. For pressure activated mines, the sampling parameters would include right or left track and the location under the track.

4–22. Exclusion rules

Exclusion rules may also be established for rejecting random shotline draws. Typically, these exclusion rules for armored targets reject shots that:

a. Do not impact turret or hull armor.

b. Are a repeat of another random shotline.

c. Are a repeat of a previous full-up vehicle shot.

d. Are expected to result in insignificant damage.

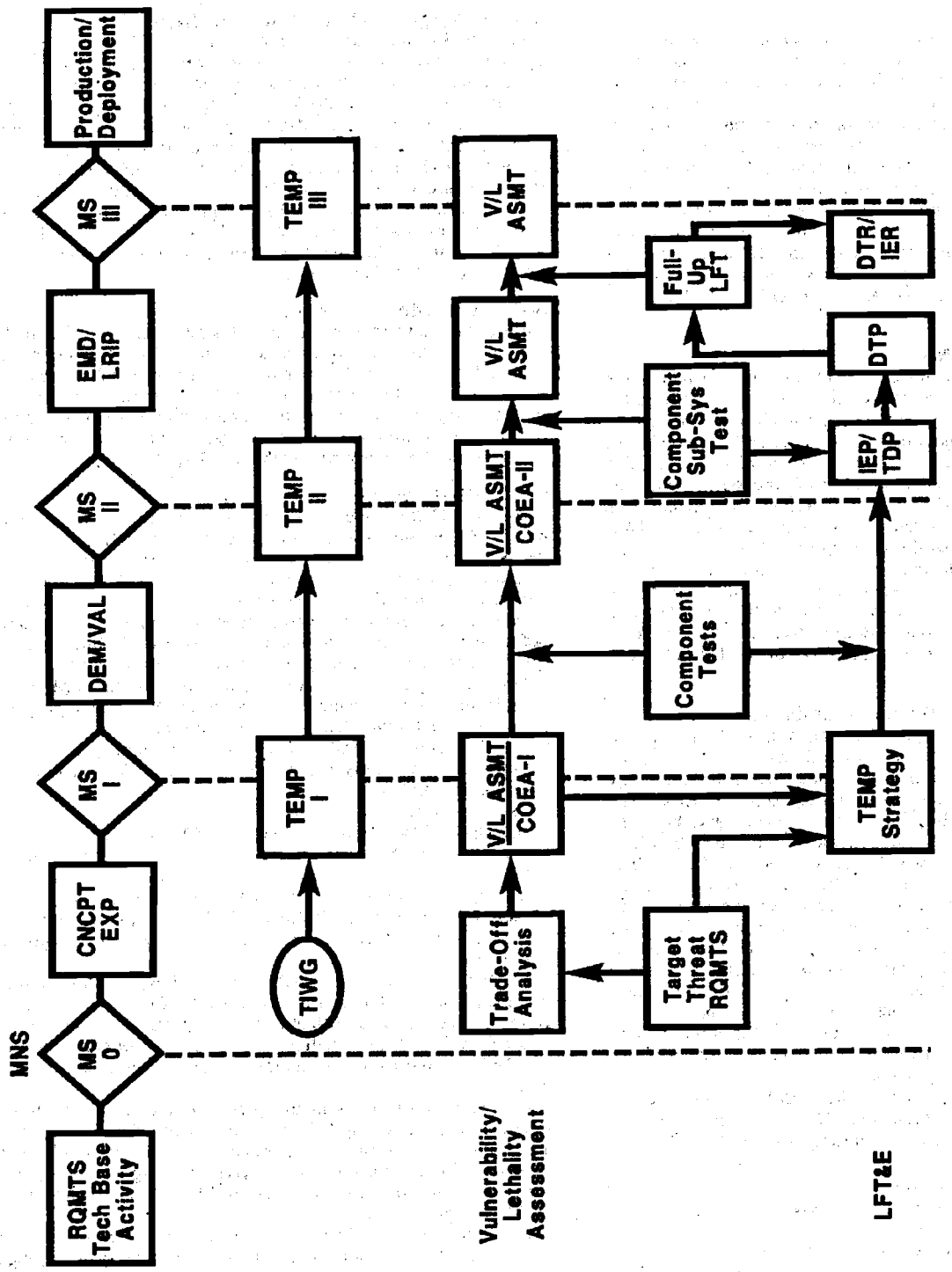


Figure 4-1. LFT&E in the material acquisition process

Chapter 5
LFT&E Review and Approval Process

Section I
Test and Evaluation Master Plan

5–1. Overview
Figure 1–1 provided an overview of the LFT&E process from initial strategy definition to the distribution of the final test reports. Key to that process is the review and/or approval of the strategy, T&E plans, and test reports by senior decision makers within HQDA and OSD. The LFT&E review and approval process builds upon the existing T&E review and approval process and ensures that the "chain-of-command" is not only kept informed of, but also approves all aspects of the LFT&E program for a given system. This review and approval process will ensure an adequate vulnerability/lethality assessment and provide the development community the necessary information to conform to the latest AAE ASARC review process guidance, that is, pre-ASARCs and ASARCs will include a briefing covering the assessment of the vulnerability and CM/CCM of the system.

5–2. LFT&E and the TEMP
The TEMP is the basic planning document for all T&E and is the document by which the Army formally coordinates and approves the LFT&E strategy for a given system and communicates that strategy to OSD. The preparation and processing of TEMPs is conducted under the auspices of the TIWG. (See DA Pam 73–2 and HQDA memorandum for guidance concerning TEMP procedures and formats to be followed in the TEMP preparation.) The TIWG provides the forum to effect coordination and resolve problems in the LFT&E process. A separate LFT&E working group (which AMSAA chairs) under the TIWG is formed to prepare the LFT&E strategy and the LFT&E input to the TEMP. This smaller group combined with the classified nature of LFT&E enables these items to be developed in a more timely and efficient manner. Additionally, the LFT&E working group may assist in any required briefings of the LFT&E strategy to HQDA and OSD.

5–3. The TEMP (Part III Developmental Test and Evaluation, paragraph d, Live Fire Test and Evaluation)
The TEMP (Part III Developmental Test and Evaluation, paragraph d, Live Fire Test and Evaluation) shall contain the LFT&E strategy for the program throughout its materiel acquisition process. The TEMP summarizes what, why, who, where, when, and how the LFT&E issues will be tested and evaluated. All LFT&E which impacts on program decisions will be outlined in the TEMP. The TEMP shows the relationship of the LFT&E issues to the required technical and operational characteristics; describes the critical vulnerability/lethality issues and evaluation criteria; outlines the planned LFT&E; discusses the amount and type of LFT&E that will be performed to support each program decision point; includes a LFT&E planning matrix covering the tests in the strategy, their schedules, the issues they will address, and which planning documents will be proposed for submission to DOT&E for approval; and indicates where schedule, resource, or budget constraints may impact the adequacy of planned LFT&E.

a. Specific items to be addressed in the TEMP are discussed in the OSD LFT&E Guidelines (appendix C), DA Pam 73–2, and HQDA memorandum, and include a description of the following items:

(1) The overall LFT&E strategy.
(2) Related prior and future LFT&E efforts.
(3) The evaluation plan.
(4) The major test limitations.
(5) The shot selection process.

b. The primary LFT&E resource requirements should be identified and addressed in the T&E Resource Section of the TEMP as early as possible (to facilitate budget and schedule projections); initial resource requirements should be identified prior to the Milestone I decision. This will ensure that adequate time is allowed for long lead items such as targets for lethality tests and threat munitions for vulnerability tests. Additionally, it ensures the early identification and programming of the funds required for test execution.

5–4. Strategy briefing to the DUSA(OR)
Since the LFT&E strategy is part of the TEMP, the review and approval process established for the TEMP (see DA Pam 73–2) necessarily applies to the LFT&E strategy. Specifically, AMSAA, in coordination with the TIWG, develops the LFT&E strategy and incorporates it into the TEMP. Upon completion of initial coordination, but before formal TEMP submission to HQDA, it is advisable to brief the LFT&E strategy to the DUSA(OR) to solicit initial guidance/agreement in principle on the proposal. Any acquisition category program with an LFT&E requirement is necessarily on the OSD oversight list (even if just for LFT&E purposes), and thus such TEMPs must be submitted to HQDA for approval before submission to OSD (see DA Pam 73– 2).

5–5. Resolution of issues
During the planning and conduct of a LFT&E program, the TIWG will attempt to resolve all issues. Those issues which cannot be resolved by the TIWG will be forwarded through the PEO/PM to the DUSA(OR) for final resolution. In some cases, issues may be raised during the conduct of the LFT&E program which require off-line tests or additional full-up firings. In all cases, any additional firings must be approved by the DUSA(OR).

5–6. LFT&E waiver
a. The LFT&E legislation contains a provision allowing the Secretary of Defense to waive the requirement for full-up LFT&E, if the Secretary of Defense certifies to Congress that such LFT&E would be unreasonably expensive and impractical. In time of war or mobilization, the LFT&E requirement may be suspended by the President. A request for waiver must be submitted and approved before the Milestone II decision. The review and approval process (per HQDA memorandum) for waivers is as follows:

(1) The request for waiver is prepared by the PM and must include the strategy which will be followed in assessing overall system vulnerability/lethality in lieu of full-up testing and an assessment of possible alternatives to realistic system testing.

(2) Request for waiver is submitted by the PM to the TIWG for coordination and approval.

(3) For ACAT ID systems:

(a) Upon TIWG approval, the PEO/PM submits the request for waiver through the DUSA(OR) for review and approval by the AAE.

(b) Upon approval by the AAE, the DUSA(OR) submits the request for waiver through the DOT&E for approval and certification to Congress by the Under Secretary of Defense (Acquisition & Technology).

(4) For less than ACAT ID systems, the PEO/PM submits the request for waiver through the DUSA(OR) for approval and certification by the AAE. Certifications and reports outlining the alternative LFT&E strategies shall be submitted to Congress through the DOT&E and the Under Secretary of Defense (Acquisition & Technology).

b. The waiver process should normally be considered a last resort in addressing the full-up LFT&E requirement. The development and articulation of a well-planned strategy which takes advantage of extensive component/sub-system/system testing and a limited but reasonable full-up, sub-system/system LFT&E phase can satisfy the LFT&E requirement.

c. A request for waiver in lieu of a limited, full-up sub-system/system LFT&E program can also be perceived by system critics as a cover-up for potential system deficiencies. More importantly, the system users need to have as complete an understanding as possible of the vulnerability/lethality strengths and weaknesses of a system before they are required to use that system in combat. Thus, the

question should not be "Can we afford to conduct LFT&E?," but "Can we afford NOT to conduct LFT&E?" if we are to ensure that "surprises" are found during system development and not on the battlefield.

Section II
Independent Evaluation Plan/Test Design Plan

5–7. Content
The IEP/TDP defines the critical issues that form the basis for the LFT&E program and provides the crosswalk between the critical issues and the data requirements. Additionally, the data sampling plan and analysis techniques are specified to ensure the logic of the evaluation is understandable. The IEP/TDP will include a section describing the types of threats or targets that the system is expected to encounter during the operational life of the system and the key characteristics of the threats/ targets which affect system vulnerability/lethality. A reference to the specific threat definition document/ authority will be presented with further discussion of the rationale/ criteria used to select the specific threats/targets or surrogates and the basis used to determine the number of threats/targets to be tested in the LFT. Any test limitations or shortfalls and their impact on the test will be identified. Furthermore, any previous data that will be used to support the evaluation will be discussed.

5–8. Preparation and approval
The independent developmental evaluator prepares the IEP/TDP and addresses all aspects of the evaluation and LFT required to satisfy the critical issues. The IEP/TDP is the responsibility of AMSAA with assistance from the other members of the TIWG. It is a stand-alone document and must be developed and then approved by the DUSA(OR) 6 months before test initiation. The approved IEP/TDP will also be submitted to the DUSA(OR) when the DTP is submitted for approval.

Section III
Detailed Test Plan

5–9. Content
The DTP provides explicit instructions for the conduct of the LFT. It is prepared by the developmental tester and is derived from and implements the requirements of the AMSAA IEP/TDP. The exact format can vary depending on the test program but, as a minimum, it should contain individual sections which address the major categories listed below.

a. Introduction. This section should contain a summary description of the test program, the principal participants and their roles, the test item and its performance characteristics, previous vulnerability or lethality testing, the test objectives, and any other information that supports LFT.

b. Test conduct. This section covers how the test will be conducted; which threats or targets are being used; what surrogates, if any, will be used; what procedures will be used to ensure test discipline; how threats will be fired/launched; and what potential lack of realism may result from absence of components, from use of surrogate components, from the inerting of fuzes on stowed ammunition, and so forth. A tabular listing of all threats/munitions to be fired and target impact conditions/locations will be provided via summary tables; pictorial representations of each target impact location and attack angle will also be provided. Finally, the procedures to be used for the crew casualty and system damage assessments will be described.

c. Appendixes. Individual appendixes should be used to address subjects such as:

(1) *System configuration.* This appendix describes the target configuration and its fidelity (that is, BH&T; full-up, target simulants, and so forth) and discusses how the test item compares to the actual, combat configured target. All stowage plans for full-up targets will be pictorially presented to show locations and quantity of items stowed on-board (as configured for combat). These stowage plans will be approved, by the combat user for U.S. systems and by the intelligence community for foreign systems, before they are incorporated into the DTP. A more detailed discussion of system configuration is found in paragraph 7–2.

(2) *Instrumentation plan.* This appendix describes the instrumentation suite required to record test conditions and measure system response (projectile striking velocity, fuel temperature, component acceleration, and so forth). The tester will define specific instrumentation requirements based on the IEP/TDP data requirements.

(3) *Battlefield damage assessment and repair.* This appendix defines the level of BDAR to be performed and describes team membership, repair skill level requirements, times for repair, and so forth. The BDAR teams support required will be decided on a case-by-case basis depending on the fidelity of the target. Typically, BDAR teams perform crew, organizational support, and/or direct support levels of repairs.

(4) *The operational security (OPSEC) plan.* This plan is included as part of the DTP to ensure that all test participants are aware of the security aspects of the LFT and how the data are to be handled. Furthermore, the high visibility and sometimes controversial nature of LFT requires strict compliance with OPSEC safeguards and a public affairs plan to cover any questions asked by outside activities or private citizens.

5–10. Preparation and approval
The DTP is prepared by the tester and coordinated with members of the LFT&E working group. After coordination, two copies of the DTP, along with two copies each of the previously approved AMSAA IEP/TDP and the SLAD Pre-Shot Prediction Report, are forwarded to the DUSA(OR) at least 60 days before test initiation. The DTP is either approved by the DUSA(OR) or returned to the tester for changes or corrections. Testing will not start until the DTP is approved by the DUSA(OR).

5–11. Change procedures
The Army approved DTP, along with the Army approved IEP/TDP, and the Pre-Shot Prediction Report are forwarded to DOT&E for review and comment or approval; DOT&E suggested changes are reviewed by the DUSA(OR) and incorporated by the appropriate lead activity as directed by the DUSA(OR). The DTP must outline the detailed procedures to be followed to accommodate unexpected changes to the LFT that may occur during actual testing. When a change to the approved DTP is required, it is essential that strict adherence to the change procedures be followed to avoid repeating test shots and to dispel any perceptions of fixing the test to achieve desired results. The TECOM takes the lead in coordinating changes to the DTP and ensures these changes are fully coordinated with all participating LFT&E agencies. Written notification of the proposed changes is forwarded to the DUSA(OR) for approval. No change from the DTP is undertaken until approved by the DUSA(OR) and provided to DOT&E for review and comment or approval. After DUSA(OR) approval (and DOT&E approval if required), all participating agencies are notified of the change approval. The change will also be documented in the DTR along with the supporting rationale.

Section IV
Pre-Shot Prediction Report

5–12. Content and preparation
The Pre-Shot Prediction Report provides the vulnerability/lethality analysts' best estimate of the expected outcome of each shot before actual test conduct (that is, a pre-shot prediction). It is a requirement for all LFTs and provides a snapshot of the vulnerability/lethality analysts' current understanding of the munition/target interaction. These predictions can range from subjective engineering judgments of the expected damage level through computer generated estimates of crew casualties and loss of critical system capabilities. The SLAD is responsible for generating the pre-shot predictions for each shotline. Appropriate pre-shot prediction techniques will be determined by SLAD on a case-by-case basis and will be consistent with the technique planned for casualty/damage assessment. The SLAD

will prepare the Pre-Shot Prediction Report; it must be submitted to the DUSA(OR) along with the DTP 60 days before test initiation. The Army approved Pre-Shot Prediction Report is forwarded along with the DTP and the IEP/TDP to DOT&E for review and comment.

5–13. Necessity

The pre-shot predictions are necessary for the following reasons:

a. To ensure useful insights will be gained about the relative vulnerability or lethality of the system involved.

b. To establish a baseline estimate of the understanding of the munition/target interaction before test.

c. To assist in shot prioritization from least to most damaging. This will ensure that most of the testing will be completed before the high risk shots are fired. This works well for both vulnerability and lethality tests since target repair is a major driver in the turnaround time between LFT shots.

Section V
Detailed Test Report

5–14. Content, preparation, and approval

The DTR, prepared by the tester, provides a formal detailed record of the test data and information obtained during the conduct of the LFT, and describes the conditions which actually prevailed during test execution and data collection. The test report documents all individual shot test conditions and test results required by and identified in the DTP and approved changes to the DTP. Sixty days after test completion, the DTR is provided to AMSAA to support their independent evaluation, and forwarded to the DUSA(OR) for approval. The approved DTR and IER must be forwarded to DOT&E within 120 days after test completion and 45 days before the full-rate production decision. Schedules must be planned accordingly to accommodate these mandatory reporting milestones.

Section VI
Independent Evaluation Report

5–15. Content and preparation

The IER documents the independent evaluation of the LFT and contains the assessment of the critical issues and conclusions concerning the vulnerability/lethality of the system. The IER is the sole responsibility of AMSAA, the independent developmental evaluator. The IER addresses the test objectives, issues, and criteria as defined in the IEP/TDP. It discusses the crosswalk between results and the evaluation and specifies any limitations relative to the analysis. All aspects of the test will be evaluated, both negative and positive. The evaluation will be balanced by the discussion of vulnerability/lethality based on the likelihood of occurrence on the battlefield. The IER is submitted to the DUSA(OR) for review and together with the DTR is forwarded to DOT&E within 120 days after test completion. The IER and all LFT&E reports (to include the OSD assessment report to Congress) must be rendered prior to the Milestone III, full-rate production decision.

Section VII
Detailed Damage Assessment Report

5–16. Content and preparation

The Detailed Damage Assessment Report documents the detailed analyses and crew casualty and system damage assessments of the individual test events. It includes an in-depth comparison of the pre-shot predictions of crew and system damage and the observed test outcomes. This process requires a detailed examination of component damage states, failure modes, damage mechanisms, and so forth, to ensure a full understanding of model predictive capability. Anomalies will be identified and, if required, model updates specified. These in-depth analyses will not preclude SLAD from providing its required support to the LFT evaluation. The individual shot damage assessment records will be provided by SLAD to the tester within 30 days after test completion and subsequently to AMSAA to support its independent evaluation. Within 6 months after completion of the test, the SLAD will publish the Detailed Damage Assessment Report.

Chapter 6
Modeling

6–1. Introduction

a. Much of the early controversy surrounding LFT&E focused on the adequacy of existing Army vulnerability/lethality models and their appropriate role in the overall LFT&E process. Too often people interpreted the debate over these issues in such a manner that modeling and testing were viewed as an either-or proposition. The basic fact is that both are needed and are essential to a comprehensive and effective LFT&E program. They are complementary efforts and the LFT&E strategy and planning must be based on this view. This chapter will attempt to provide a better understanding of the Army's vulnerability/lethality models and their role in LFT&E.

b. Live Fire testing, even when supplemented with developmental testing, cannot produce enough data to assess the vulnerability or lethality of a system for all combinations of threat, impact, and engagement conditions. Thus, modeling must be used to extend test results to account for conditions impractical or impossible to test. The reader is reminded that modeling here is defined in the broad sense given in the glossary.

6–2. Role of modeling

In the context of LFT&E, vulnerability/lethality modeling has four basic roles: support test design, support the evaluation of system and crew vulnerability or munition lethality, guide and evaluate vulnerability reduction or lethality enhancement efforts, and methodology diagnosis.

a. Test design support. Live fire testing is expensive and it is absolutely essential that the maximum information be collected with the resources allocated to LFT&E. Modeling is used:

(1) To determine which engineering shots make the most sense in terms of what is known about the vulnerability or lethality of the system being tested, the expected performance of the threat munitions or target, and the specific evaluation issues for the system being tested.

(2) To develop and apply exclusion rules for randomly selected shots and, once those shots have been selected, to determine from pre-shot predictions which, if any, should be conceded to avoid unnecessary loss of test assets.

(3) To "filter" random and/or engineering shotlines to ensure a specified level of damage will be considered (for example, using loss of function (LOF) matrices to identify weapon/target impact locations which satisfy a preselected criteria that only "shotlines with a LOF greater than or less than a certain value will be considered," or to identify weapon or target impact locations which satisfy preselected damage criteria).

b. Evaluation support. Model outputs, together with LF and development test results, are used by AMSAA to address critical evaluation issues pertaining to system vulnerability or lethality, crew casualties, and logistic supportability. It is difficult to separate vulnerability or lethality evaluations directly supporting LFT from those required to support the entire acquisition process because, in a broader context, model generated vulnerability and lethality estimates are critical inputs to system effectiveness studies, such as the cost and operational effectiveness analysis (COEA), designed to determine force exchange ratios, optimum tactical deployment schemes, wartime maintenance and medical requirements, and other measures of system cost and benefit.

c. Vulnerability reduction/lethality enhancement. Modeling also supports vulnerability reduction and lethality enhancement efforts by

allowing the analyst to evaluate the potential payoff of design changes intended to reduce casualties/system vulnerability or increase munition lethality.

d. Methodology diagnosis. One objective of LFT is to determine the extent to which the vulnerability and lethality models account for all pertinent munition damage mechanisms and target failure modes. In this context, modeling, via comparing pre-shot predictions with test results, can provide insights into the fidelity of the models themselves. Seldom will enough data be generated from a single LFT to allow a complete verification of model performance. But, insights can be gained to suggest whether significant munition/target interactions are being neglected by the models and to identify areas of model performance which need to be more thoroughly examined in on-going model improvement programs.

6–3. Assessment techniques

a. Vulnerability or lethality modeling can be as simple as using a series of charts to determine whether missile fragments are likely to sever a drive shaft in the LFT, or a subset of the LFT conducted on a component or sub-system level. At the other extreme, modeling may involve the use of several large-scale computer codes to generate distributions of damaged components or other metrics which take into account all known munition/target interaction phenomena and, in addition, address the stochastic nature of these interactions.

b. In general, more than one model must be used to characterize such phenomena as target geometry, munition performance, armor performance, BAD, personnel injuries, component and sub-system failure modes, aircraft airspeed and altitude dependence, and component kill probabilities. Usually, these models are implemented and applied with personal and mainframe computer codes which, depending on their complexity and sophistication, have modules to implement these models or use as input the products of auxiliary codes. It is important to recognize that the choice of models cannot be specified arbitrarily. Rather, the appropriate model or assessment technique must be chosen on the basis of how much is known about the threat munition or target, input data that are available, and perhaps most importantly, the vulnerability or lethality issues that the LFT is designed to address. While the most detailed and sophisticated models consistent with these criteria should always be used, it is not unusual for one suite of models to be most appropriate for pre-shot predictions while another suite of models is best for some other aspect of the LFT&E effort. This flexibility in model selection is especially necessary for lethality LFT&E because the level of knowledge of the threat target is often extremely limited.

c. For any given LFT, be it vulnerability or lethality, the suite of analysis models must be selected by the vulnerability/lethality analyst in coordination with AMSAA. However, once this choice of assessment technique is made, it is important to create an audit trail. The underlying rationale for the model or its modification, model limitations, assessment procedures, and required input data should be documented. The models to be used must, of course, be specified in the IEP/TDP. However, depending on the level of development of the LFT&E strategy, they may or may not be identified in the earliest versions of the TEMP.

6–4. Databases

Regardless of the specific models selected to support any given LFT, there are several databases that must be developed prior to LFT. The exact nature of these databases will, of course, vary depending on the models actually used. However, they will usually include such things as component Pk/hs, target descriptions, threat munition and armor performance, BAD characteristics, failure modes and component/sub-system criticality, kill criteria, DALs, helicopter altitude-airspeed diagrams, and the sensitivity of combustibles to fragment and penetrator impacts. Development of these supporting databases must begin 1 to 2 years in advance of the start of the LFT. A potential problem with the scheduling of tests and analyses to generate these databases is that the data must be pertinent to the planned production design of the system or munition being tested. For example, penetration characteristics for a new projectile must be for the production design as opposed to evolutionary development prototypes. Some of these databases will be developed wholly or in part to support the overall T&E process; others are needed to directly support LFT. In any event, costs and hardware requirements must be identified as early as possible in the TEMP in order to permit their inclusion in budget and contractual documents.

6–5. Vulnerability/lethality estimates

Vulnerability and lethality estimates are typically generated by, or under the auspices of SLAD. (For JLF Programs and Army LFT of multiservice equipment or munitions, vulnerability/lethality modeling may be conducted or supported by the Navy or Air Force.) These vulnerability and lethality estimates are essential inputs to system effectiveness studies; they also provide a basis for relative comparisons (for example, to determine whether the requirement to reduce the average vulnerability by some amount has been met). However, the vulnerability and lethality estimates do not account for combat attack distributions, deployment conditions, or weapon hit probabilities. Typically, AMSAA applies these factors to the vulnerability and lethality estimates. Resulting metrics are then used by AMSAA, TRADOC, or other agencies to evaluate system survivability or firepower to determine force exchange ratios, identify maintenance requirements, or determine some other measure of system effectiveness. Thus, there is clearly a critical link between vulnerability/lethality modeling and system level evaluations. It is evident that vulnerability and lethality analyses must be responsive to the requirements of the system level studies. Conversely, evaluation strategies must be based on the type, quality, and quantity of vulnerability/lethality estimates that can be reasonably expected to be generated in light of the limitations discussed above. In addition, data requirements must be identified in a timely manner to allow input databases to be developed and necessary model modifications to be made.

6–6. Classes of models/algorithms

There are a great number of models or algorithms used to support the vulnerability/lethality assessment process. In table 6–1, three classes of such models are compared for output measure, level of detail, and applications. This table is by no means all-inclusive and is included here to illustrate the primary factors associated with vulnerability/lethality models.

Table 6–1
Comparison of three types of vulnerability models

Model Type	Output Measures	Level of Detail	Applications
Lumped parameter (e.g., compartment)	Expected M-Kill Expected F-Kill Expected M/F-Kill Expected K-Kill	Structure external suspension compartments (crew, ammo, engine) crew casualty	COEAs, MAAs, SSEBs, Compartment-level trade-off analyses, Vulnerability reduction
Expected value Point Burst (e.g., VAST, HEVART)	Same as above plus component Pks attrition forced landing mission abort repair times	Structure suspension components crew casualty	Same as above plus component level trade-off SPARC analyses

Table 6–1
Comparison of three types of vulnerability models—Continued

Model Type	Output Measures	Level of Detail	Applications
Stochastic Point Burst (e.g., SAFE, SQuASH)	M-kill Pdf F-Kill Pdf M/F-Kill Pdf K-Kill Pdf Component Pks component damage state Pdf	Same as above	Same as above plus estimation of errors in field sampling, propagation of uncertainities, and calibration of lower- level models.

Notes:
F-kill = firepower kill
K-kill = catastrophic kill
M-kill = mobility kill
M/F-kill = mobility or firepower kill
HEVART = high explosive vulnerable areas and repair times
MAA = mission area analysis
Pdf = probability density function
SSEB = source selection evaluation board
SAFE = stochastic analysis of fragmentation effects
SquASH = stochastic qualitative assessment of system hierarchies
VAST = vulnerability analysis of surface targets
See paragraph 7-12 for definitions.

Chapter 7
Test Conduct and Parameters

Section I
Test Item Configuration

7–1. Overview

This chapter provides general guidance for the conduct of LFT and discusses those parameters and functions which must be considered during test planning (vehicle stowage, instrumentation, scheduling, and so forth); actual test requirements will be established on a case-by-case basis to address the data requirements defined in the IEP/TDP. Guidance presented in this chapter is based on Army LFT&E experience to date with armor/anti-armor systems. Test conduct, test parameters/functions, and terminology discussed in the following sections reflect this experience. Because the primary purpose of LFT&E is to address crew survivability, most of the parameters/functions and the testing discussed in this chapter is applicable to any type of system and the remaining items are easily extrapolated to other types of systems. Again, the reader is cautioned that, all requirements must be determined on a case-by- case basis.

7–2. Vulnerability LFT&E

a. Vulnerability LFT&E is conducted to identify potential system integration vulnerabilities which cannot be adequately addressed through component and/or sub-system testing. In order to provide the most realistic test possible and to accurately assess the vulnerability of the system and the survivability of the crew, the weapon system must be as close to its combat configuration as possible. Combat configuration denotes a fully operational test item complete with all sub-systems and on-board stowage items.

b. The presence of a fully operational test item with all sub-systems is particularly important in evaluating ballistic shock damage and the interaction between sub-systems as a result of damage to different components. In order to determine the individual effects of each shot on the test item, the test item is repaired and baseline performance characteristics determined before each test shot. Baseline procedures should include a complete functional check of all major sub-systems on the test item and may also include performance checks such as mobility or firepower characteristics.

c. Systems undergoing LFT&E testing are stowed in a combat configuration so that the effects of the stowage on the system vulnerability and crew survivability can be assessed. Stowage in a combat configuration includes ammunition, fuel, additional authorized list (AAL) items, and basic issue items (BII). Anthropomorphic simulants and/or wooden mannequins are located in crew positions as an aid in crew survivability assessments. Ammunition should be live, with inert fuzes or fuzes removed (live fuzes damaged during test conduct could present a hazard to test personnel). However, if the reaction correlation between inert and live ammunition is known and predictable, inert rounds may be stowed to ensure survivability of limited assets. The use of inert rounds instead of live ammunition will be approved by the DUSA(OR) on a case-by-case basis. Any planned shot which the PM considers to be catastrophic or of significant damage may be conceded; however, conceded shots will be assigned a Pk = 1.0 for the evaluation.

d. All fuel in the test item will be at normal operating temperatures for the system at the time of the test firing. This is necessary since the flammability of the fuel increases as its temperature increases. Typically, this is done by adding heated fuel to the test item before the test firing.

e. The AAL and BII are stowed on the test item in accordance with an approved stowage plan. Typically the stowage plan is developed by the responsible TRADOC school and verified by the tester before testing. Crew simulants are dressed in the appropriate ensemble to include helmet, personal weapons, goggles, gloves, boots, coveralls, ballistic vest, and battle dress uniform, as prescribed by Army doctrine. This ensures that the anthropomorphic simulant or wooden mannequin is representative of an actual crew member and that the protective features of the uniform are accounted for in the crew injury evaluation.

f. A hazard analysis is performed on all of the stowage items. Any stowage item which could pose a hazard to test personnel, if damaged during testing, must be modified or replaced. Those items modified or replaced must be listed in the DTP. For example, certain types of chemical detectors used on combat vehicles contain a radioactive isotope as part of the sensor. This isotope would be removed before stowing the detector.

7–3. Lethality LFT&E

a. Lethality LFT&E is conducted to demonstrate the effectiveness of U.S. munitions against required or representative threat targets. Targets for lethality LFT&E can include target simulants (that is, targets constructed to represent a shotline against a known threat), residual penetration packets, and BAD collection packets to determine residual penetration and spall data, respectively, and, if possible, full-up systems. The full-up system could be the actual threat, or, if available, an "older" threat, or an approved surrogate (see chap 4 and app E). The actual targets and full-up systems to be used are determined on a case-by-case basis and will be specified in the LFT&E portion of the TEMP.

b. As with vulnerability LFT&E, the full-up threat system will be in a full combat configuration (that is, fully operational and stowed per an approved stowage plan). The full-up system test provides a

mechanism for evaluating overall munition effectiveness due to penetration/perforation, spall, ballistic shock, fire, blast overpressure, toxic fumes, and so forth. The use of inert ammunition in lethality LFT&E is subject to the same conditions given in paragraph 7–2c.

7–4. Simulated targets

To preserve valuable threat assets or when threats are not available for lethality LFTs, targets constructed to represent a given threat characteristic can be used in lieu of full-up targets. Tests conducted with these targets should be used to supplement a limited full-up LFT; simulated target tests alone do not provide an adequate demonstration of a system's lethality. Data which can be obtained from simulated target testing (either directly or from modeling efforts) are: profile hole diameters; BAD (fragment mass, velocity, and spatial distribution); residual penetration; and individual Pks for a selected target impact location. If side-by-side testing of two or more munitions is conducted, statistical tests (for example, Sign test, Student t-test, and so forth) can be used to conduct lethality comparisons.

Section II
Resources and Schedule

7–5. Resources

The LFT is normally the last test to be conducted before the full-rate production decision and, as such, planning and resourcing must be addressed early-on in the LFT&E program. The strategy and resource requirements (to include targets/ munitions) to accomplish an efficient and effective LFT&E program must be included in the TEMP T&E Resource Section.

7–6. Schedule

Conduct of the LFT is driven by the time required between shots to repair the target. Full-up system tests, especially vulnerability tests, may require extensive repairs and repair time. Experience indicates that there is roughly a three-to-one ratio of repair time to test range time. To increase test efficiency and provide maximum utilization of personnel and hardware, it is advantageous to conduct LFTs with multiple target assets. Multiple target assets allow for overlapping of test and repair time, thus, increasing testing efficiency. When multiple test assets are not feasible, the LFT&E schedule must reflect the total time required to complete the testing. If the schedule cannot accommodate these time requirements, it may be necessary to restructure the strategy. Decisions concerning assets, schedules, and strategy are addressed by the LFT&E working group. As with other phases of the T&E process, unresolved issues are forwarded to higher headquarters for resolution.

Section III
Instrumentation and Facilities

7–7. Instrumentation

Test assets and the LFT are expensive; therefore, a complete set of data must be gathered on each shot to facilitate the crew and system damage assessment, to measure and/or record test conditions, and to ensure test conformity (that is, compliance with the DTP). In addition to instrumentation for addressing crew/system damage, the test item is instrumented to provide early warning of potential problems resulting from the test event. Parameters measured could include: engine rpm, voltage, hydraulic fluid pressures and temperatures, oil pressures and temperatures, coolant temperatures, and automatic fire suppression/fire extinguishing system discharges. Actual instrumentation suites are determined by the tester on a case-by-case basis to address the IEP/TDP data requirements and test item safety/security requirements. These instrumentation packages typically include the following:

a. Video and high-speed photography to provide visual documentation of the test event. Video documentation provides real time monitoring of the interior and exterior of the test item. The exterior video also assists in locating parts displaced by the munition/target interaction. The internal video provides real-time information on perforation of the target protective system, the presence and extent of internal fires, and test item status information required for determining when it is safe for test personnel to re-enter the test site.

b. Projectile flight/performance instrumentation to record striking velocity, velocity profile from launch to impact, pitch/yaw history, and penetration characteristics. Video cameras, high speed cameras, and/or flash x-rays may be used.

c. Toxic fumes instrumentation to record the levels of potentially hazardous gases (for example, nitric oxide, nitrogen dioxide, carbon monoxide, carbon dioxide, hydrogen fluoride, hydrogen bromide, cyanide, aldehydes, and so forth) and airborne particulates. Toxic fumes data are collected at crew member locations. Specific items and crew locations to be sampled are system dependent and will be determined based on an analysis of the potential hazard posed by on-board materials.

d. Thermal effects instrumentation to record temperature and heat flux data related to the crew and test item. These data are used to assess crew survivability, provide engineering data to assess hardware vulnerability, and ensure compliance with the DTP parameters (for example, fuel temperature at shot time).

e. Blast overpressure instrumentation to record pressure time histories. Overpressure data are collected in the crew compartment and external to the test item to assist in assessing personnel casualties and to provide engineering data to assess hardware vulnerability.

f. Ballistic shock instrumentation to record accelerations and forces on the crew and critical system components. Accelerometers, strain gages, and/or velocity gages can be placed on components to measure the ballistic shock transmitted through the structure of the test item to the components, and on anthropomorphic simulants to measure acceleration and forces transmitted to the crew. The simulants are positioned in crew locations away from the primary penetrator path/spall cone where ballistic shock to crew is of concern. Wooden mannequins can be placed in other crew locations to record the effect of the penetrator/spall cone.

g. Plate arrays and BAD packets to record penetration performance, residual penetration, and spall cone characteristics (fragment number, size, velocity, and spatial distribution).

7–8. Facilities

Live fire testing often requires extensive test facility capabilities to allow for realistic and cost effective testing. Actual facilities for a given program will be driven by the test and data requirements. Test facility capabilities which could be required to support a given program are:

a. Multimunition firing. The threat could consist of gun fired rounds, missiles, rockets, mines, and so forth, requiring a variety of launching capabilities. Threats could require real range firings, reduced range firings, and static firings (for example, mine firings in prepared soil with specified density and moisture content). Launch conditions could be direct fire, superelevation (anti-air simulation), or high angle of fall (indirect fire simulation).

b. Instrumentation suite. Live fire testing is instrumentation intensive and could require upwards of 200 channels of data collection during any given shot. Substantial video and high-speed film coverage for documentation and test item security could be required.

c. Range/test item security. In addition to video to provide real-time visual security, an auxiliary fire suppression system could be required to protect range and instrumentation suite facilities as well as test item security. Providing adequate protection to instrumentation cables from fragments and/or fire to ensure test requirements are not compromised must be a prime consideration. Additionally, environmental protection in accordance with Federal and State government mandates must be adequately addressed. (Environmental impact statements must be developed, staffed, and approved before test initiation.)

d. Repair facility. Because test assets are limited and LFT&E test item/target configuration requirements are stringent, the ability to

perform repairs will be necessary. These repairs could include welding, machining, fabricating/replacing damaged components, and major reconstruction of the test item. Repair up to depot level could be required.

Section IV
Test Discipline

7–9. Key test discipline items

The high-visibility and oversight of LFT requires strict discipline during the conduct of the testing. This paragraph summarizes key test discipline items which are applicable to future LFTs.

a. Follow the DTP. One of the primary responsibilities of the tester is to ensure that the test is conducted in accordance with the HQDA approved DTP. Unauthorized deviations from the DTP are not permitted. Additionally, the LFT will not start until the DTP is approved. With LFT&E scheduled near the critical full-rate production decision milestone and test shots relatively expensive, it is essential that the DTP be followed to avoid potential problems. Conducting the test according to an approved DTP will eliminate the perception of bias or of rigging the test in order to ensure positive results. Changing shotlines, threats, stowage, and so forth, even for sound technical reasons, without proper coordination and authorization, is not permitted.

b. Change procedures. A LFT is rarely conducted without some deviation from the approved DTP being required. To address these potential deviations and retain testing integrity, a strict procedure has been adopted for approving changes to the DTP. This change procedure is described in paragraph 5–11.

c. Reporting emerging results. The dissemination of emerging results provides test participants a continuing awareness of test progress and an early identification of potential vulnerability/lethality shortcomings. Data is usually disseminated at data review meetings. These meetings should be held periodically throughout the test so that data can be reviewed, commented on, and necessary subjective judgments reviewed for consistency and soundness. Representatives of the damage assessment team (DAT) (see para 7–10), PM, and system contractor are typically present at these meetings. However, it should be noted that in assessing the shots, the PM and system contractor have no vote, but are present to provide information on system design characteristics, if required. The DOT&E will have access to these meetings; however, any results addressed during these meetings and used in the DOT&E assessment report will be provided to the Army for factual review before its use.

Section V
Damage/Casualty Assessment

7–10. Damage assessment team

After each shot, the target is examined and the system damage and crew casualties are assessed. This section defines the Army approach to this process. The DAT collects and assesses crew incapacitation and/or test item/target damage after each shot. The DAT will be chaired by SLAD and will include the tester and the user (for vulnerability LFTs) as a minimum. Other interested organizations will be requested to support the DAT as required. The specific tasks of the DAT are to:

a. Document any physical damage to the simulated crew members and assess the extent of their injuries (that is, level of incapacitation).

b. Document any physical damage to the test/target item.

c. Determine if any injury, degradation, and/or loss of system capability occurred which would affect the ability of the crew and system to perform their mission.

d. Determine the damage mechanisms causing any injury, degradation, and/or LOF.

e. Characterize the test item's performance and other parameters, before and after each shot, to allow for future vulnerability reduction/lethality enhancements.

f. Document and characterize behind-armor effects produced by the test munition.

g. Use the preceding information to assess crew casualties and determine system loss of function or degraded combat utility for the test munition.

h. Provide a final damage assessment report for each shot; necessary subjective judgments will be based upon the majority viewpoint of the DAT.

7–11. Crew Vulnerability

Crew vulnerability can be assessed by examining data collected with crew simulants and crew environment instrumentation.

a. Crew simulants can be used to assess the expected damage to the crew members. The following simulants have been used in previous LFTs:

(1) Fully combat dressed wooden mannequins placed in crew positions in the expected penetrator path/spall cone where acceleration injury is not a main concern. After each shot, the fully combat dressed mannequins are assessed for damage (for example, burns on clothing, damaged body parts, fragment penetration/perforation, and similar changes).

(2) Fully combat dressed anthropomorphic simulants ("anthros") placed in crew positions where acceleration is the main concern. "Anthros" can be used to measure triaxial acceleration, compression, biaxial bending, fore-aft bending, and neck shear.

b. The crew compartments can be instrumented to collect thermal, toxic fumes, and blast overpressure data. The following crew environmental data have been collected in previous LFTs:

(1) Temperature and heat flux levels at each crew member location. These data allow a determination of the level of burn damage and the effectiveness of the crew member's protective uniform.

(2) Toxic fumes levels at each crew member location. Data on toxic gases, pyrolysis products, and airborne particulates are collected.

(3) Blast overpressure levels at each crew member location. These data are used to determine the level of crew incapacitation due to injury to the air containing structures of the body (for example, lungs and ears).

c. The collected simulant and environmental data are analyzed and compared to approved crew injury criteria to determine an expected level of crew incapacitation. These data are used by SLAD in the overall crew survivability assessment.

7–12. Vehicle vulnerability

a. After each individual shot, all damage is recorded, as well as obvious vehicle functional degradation (for example, engine will not run). This damage assessment is then used to determine vehicle vulnerability in the form of system loss of function or degraded combat utility. These estimates are derived through the use of fault-tree or deactivation diagrams. Some existing degraded combat utility kill categories for armored vehicles and aircraft systems are presented below.

(1) *Mobility kill (M-kill).* An armored vehicle suffers an M-kill if it becomes incapable of executing controlled movement and cannot be repaired by the crew (within approximately 10 minutes) on the battlefield.

(2) *Firepower kill (F-kill).* An armored vehicle suffers an F-kill if it becomes incapable of delivering accurate, controlled firepower and cannot be repaired by the crew (within approximately 10 minutes) on the battlefield.

(3) *Catastrophic kill (K-kill).* An armored vehicle sustains a K-kill when both an M-kill and an F-kill occur and it is not economically repairable.

(4) *Attrition kill.* An attrition kill is obtained when an aircraft sustains combat damage so extensive that it is neither reasonable nor economical to repair. This category is divided into six levels of kill depending on the time after impact at which manned control is no longer achievable.

(5) *Forced landing.* This kill is obtained when an aircraft sustains combat damage that forces the crew to execute a controlled landing (powered or unpowered). This category includes aircraft which will

require repairs for flight to another area and aircraft which cannot be repaired on-site but can be recovered by a special team.

(6) *Mission abort.* This kill is obtained when an aircraft sustains combat damage that prevents completion of the designated mission but permits the aircraft to return to base.

(7) *Mission available.* This kill is obtained when an aircraft has landed but will require repair before returning to a mission-ready status.

b. In addition to providing insights into system vulnerability, LFT&E can provide the user "hands-on" experience in BDAR. During LFT&E, BDAR can provide the user insights into the time, parts, tools, and skills required to repair the system to a combat-capable condition. Evaluation of a system's capabilities immediately following a simulated threat attack compared to the system's capabilities following crew, organizational, and direct support repair provides insights into the overall fightability of the system. Another application of the repair process is to examine the spare part supply line to ensure that parts stocked are in fact those required to support damage sustained from a battlefield encounter.

Chapter 8
Lessons Learned

8–1. Introduction

a. Live Fire testing is one of the most visible and expensive phases of developmental testing and requires detailed planning, documentation, and coordination in order to ensure an efficient and effective program. To make it affordable and efficient and to ensure that the Army is provided the best information for its investment, future LFT&E efforts must take advantage of experience gained during the development and conduct of previous LFT&E programs. Incorporation of these lessons into the planning and conduct of future LFT&E efforts will ensure the maximum return on the Army's investment in LFT&E.

b. To keep LFT&E affordable, the number of full-up shots must be kept to an absolute minimum. To minimize the number of full-up, system-level shots, the LFT&E strategy must be structured with extensive component-level tests which collectively support resolution of critical system survivability and/or lethality issues. A successful component-level test program can minimize the number of required full-up, system-level shots and thereby reduce LFT costs. The information from a few, well-designed full-up, system-level shots can lead to system vulnerability reductions or lethality enhancements which can make a difference in the battlefield survivability of both the crew and the system.

8–2. Test planning and execution

The Army has conducted extensive LFTs on a number of combat vehicles including the Abrams tank, the Bradley Fighting Vehicle, and the Paladin howitzer. This paragraph summarizes key lessons learned from a test planning and test execution standpoint which apply to future vulnerability and lethality LFTs.

a. Management. Management of a LFT is best accomplished by a matrix organization which performs test planning, test execution, evaluation of test results, and test documentation. That organization must have access to professionals with expertise in ballistics, vulnerability/lethality modeling, casualty and damage assessment, developmental testing, combat vehicle repair, BDAR, and materiel systems analysis and evaluation. Figure 8–1 illustrates the matrix organization created by the Army to conduct of the Bradley and Abrams LFTs.

b. Documentation. Prior to firing a round, prepare an IEP/TDP, a DTP, and obtain approval/comments from both the Army and OSD leadership. Include in the IEP/TDP and the DTP all information required by the OSD LFT&E Guidelines (appendix C) and ensure all testing and subsequent evaluations are conducted in strict compliance with these plans. These plans must be of sufficient detail to preclude misunderstanding by the Army and OSD leadership.

c. Participants. Identify all oversight organizations (for example, OSD, General Accounting Office, and so forth) and involve them both in the test design and test execution processes. Concerns by these organizations must be raised and addressed prior to or during testing, not after test completion.

d. Data sharing. Share test data with all activities as soon as data are validated so that oversight organizations, the independent evaluator, the PM, and the user representatives have the same information at any point during the test.

e. Emerging results. Establish a formalized emerging results forum where the matrix test team can identify and document potential evaluation issues. Follow-up with research by the PM and/or off-line tests and investigations by the system contractor to shed additional light on these potential issues so that they are either resolved before test completion or identified for inclusion in the final evaluation report. The guiding principle must be to address all vulnerability/lethality concerns in the emerging results forum as they are identified to preclude "surprises" by the contents of the final reports. The DOT&E will be provided access to the emerging results. However, all emerging results identified by DOT&E for use in supporting its independent assessment report will be provided to the Army for factual review prior to its use.

f. Evaluation. Prepare a balanced evaluation report which objectively describes both the negative and positive aspects of the results. For example, not all vulnerabilities identified in a vulnerability LFT&E can be fixed. Constraints on system funding, system weight, and other aspects necessitate that the matrix team participate in ranking the identified vulnerabilities from the perspectives of likelihood of occurrence on the battlefield and the degree of system degradation given an occurrence. The final evaluation report provides this information to the user and to the PM for resolution.

8–3. Technical lessons learned

During the conduct of previous LFT&Es, lessons learned from a technical aspect were identified and are enumerated below. These technical lessons learned not only address LFT&E but also weapon system design principles which may prove useful in future development endeavors.

a. Benefits of live fire testing. Extensive use of off-line testing to address such issues as sympathetic detonation, ammunition/propellant compartmentalization, and collateral damage will keep LFT&E affordable while ensuring that critical issues are adequately addressed. Preserve valuable assets to address those issues which require a full-up system to answer.

b. Enhancement measures. Identify vulnerability reduction/lethality enhancement measures early in the development process. Take advantage of the SLAD expertise in this area. Do not wait until LFT to ensure vulnerability reduction/lethality enhancement measures are adequate. Vulnerability reduction/lethality enhancement measures must be considered during the system design process.

c. Dual use in peace and war. Design the system for both peacetime and wartime use. For example, the Abrams tank was developed with an inhibitor which would not allow the driver to exceed 2 miles per hour if the system indicated the engine had been damaged. Obviously, this would preserve valuable engines during peacetime training or testing operation but could significantly limit vehicle performance during combat situations. Thus, "combat overrides" to"peacetime inhibitors" should be a principal design consideration. The problem cited in this example was identified during the Abrams Vulnerability LFT; the PM has developed a fix which corrects this problem.

d. Total systems look. Take a total systems look at crew and system vulnerability. This means one must consider the contribution of all items (crew clothing, component hardware, ammunition, fuel, and stowage items) to crew and system vulnerability. For example, design or store stowage items so that they do not pose a fire hazard to the crew.

e. Proveout test configuration/firing method prior to LFT. Proveout, during early developmental testing of missile systems, a test configuration and firing method that emulates the function and

performance of the tactical missile warhead when fired on ballistic sled tracks against small target arrays, such as range targets. This will minimize program risk that can occur if an unproven test configuration/firing method is introduced for LFT where it is essential to test items that are production representatives (that is, in terms of function and performance of the warhead).

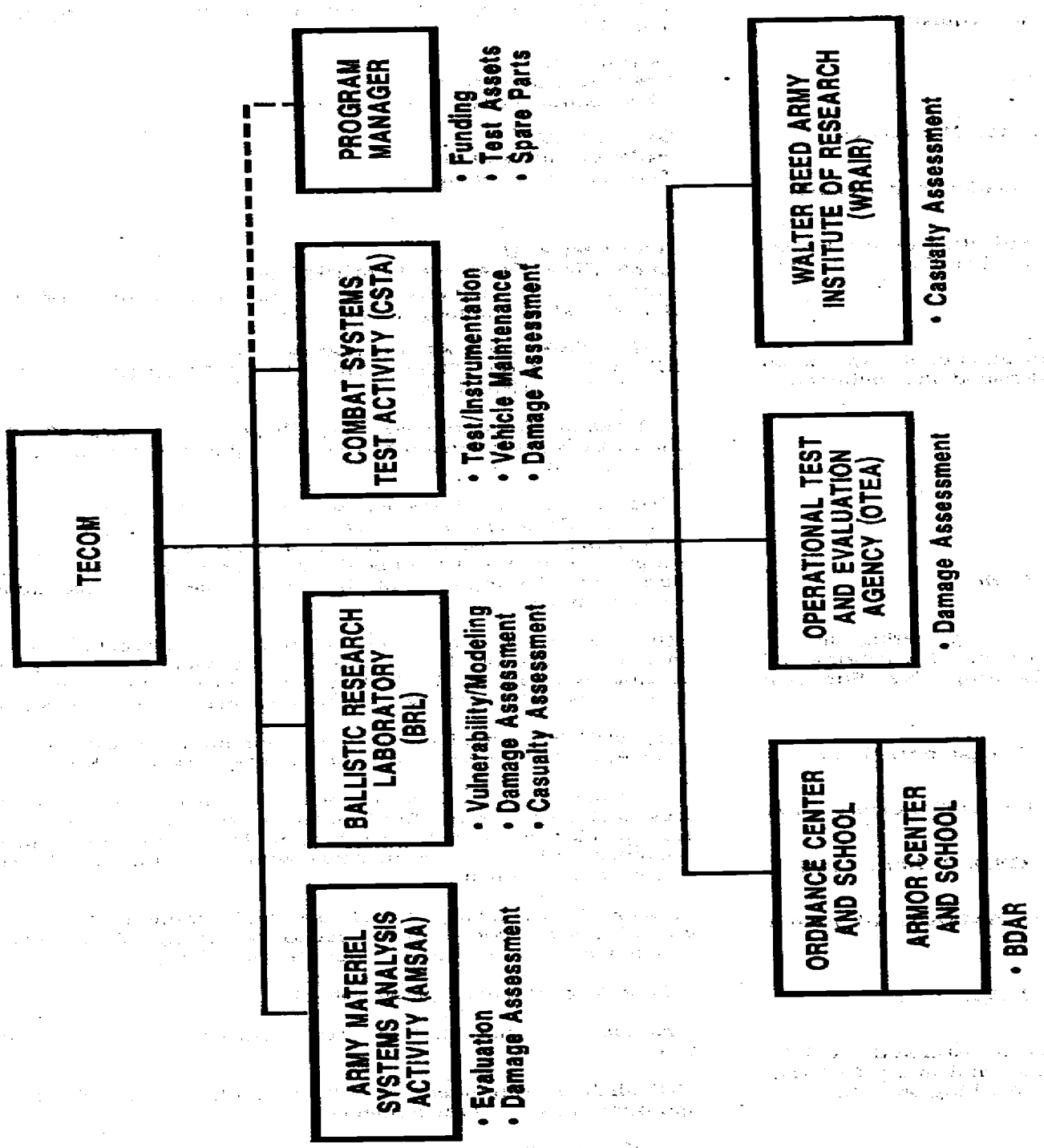


Figure 8-1. Bradley and Abrams LFT&E matrix organization

Appendix A
References

Section I
Required Publications

DA Pam 73–1
Test and Evaluation in Support of System Acquisition. (Cited in para 4–1.)

DA Pam 73–2
Test and Evaluation Master Plan Guidelines. (Cited in paras 5-2, 5-3, 5-4.)

DODI 5000.2
Defense Acquisition Management Policies and Procedures. (Cited in paras 2-4, 3-1, and 4- 2.)

DOD 5000.2–M
Defense Acquisition Management--Documentation and Reports. (Cited in paras 3-1 and 3-2.)

HQDA Memorandum
Implementation Effects of Sections 3012 and 3014 of the Federal Acquisition Streamlining Act of 1994 on Live Fire Test and Evaluation. (Cited in paras 5-3 and 5-6.) Copies of this memorandum may be obtained from the Test and Evaluation Management Agency, HQDA, DACS-TE, 200 Army Pentagon, WASH, D.C. 20310-0200.

Section II
Related Publications

A related publication is merely a source of additional information. The user does not have to read it to understand this publication.

AR 70–1
Army Acquisition Policy

AR 73–1
Test and Evaluation Policy

DODD 5000.1
Defense Acquisition

Chapter 139, Title 10 of United States Code

Letter
National Research Council, Commission on Engineering and Technical Systems, Board on Army Science and Technology, 20 October 1986, subject: Methodology for Choosing Live- Fire Test Shotlines.

Memorandum
Live Fire Candidate System, SAUS-OR, 20 September 1989

Memorandum
Live Fire Test and Evaluation Guidelines, OSD, 27 January 1994

Memorandum
Live Fire Test and Evaluation Guidelines, OSD, 1 June, 1988

Memorandum
Live Fire Lethality Test Target Surrogates, AMSAA, 14 March 1989 and 19 May 1989

Memorandum
AMSAA Live Fire Test Policy, AMSAA, 7 April 1989

Report
Medical Evaluation of Non-fragment Injury in Armored Vehicle Live Fire Tests— Instrumentation Requirements and Injury Criteria, Walter Reed Army Institute of Research, Washington, D.C., September 1989, ADA 233 058.

Report
Live Fire Test and Evaluation Planning Guide, Director, Live Fire Testing, Office of the Deputy Director, Defense Research and Engineering, June 1989.

Report
Combat Vehicle Vulnerability to Anti-Armor Weapons—A Review of the Army's Assessment Methodology, National Research Council, 1989.

Army Research and Acquisition Bulletin
Live Fire Testing: Legislation and Its Impact, O'Bryon, J.F., pp. 1–3, 1987.

Section III
Prescribed Forms

This section contains no entries.

Section IV
Referenced Forms

This section contains no entries.

Appendix B
Live Fire Testing Legislation

This appendix contains verbatim amended sections of the United States Code pertaining to LFT&E.

B–1. FY86 DOD Authorization Act

SEC.123. CONDITIONS ON PROCUREMENT OF CERTAIN COMBAT VEHICLES

(a) Testing Requirements - (1) Chapter 139 of title 10, United States Code, is amended by adding at the end thereof the following new section:

2362. Testing requirements: wheeled or tracked armored vehicles

(a) The Secretary of Defense shall provide that a contract for procurement by the Department of Defense under a major vehicle program may not be entered into unless the testing carried out during the development of the vehicle meets the requirements of subsection (b).

(b) The testing of a vehicle referred to in subsection (a) shall include testing of the vulnerability of such vehicle to the most capable weapon that is likely to be a combat threat to the vehicle and against which the vehicle is designed to survive. Such tests--

(1) shall be carried out in a manner modeled after the Joint Live-Fire Test Program for the Bradley Fighting Vehicle; and

(2) if the test vehicle is to replace an existing vehicle, shall at least include test shots fired under the same conditions at both the test vehicle and the vehicle it is to replace, with each vehicle being equipped with all of the elements with which the vehicle would be equipped in combat.

(c)(1) The Secretary of Defense shall submit to the defense committees a report with respect to the testing of each vehicle for which testing is required under this section.

(2) A Report under paragraph (1)--

(A) shall be submitted in both a classified and unclassified form;

(B) shall be submitted with the first request to Congress for appropriations for procurement--

(i) of the vehicle; or

(ii) of modifications to an existing vehicle.

(3) Each such report shall include--

(A) a complete description of the firing parameters used in the testing and an analysis of the effect on the vehicle of each test shot made;

(B) a description and justification of the merit and pass/fail criterion used in carrying out the test;

(C) a description of the potential shortcomings of the vehicle that were revealed by the testing and (if any were revealed) the plan of the Secretary to incorporate into the design of the vehicle changes that are considered cost effective and that are necessary to overcome such shortcomings; and

(D) if the test vehicle is to replace an existing vehicle, a comparison--

(i) of the estimated unit cost of each newly developed vehicle (or of the newly developed survivability modifications being made to an existing vehicle); with--

(ii) the unit cost of the vehicle that is to be replaced by the test vehicle.

(d) The Secretary of Defense shall include in the Department of Defense plan referred to as the Test and Evaluation Master Plan that is established for any major vehicle program an estimated cost and schedule of the testing to be carried out with respect to the program.

(e) In this section:

(1) 'Major vehicle program' means a major defense acquisition program for the acquisition of--

(A) a newly developed combat wheeled or tracked armored vehicle; or

(B) a combat wheeled or tracked armored vehicle with significant newly developed survivability modifications.

(2) 'Major defense acquisition program' means a program subject to the Selected Acquisition Report requirements of section 139a of this title.

(3) 'Defense committees' means the Committees on Armed Services and on Appropriations of the Senate and House of Representatives.

(2) The table of sections at the beginning of such chapter is amended by adding at the end thereof the following new item:

2362. Testing requirements: wheeled or tracked armored vehicles

(b) Effective Date - The amendments made by subsection (a) shall take effect on January 1, 1987.

B–2. FY86 DOD Authorization Act Conference Report

Condition on procurement of certain combat vehicles (sec. 123) The House amendment contained a provision (sec. 117) that would prohibit the Department of Defense from procuring any new combat wheeled or armored vehicles until these vehicles have undergone live-fire survivability testing.

The Senate bill contained no similar provision.

The Senate recedes with an amendment that applies this prohibition only to major defense acquisition programs, consistent with section 139 of title 10, United States Code. The conferees agree that this provision is not intended to criticize the Army's current testing procedures or programs.

B–3. FY87 DOD Authorization Act

SEC. 910. TESTING OF CERTAIN WEAPON SYSTEMS AND MUNITIONS

(a) Survivability and Lethality Testing and Operational Testing.

(1) Chapter 139 of title 10, United States Code, is amended by adding after section 2365 (as added by section 909) the following new section: 2366. Major systems and munitions programs: survivability and lethality testing; operational testing.

(a) Requirements - The Secretary of Defense shall provide that-

(1) a covered system may not proceed beyond low-rate initial production until realistic survivability testing of the system is completed in accordance with this section;

(2) a major munition program or a missile program may not proceed beyond low-rate initial production until realistic lethality testing of the program is completed in accordance with this section; and

(3) a major defense acquisition program may not proceed beyond low-rate initial production until initial operational test and evaluation of the program is completed in accordance with this section.

(b) Test Guidelines - (1) Survivability and lethality tests required under subsection (a) shall be carried out sufficiently early in the development phase of the system or program to allow any design deficiency demonstrated by the testing to be corrected in the design of the system, munition, or missile before proceeding beyond low-rate initial production.

(2) In the case of a major defense acquisition program, no person employed by the contractor for the system being tested may be involved in the conduct of the operational test and evaluation required under subsection (a)

(3) The costs of all tests required under that subsection shall be paid from funds available for the system being tested.

(c) Waiver Authority - The Secretary of Defense may waive the application of the survivability and lethality tests of this section to a covered system, munitions program, or missile program if the Secretary, before the system or program enters full-scale engineering development, certifies to Congress that live-fire testing of such system or program would be unreasonably expensive and impractical.

(d) Waiver in Time of War or Mobilization - In time of war or mobilization, the President may suspend the operation of any provision of this section.

(e) Definitions - In this section:

(1) The term 'covered system' means a vehicle, weapon platform, or conventional weapon system--

(A) that includes features designed to provide some degree of protection to users in combat; and (B) that is a major system within the meaning of that term in section 2303(5) of this title

(2) The term 'major munitions program' means--

(A) a munition program for which more than 1,000,000 rounds are planned to be acquired; or

(B) a conventional munitions program that is a major system within the meaning of that term in section 2302(5) of this title.

(3) The term 'major defense acquisition program' means--

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

(B) is designed for use in combat.

(4) The term 'realistic survivability testing' means, in the case of a covered system, testing for vulnerability and survivability of the system in combat by firing munitions likely to be encountered in combat (or munitions with a capability similar to such munitions) at the system configured for combat, with the primary emphasis on testing vulnerability with respect to potential user casualties and taking into equal consideration the operational requirements and combat performance of the system.

(5) The term 'realistic lethality testing' means, in the case of a major munitions program or a missile program, testing for lethality by firing the munition or missile concerned at appropriate targets configured for combat.

(6) The term 'configured for combat,' with respect to a weapon system, platform, or vehicle, means loaded or equipped with all dangerous materials (including all flammables and explosives) that would normally be on board in combat.

(7) The term 'operational test and evaluation' has the meaning given that term in section 138(a)(2)(A) of this title.

(2) The table of sections at the beginning of such chapter is amended by adding after the item relating to section 2365 (as added by section 909) the following new item.

2366. Major systems and munitions programs: survivability and lethality testing; operational testing.

(b) Effective Date - Section 2366 of title 10, United States Code (as added by subsection (a)), shall apply with respect to any decision to proceed with a program beyond low-rate initial production that is made--

(1) after May 31, 1987, in the case of a decision referred to in subsection (a)(1) or (a)(2) of such section; or

(2) after the date of the enactment of this Act, in the case of a decision referred to in subsection (a)(3) of such section.

(c) Time for Submission of Annual Report of Director (OT&E) - Subsection (g)(1) of section 138 of such title (as redesignated by section 101(a) of the Goldwater-Nichols Department of Defense Reorganization Act of 1986 (Public Law 99-433)) is amended by striking out 'January 15' in the second sentence and all that follows through 'is prepared' and inserting in lieu thereof '10 days after the transmission of the budget for the next fiscal year under section 1105 of title 31.'

B–4. FY87 DOD Authorization Act Conference Report

Survivability, lethality and operational testing (sec. 910)

Section 214 of the House amendment contained a provision that would require all new major conventional systems and weapons to be subjected to realistic, live-fire testing before entering production. A system would be tested for vulnerability and survivability by firing all the conventional threat munitions likely to be encountered in combat at the system configured for combat. A weapon would be tested for lethality by firing it at foreign targets configured for combat. The amendment would also require that independent operational testing be conducted for all new major conventional systems before entering production and that such test would include a side-by-side test of the system being acquired with equal-cost quantities of the system intended to be replaced or the nearest competitor of the system being acquired. The Senate bill contained no similar provision. The conferees agreed to a modified version of the House provision contained in section 214. The provision would require that a major conventional weapons system not proceed beyond low-rate initial production until (1) a realistic survivability or lethality test is completed; and (2) an initial operational test and evaluation is completed. Such survivability and lethality tests would be carried out early enough to allow design deficiencies to be corrected before production. Employees of the contractor for the system being tested would not be involved in the conduct of the initial operational test and evaluation.

The conferees direct that the Secretary of Defense conduct, as a matter of high priority, a comprehensive review of testing policy in the Department. The conferees believe that the Secretary's review should include the following issues:

(1) A review of the length of time currently required in the acquisition process and ways to reduce the time devoted to testing;

(2) A review of existing testing policies of the Department and the Military Departments, and a determination of inconsistencies in fundamental testing philosophies and approaches;

(3) A review of the relationship between development testing and initial operational testing, and what role each plays in the acquisition process.

The last issue merits special attention by the Secretary. The conferees believe that developmental testing and initial operational testing are separate, yet complementary, elements in the acquisition process. Developmental testing is designed to support the development of improved weapon systems. Initial operational testing is designed to prevent the production of flawed systems. Initial operational testing can never assume the functions of developmental testing, because the legislative history that established the Office of Operational Test and Evaluation inherently created an independent inspector general-type of function. Similarly, development testing (by definition) implies close collaboration with the developers of new systems, which prohibits such testing from performing the role the Congress intended for initial operational testing.

This situation suggests that fundamental review by the Secretary is in order. The conferees invite the Secretary to comment on section 910, as well as section 123 in Public Law 99-145 and other testing statutes. The Committees on Armed Services in both the U.S. Senate and the House of Representatives intend to conduct comprehensive hearings on testing policies and procedures next year and are prepared to amend section 910 and other statutory testing provisions after thorough consideration of the Secretary's review. The Secretary is invited to offer draft legislation if his review suggests such a course is warranted.

The Secretary shall transmit his report to the Committees on Armed Services of the Senate and the House of Representatives by March 15, 1987 to facilitate early hearings.

B–5. FY88-89 DOD Authorization Act

SEC. 802 SURVIVABILITY AND LETHALITY TESTING OF MAJOR SYSTEMS

(a) Inclusion of Significant Product Improvement Programs--

(1) Subsection (a) of section 2366 of title 10, United States Code, is amended--

(A) by inserting '(1)' after 'Requirements.-- ';

(B) by redesignating paragraphs (1), (2), and (3) as subparagraphs (A), (B), and (C), respectively; and

(C) by adding at the end the following:

(2) The Secretary of Defense shall provide that a covered product improvement program may not proceed beyond low-rate initial production until--

(A) in the case of a product improvement to a covered system, realistic survivability testing is completed in accordance with this section; and

(B) in the case of a product improvement to a major munitions program or a missile program, realistic lethality testing is completed in accordance with this section

(2) Subsection (b)(1) of such section is amended--

(1) by inserting '(including a covered product improvement program)' after 'system or program,' and

(2) by inserting '(or in the product modification or upgrade to the system, munition, or missile)' after 'or missile.'

(3) Subsection (c) of such section is amended by striking out 'or missile program' and inserting in lieu thereof 'missile program, or covered product improvement program.'

(4) Subsection (e) of such section is amended--

(A) by inserting '(or a covered product improvement program for a covered system)' in paragraph (4) after 'in the case of a covered system';

(B) by inserting '(or a covered product improvement program for such a program)' in paragraph (5) after 'missile program,' and

(C) by adding at the end the following new paragraph:

(8) The term 'covered product improvement program' means a program under which--

(A) a modification or upgrade will be made to a covered system which (as determined by the Secretary of Defense) is likely to affect significantly the survivability of such system; or

(B) a modification or upgrade will be made to a major munitions program or a missile program which (as determined by the Secretary of Defense) is likely to affect significantly the lethality of the munition or missile produced under the program.

(b) Use of Contractor Personnel in Operational Test and Evaluation--Subsection (b)(2) of such section is amended by adding at the end the following new sentence: 'The limitation in the preceding sentence does not apply to the extent that the Secretary of Defense plans for persons employed by that contractor to be involved in the operation, maintenance, and support of the system being tested when the system is deployed in combat.'

(c) Explanation for Waivers by Secretary of Defense--Subsection (c) of such section is amended by adding at the end the following new sentence: 'The Secretary shall include with any such certification a report explaining how the Secretary plans to evaluate the survivability or the lethality of the system or program and assessing possible alternatives to realistic survivability testing of the system or program.'

(d) Reporting to Congress--Such section is further amended--

(1) by inserting '(1)' in subsection (c) before 'The Secretary.'

(2) by striking out '(d)' and all that follows through 'In time of war' and inserting in lieu thereof '(2) In time of war'; and

(3) by inserting before subsection (e) the following new subsection (d):

'(d) Reporting to Congress--At the conclusion of survivability or lethality testing under subsection (a), the Secretary of Defense shall submit a report on the testing to the defense committees of Congress (as defined in section 2362(e)(3) of this title).'

(e) Definition of Realistic Survivability Testing--Subsection (e)(4) of such section is amended--

(1) by striking out 'and survivability,' and

(2) by striking out 'operational requirements' and inserting in lieu thereof 'susceptibility to attack.'

B–6. FY88-89 DOD Authorization Act Conference Report

Live-Fire Testing (Sec. 802)

The House bill contained a provision (section 822) that would amend section 2366 of title 10, United States Code governing live-fire testing by the Department of Defense. The provision would require that covered programs not proceed beyond low-rate initial production until vulnerability testing is completed, require the Secretary of Defense to designate a civilian official in the Department of Defense responsible for vulnerability and lethality testing, and other actions. The Senate amendment contained a provision (sec. 806) that would repeal section 2366. The Senate recedes with an amendment that would require covered product improvement programs not proceed beyond low-rate initial production until survivability and lethality testing is completed, provide for reports to Congress on such tests, clarify the definition of realistic survivability testing, and clarify contractor involvement during operational testing.

The conferees believe that live-fire testing is a valuable tool for determining the inherent strengths and weaknesses of adversary, U.S. and allied weapon systems.

The conferees intend that the Secretary of Defense implement this section in a manner which encourages the conduct of full-up vulnerability and lethality tests under realistic combat conditions, first at the sub-scale level as sub-scale systems are developed, and later at the full-scale level mandated in the legislation.

The conferees intend that this type of developmental testing be performed as part of the responsibilities of the Under Secretary of Defense for Acquisition. Before such testing begins, the office of the Under Secretary should have reviewed the adequacy of the test plans, or alternatives to full-scale testing, prepared by the services concerned. While testing is underway, the Under Secretary should

have full access to all test data and reports and should ensure adequate resources are provided for the conduct of realistic tests, including threat munitions and targets, for instruments and facilities, and for adequate staff and funding for the Office of Live-Fire Testing. The conferees realize the Department of Defense, at times, conducts operational tests and developmental tests simultaneously. It is not the intent of the conferees to exclude contractor involvement in the development portion of these tests.

B–7. FY89 DOD Authorization Act Conference Report

Live Fire Testing Programs

Section 236 of the House bill would amend section 2366(b)(3) of title 10, United States Code, to allow the Secretary of Defense to conduct live fire testing and to evaluate such testing using appropriations available for procurement of the systems being tested.

The Senate amendment contained no similar provision.

The House recedes. The conferees agree with the intent of the House provision to allow the Secretary of Defense to reprogram up to one third of one percent of the total funds approved by Congress for the procurement of a specific system that has been identified as a live fire testing candidate, for the purpose of conducting necessary vulnerability/lethality live fire tests and evaluations in compliance with the fiscal years 1987 and 1988 Defense Authorization Acts (Public Law 99-661 and 100-180). The conferees agree to provide this discretionary authority to the Secretary of Defense through this statement of managers.

B–8. FY90-91 DOD Authorization Act

Sec. 804. Modifications with Respect to Reports on Live Fire Testing Programs

(a) Testing report to be submitted before production.-- Subsection (a) (1) of section 2366 of title 10, United States Code (as amended by section 842), is amended by inserting 'and the report required by subsection (d) with respect to that testing is submitted in accordance with the subsection' after 'this section' in subparagraphs (A) and (B).

(b) Content of testing report.--Subsection (d) of such section is amended by adding at the end of the following: 'Each such report shall describe the results of the survivability or lethality testing and shall give the Secretary's overall assessment of the testing.'

B–9. FY90-91 Authorization Act Conference Report

Live Fire Testing Program (Sec. 804)

The House bill contained a provision (sec. 133) that would amend section 2366 of title 10, United Stated Code, to require the Department of Defense to report the results of live fire testing before a major covered system could enter full-rate production. The provision would also permit the Secretary of Defense to fund live fire tests from procurement funds available for the weapon system, but not to exceed one-third of one percent of the total program cost.

The Senate amendment contained no similar provision.

The Senate recedes with an amendment that would require the Department of Defense to report the results of live fire testing prior to full-rate production. The conferees agree with the intent of the House provision to allow the Secretary of Defense to reprogram up to one-third of one percent of total funds approved by Congress for procurement of a specific system that has been identified as a live fire testing candidate. The conferees note that the Department of Defense has issued directives implementing this direction. Consequently, statutory language on this point is not necessary at this time.

B–10. FY94 DOD Authorization Act Conference Report

Subtitle C--Provisions to Revise and Consolidate Certain Defense Acquisition Laws.

Section 821. Repeal and amendment of obsolete, redundant or otherwise unnecessary laws applicable to Department of Defense generally.

(a) Repeals. The following provisions of law are repealed:

(3) Section 2362 of Title 10, United States Code (relating to testing requirements for wheeled or tracked vehicles).

Section 2362. Testing requirements: wheeled or tracked armored vehicles

(a) The Secretary of Defense shall provide that a contract for procurement by the Department of Defense under a major vehicle program may not be entered into unless the testing carried out during the development of the vehicle meets the requirements of subsection (b).

(b) The testing of a vehicle referred to in subsection (a) shall include testing of the vulnerability of such vehicle to the most capable weapon that is likely to be a combat threat to the vehicle and against which the vehicle is designed to survive. Such tests--

(1) shall be carried out in a manner modeled after the Joint Live-Fire Test Program for the Bradley Fighting Vehicle; and

(2) if the test vehicle is to replace an existing vehicle, shall at least include test shots fired under the same conditions at both the test vehicle and the vehicle it is to replace, with each vehicle being equipped with all of the elements with which the vehicle would be equipped in combat.

(c)(1) The Secretary of Defense shall submit to the defense committees a report with respect to the testing of each vehicle for which testing is required under this section.

(2) A report under paragraph (1)--

(A) shall be submitted in both a classified and unclassified form;

(B) shall be submitted with the first request to Congress for appropriations for procurement--

(i) of the vehicle; or

(ii) of modifications to an existing vehicle.

(3) Each such report shall include--

(A) a complete description of the firing parameters used in the testing and an analysis of the effect on the vehicle of each test shot made;

(B) a description and justification of the merit and pass/fail criterion used in carrying out the test;

(C) a description of the potential shortcomings of the vehicle that were revealed by the testing and (if any were revealed) the plan of the Secretary to incorporate into the design of the vehicle changes that are considered cost effective and that are necessary to overcome such shortcomings; and

(D) if the test vehicle is to replace an existing vehicle, a comparison--

(i) of the estimated unit cost of each newly developed vehicle (or of the newly developed survivability modifications being made to an existing vehicle); with

(ii) the unit cost of the vehicle that is to be replaced by the test vehicle.

(d) The Secretary of Defense shall include in the Department of Defense plan referred to as the Test and Evaluation Master Plan that is established for any major vehicle program an estimated cost and schedule of the testing to be carried out with respect to the program.

(e) In this section:

(1) The term 'major vehicle program' means a major defense acquisition program for the acquisition of--

(A) a newly developed combat wheeled or tracked armored vehicle; or

(B) a combat wheeled or tracked armored vehicle with significant newly developed survivability modifications.

(2) The term 'major defense acquisition program' means a program subject to the Select Acquisition Report requirements of section 2432 of this title.

(3) The term 'defense committees' means the Committees on Armed Services and on Appropriations of the Senate and House of Representatives.

B–11. Federal Acquisition Streamlining Act of 1994

Subtitle B - Testing Statutes

Section 3012. Responsibility of Director of Operational Test and Evaluation for Live Fire Testing.

(a) Oversight of Live Fire Testing - Subsection (b) of section 139 of title 10, United States Code, is amended--

(1) by striking out 'and' at the end of paragraph (4);

(2) by striking out the period at the end of paragraph (5) and inserting in lieu thereof ' and'; and

(3) by adding at the end the following new paragraph: '(6) monitor and review the live fire testing activities of the Department of Defense provided for under section 2366 of this title.'

Section 3014. Survivability and Lethality Testing.

(a) IN GENERAL - Section 2366(c) of title 10, United States Code, is amended -

(1) by redesignating paragraph (2) as paragraph (4);

(2) by designating the second sentence of paragraph (1) as paragraph (3) and in that paragraph by striking out 'such certification' and inserting in lieu thereof 'certification under paragraph (1) or (2)'; and

(3) by inserting before paragraph (3) (as so designated) the following new paragraph:

In the case of a covered system (or covered product improvement program for a covered system), the Secretary may waive the application of the survivability and lethality tests of this section to such system or program and instead allow testing of the system or program in combat by firing munitions likely to be encountered in combat at components, subsystems, and subassemblies, together with performing design analyses, modeling and simulation and analysis of combat data. Such alternative testing may not be carried out in the case of any covered system (or covered product improvement program for a covered system) unless the Secretary certifies to Congress, before the system or program enters engineering and manufacturing development, that the survivability and lethality testing of such system or program otherwise required by this section would be unreasonably expensive and impracticable.

(b) TERMINOLOGY CORRECTION - Section 2366(c)(1) of such title is amended by striking out 'full-scale engineering development' in the first sentence and inserting in lieu thereof 'engineering and manufacturing development.'

Appendix C
OSD Live Fire Test and Evaluation (LFT&E) Guidelines

This appendix is a verbatim listing of the January 1994 OSD LFT&E Guidelines.

C–1. Purpose

The purpose of these guidelines is to describe a disciplined management approach for the conduct of Live Fire Test and Evaluation (LFT&E), within the Department of Defense (DOD), in compliance with LFT legislation. Section 2366, Title 10 United States Code (USC), contains requirements for vulnerability and lethality Live Fire Testing of covered systems, major munitions programs, and product improvements to covered systems and major munition programs. The guidelines describe the objective and scope of LFT&E; provide guidance for LFT&E planning, testing, evaluation, and documentation; and discuss the responsibilities of LFT&E principals. Applicable documents are DoD Directive 5000.1, DoD Instruction 5000.2, and DoD Manual 5000.2–M.

C–2. Objective

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 full-rate production. In particular:

a. To provide information to decision makers on potential user casualties, vulnerabilities, and lethality, taking into equal consideration susceptibility to attack and combat performance of the system.

b. To ensure that knowledge of user casualties and system vulnerabilities or lethality is based on testing of the system under realistic combat conditions.

c. To allow any design deficiency identified by the testing and evaluation to be corrected in design before proceeding beyond low-rate initial production.

C–3. Scope

These guidelines apply to the Office of the Secretary of Defense (OSD), the Organization of the Joint Chiefs of Staff, the Unified and Specified Commands, the Military Departments, and all DOD Components which have responsibilities associated with the design, development, procurement, or modification of combat materiel items. Heads of DOD Components may issue implementing guidance to provide for unique requirements within their respective Component.

C–4. Definitions

The legislation covering LFT also provides definitions of"covered system,""major munitions program,""covered product improvement programs,""realistic survivability testing,""realistic lethality testing," and "configured for combat." The following definitions are not given in that legislation be are provided here to permit a better understanding of LFT requirements:

a. Full-up Test. A vulnerability test conducted on a complete or

partial system loaded or equipped with all dangerous materials (including flammables and explosives) that would normally be on board in combat (configured for combat). All critical subsystems which could contribute to the test outcome must be operating (e.g., hydraulic and electrical power) under realistic conditions. For lethality testing, the munitions or missile must be production- representative. The target must be representative of the class of systems that includes the threat and be sufficiently realistic to demonstrate the lethal effects the weapon is designed to produce. This testing alone may not satisfy Section 2366, Title 10, USC. See paragraph d., below.

b. System-Level Test. A test conducted on the complete system, but may or may not be a full-up test. This testing alone may not satisfy Section 2366, Title 10, USC. See paragraph d., below.

c. Live Fire Test. A test within the OSD approved LFT&E strategy that involves the firing of actual munitions at target components, target sub-systems, target sub-assemblies or system- level targets (which may or may not be configured for combat) to examine personnel casualty, vulnerability, and/or lethality issues. This testing alone may not satisfy Section 2366, Title 10, USC. See paragraph d., below.

d. Full-up, System-Level Test. A LFT&E Strategy for a covered system, major munition program, or missile program, or covered product improvement program will include full-up, system-level tests. The term "Full-up, System-Level Test" is that testing that fully satisfies the statutory requirement for "realistic survivability testing" or "realistic lethality testing" as defined in Section 2366, Title 10, USC.

e. Survivability. The capability of a system to avoid or withstand a man-made hostile environment without suffering an abortive impairment of its ability to accomplish its designated mission.

f. Vulnerability. The characteristic of a system which causes it to suffer a definite degradation (loss or reduction of capability to perform its designated mission) as a result of having been subjected to a certain (defined) level of effects in an unnatural (man-made) hostile environment. Vulnerability is considered a subset of survivability.

g. Lethality. The ability of a munition (or laser, high power microwave, etc.) to cause damage that will cause the loss or a degradation in the ability of a target system to complete its designated mission(s).

h. Susceptibility. The degree to which a weapon system is open to effective attack due to one or more inherent weakness. (Susceptibility is a function of operational tactics, countermeasures, probability of enemy fielding a threat, etc.) Susceptibility is considered a subset of survivability.

C–5. Implementation

An active, well-planned, well-managed, and well-executed LFT&E strategy is essential to understanding system vulnerability/lethality and will be an essential element of the information supporting decisions regarding the acquisition of materiel as well as the development of doctrine for its proper tactical employment. The LFT&E strategy for a given system should be developed as soon as possible after Milestone I, and be structured and scheduled so that any design changes resulting from that testing and analysis, as described in the strategy, may be incorporated before proceeding beyond low-rate initial production. LFT&E considerations should be included in all phases of the weapon system acquisition cycle, beginning with concept exploration and continuing until Milestone III. Furthermore, the LFT&E strategy should be managed, including planning and programming, in such a manner that all elements of the test and evaluation (T&E) process are well-integrated and complementary. The availability of facilities, test sites, instrumentation, personnel, threat targets, munitions, and/or directed energy weapons should be managed throughout all phases of the budget cycle.

a. LFT&E should be initiated as early as possible and completed before production and deployment (Milestone III), to identify and assess possible design deficiencies so that appropriate corrective actions can be taken. Beginning with component level testing and analysis during concept demonstration and validation, live fire vulnerability/lethality test and evaluation continues through engineering and manufacturing development (EMD) with additional components/subsystem testing, and progresses to LFT&E of production representative items before the system proceeds beyond low-rate initial production. The LFT&E strategy should be structured to provide a timely and reasonable examination and understanding of the vulnerability/lethality of U.S. weapon systems and munitions/directed energy weapons to the full spectrum of validated combat threats/targets. Subsequent product improvements to covered systems/major munitions programs meeting the criteria given in Section 2366, Title 10, USC are also required to undergo Live Fire Testing if there is a significant impact to vulnerability or lethality. If any doubt exists, the system should be assumed to be covered and appropriate action taken. This includes waiver action if the testing would be unreasonably expensive or impractical. Legal counsel should be consulted to verify the final determination of program status. All LFT&E will be conducted by the Services with OSD oversight. Non-Developmental Items (NDI) and Advanced Technology Demonstrators/Prototypes that meet the definition of covered system/major munitions program may also be required to undergo LFT&E.

b. Live Fire Testing of all systems will be predicated upon the DOD Intelligence Community's official assessment of the principal threat systems and capabilities an adversary might reasonably bring to bear in an attempt to defeat or degrade a specific U.S. system as described in the System Threat Assessment Report (STAR), or equivalent document.

c. Vulnerability and lethality assessments may require the use of validated modeling/simulation and other analytic techniques. Where modeling/simulation and other analytical efforts are essential elements in a LFT&E strategy, pre-shot predictions will be included.

d. The generation of data to resolve critical LFT&E issues in an efficient and cost effective manner to represent realistic environments shall be of paramount concern in the shot-line selection process for Live Fire Testing. While an element of randomness in shot-line selection is often desirable, total reliance on complete randomness may neither be consistent with the test objectives nor be an efficient use of test resources. Random shot-lines are generated from a realistic distribution of hit points, to include such factors as the weapon system operator, target signatures and weapon seeker characteristics. In most cases a mixture of random shot-lines (shot-lines generated from likely hit points) and engineering shot-lines (i.e., shot-lines specifically selected by the evaluator to address specific vulnerability/lethality issues) will be appropriate. It is required that some portion of the total shots be randomly drawn from a combat distribution of likely hit points, when known.

e. The evaluation of LFT results will address kill given a hit (i.e., vulnerability or lethality). However, the outcome of LFT&E will not necessarily be expressed in terms of probabilities. Rather, Live Fire Testing should address vulnerability or lethality primarily by examining basic damage and kill mechanisms and their interactions with the target system. Further, the evaluation of vulnerability test results will address, where possible, the susceptibility of the system.

f. Although LFT&E programs may differ significantly in scope and timing, the level of maturity at various stages of the acquisition process is basically the following: By Milestone I, a decision should be made whether the system meets the legislative criteria for a covered system/major munitions program. Initial draft strategies should identify proposed issues, existing data in support of the issues, and Live Fire Tests to be conducted throughout the acquisition process. By Milestone II, the Test and Evaluation Master Plan (TEMP) should contain a mature strategy. In particular, the strategy must either commit to Full-up, System- Level, Live Fire Testing, or a waiver request and alternative LFT&E plan must have been submitted for approval according to DoD Manual 5000.2–M, Part 11, "Live Fire Test and Evaluation Waiver." The entire LFT&E program, to include testing, evaluation, and reporting, must be completed by Milestone III.

C–6. Responsibilities

The responsibilities of the DOD Staff and the Services relative to LFT&E are outlined below:

a. OSD. The Director, Test and Evaluation (D,T&E):

(1) Serves as the OSD focal point for review, coordination and approval of LFT&E policy.

(2) Approves LFT&E strategies, as provided in the Test and Evaluation Master Plan (TEMP), IAW DoDI 5000.2 and DoD Manual 5000– 2–M.

(3) Approves candidate systems for LFT&E. Annually reviews all potential systems for inclusion or exclusion from the LFT&E oversight list according to DoDI 5000.2, Part 8, Paragraph 5a(5).

(4) Reviews and comments upon Services' Detailed LFT&E Plans and Reports.

(5) Monitors the Services' LFT&E program during its conduct.

(6) Conducts an assessment of individual Services' LFT&E programs (to include LFT&E programs conducted under the waiver provisions of Section 2366, Title 10, U.S. Code) and prepares the Secretary of Defense LFT&E assessment report to Congress.

b. DOD Components.

(1) Recommend candidate systems for LFT&E.

(2) Develop and implement the LFT&E strategy for each affected system and ensure this strategy is fully described in the TEMP.

(3) Plan, program, and budget research, development, test and evaluation and other procurement funds in support of LFT&E including the acquisition of threat targets/munitions or acceptable surrogates.

(4) Identify critical LFT&E issues, prepare and approve required plans, reports and other documentation.

(5) Permit on-site monitoring of all LFT&E tests by OSD D, T&E.

(6) Conduct engineering assessments of possible design changes resulting from LFT&E and develop programs for incorporating cost effective design changes as early as possible commensurate with the system acquisition strategy.

(7) Prepare request for waiver from Full-up, System-Level, Live Fire Testing if such testing is unreasonably expensive and impractical. Prepare alternative plans for evaluating the vulnerability or lethality of the system for inclusion with the request for waiver.

(8) Manage Service facilities and resources and provide guidance on operating these test facilities to support LFT&E.

C–7. LFT&E Documents

Conduct of LFT&E will require the preparation and submission to OSD of the following documents.

a. Test and Evaluation Master Plan (See DoD Manual 5000.2M for format requirements). The TEMP is the basic planning document for all life-cycle T&E related to a particular system acquisition and is used by the Acquisition Executives, PEOs, and all other decision bodies in planning, reviewing, and approving T&E. As such, the TEMP will also serve as the basic planning document for the review and approval of the LFT&E strategy, and therefore should be current. Updates to the TEMP should reflect any changes to vulnerability/lethality requirements. Part III of the TEMP shall include a discussion of LFT&E that charts the LFT&E course of action during the materiel acquisition process. All LFT&E that has an impact on program decisions will be outlined in this part of the TEMP. The TEMP summarizes where, when, and how the LFT&E issues will be tested/evaluated. It shows the relationship of the LFT&E issues to the critical technical parameters and operational requirements, the planned LFT; the amount and type of LFT that will be performed to support each program decision point; and indicates where schedule, resource, or budget constraints may have an impact on the adequacy of planned LFT&E. The TEMP is a dynamic document and is prepared by the DOD Component according to guidance contained in Chapter 7, DoD Manual 5000.2–M, "Test and Evaluation Master Plan." Specific LFT&E items considered for inclusion in the TEMP are: a description of the overall Live Fire Test and Evaluation strategy for the item; critical Live Fire Test and Evaluation issues; required levels of system vulnerability/ lethality; the management of the Live Fire Test and Evaluation program; Live Fire Test and Evaluation schedule, funding plans and requirements; related prior and future Live Fire Test and Evaluation efforts; the evaluation plan and shot selection process for Full-up, System-Level Tests; and major test limitations for the conduct of Live Fire Test and Evaluation. Live Fire Test and Evaluation resource requirements (including test articles and instrumentation) will be appropriately identified early in the development cycle and appear in the Test and Evaluation Resource Summary.

b. Detailed Test and Evaluation Plan. This document describes the detailed test procedures, test conditions, and data collection and analysis processes to be used during the conduct of each Live Fire Test. Paragraph 10 provides additional detail on the content of this document. The Detailed Test and Evaluation Plan will be submitted to OSD for comment at least 30 days before test initiation. OSD shall have 15 days for submission of comments subsequent to its receipt of the Detailed Test Plan/Evaluation Plan.

c. Detailed Test and Evaluation Report. The results and overall evaluation of all testing, identified in the LFT&E strategy, will be documented by the Service and submitted to OSD no later than 120 days after test completion. The format of this report(s) is a Service option, however, to facilitate the OSD independent report to Congress, each Service report should include the firing results, test conditions, a description of any deviations approved subsequent to the preparation of the Detailed Test and Evaluation Plan, test limitations, conclusions, and the evaluation of live fire vulnerability/ lethality based on available information (if applicable). OSD shall have 45 days, from receipt of the final Service Detailed Test and Evaluation Report, for preparation and transmittal of the SecDef assessment report to Congress. Service technical review will normally be requested prior to transmittal.

Additional documentation may be prepared as part of the developmental process to support engineering tests that bear on the Live Fire Test Assessment. Review and approval of this documentation will be at the Service level.

C–8. Waivers

See DOD Manual 5000.2-M, "Live Fire Test and Evaluation Waiver." Waivers from Full-up, System-Level, Live Fire Testing (realistic survivability/lethality testing as defined in Section 2366, Title 10, USC), for covered systems/major munitions programs, including product improvements that significantly affect vulnerability or lethality, cannot be granted after Milestone II, except through legislative relief. Included with the request for waiver will be a report explaining how the Service plans to evaluate the vulnerability or lethality of the system or program, and assessing possible alternatives to Full-up, System-Level, Live Fire Testing. With the exception of the requirements for Full-up, System-Level, Live Fire Testing, the requirements for waived LFT&E programs are no less stringent than for non-waived programs, to include the inclusion of an LFT&E strategy in the TEMP and an OSD independent assessment report to Congress. Waiver requests will be submitted by the Service Secretaries to the DepSecDef.

C–9. References

a. Section 2366, Title 10, United States Code, Legislation Pertaining to Live Fire Test and Evaluation (See below).

b. Department of Defense Directive 5000.1, Defense Acquisition.

c. Department of Defense Instruction 5000.2, Defense Acquisition Management Policies and Procedures.

d. Department of Defense Manual 5000.2M

Note. A verbatim listing of the existing LFT legislation was provided in the original OSD Live Fire Test and Evaluation Guidelines. See Appendix B for this listing, including subsequent updates.

C–10. Additional Information Pertaining to the Detailed Live Fire Test and Evaluation Plan

The following paragraphs outline the required content of the Detailed Test and/or Evaluation Plan for Live Fire Testing. No standard format will be prescribed in order to allow the Services

flexibility to tailor their plans to their individual requirements. However, the Detailed Test and/or Evaluation Plan must, as a minimum, contain the material described below.

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

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

c. A page providing administrative information on the position, name, organization, telephone number, and electronic mail addresses of key LFT&E personnel.

d. A section describing the types of threats or targets that the system is expected to encounter during the operational life of the system and the key characteristics of these threats/targets which affect system vulnerability/lethality. A reference to the specific threat definition document/authority. A discussion of the rationale/criteria used to select the specific threats/targets and the basis used to determine the number of threats/targets to be tested in the Live Fire Testing.

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

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

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

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

i. An identification of any test limitations particularly any potential lack of realism from absence of components from use of surrogates, from the inerting of fuzes on stowed ammunition, etc. Identify the impact of these limitations on test results.

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

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

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

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

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

Appendix D
AMSAA Live Fire Test Policy

This appendix is a verbatim extract from Director, AMSAA Memorandum, dated 7 April 1989, subject: AMSAA Live Fire Test Policy

Background. Public Law 99–661 requires"live fire" testing of various combat systems under conditions representative of combat conditions. That means, as appropriate, testing to obtain the basic data necessary to determine the ability of the crew and hardware of a developmental system to survive and function after enemy attack by munitions expected to be employed against it and/or the effectiveness of a developmental system against typical enemy targets it is expected to engage. The applicability of this law is such that AMSAA should expect many of the systems it evaluates, which are subject to enemy attack or which are used to attack enemy targets, will be subject to the provisions of this law. Further, as the independent technical evaluator, we will be expected to include this "live fire" performance as one facet of our independent evaluation.

Policy. AMSAA will integrate a comprehensive live fire program into its independent evaluation of those systems meeting the conditions of PL 99–661 and as otherwise required by Department of the Army. This program should be executed in a manner that meets the spirit and intent of the live fire legislation, yet is cost effective. This can best be achieved by reducing expensive, time consuming "full up" system level testing through the intelligent use whenever possible of component testing, modeling, and simulation. Accordingly, the live fire analysis will start early in the program with the analysis of component and subassembly testing and modeling analysis of the full up system, and continue throughout the program to a full up live fire test, preferably with LRIP hardware before the system enters full scale production. It is expected that the testing and analysis during the program will be planned in conjunction with PMs, PEOs, R&D centers, test agencies, DUSA (OR), the OSD Live Fire Test Organization, etc., and executed such that sufficient data and analysis will be available so as to make unnecessary the extensive full up testing conducted with the Bradley and M1 vehicles. If we are to achieve the goal of reducing full up testing to a minimum required to meet the intent of the law and in recognition of the cost constraints faced by the Army, we must build upon and take every advantage of prior live fire component and full up system testing, particularly if the new system under evaluation can be characterized in whole or part in terms of comparable components/subassembly structural design or functional operation identical to, or similar to systems previously tested. In conjunction with our live fire evaluation mission, we must take an active part in defining and supporting the acquisition of adequate numbers of appropriate targets/surrogates for use in live fire testing.

Procedures. In order to effectively include live fire as part of our evaluations, it will be necessary for AMSAA to begin live fire planning and our overall IEP/TDP development process very early in the program so as to have the necessary component/subassembly testing and modeling integrated into the development program at a time when it can influence design and allow feedback to develop adequate prediction models. We must further push to see that the models are indeed developed and exercised up front. They must then evolve with the system development. This approach will lead to an evaluation before LRIP which will be used in conjunction with sufficient full up live fire testing as necessary to augment and establish the credibility of the modeling used in the live fire evaluation. Planning at all stages must include active participation by appropriate technical, research, development, test and evaluation

organizations such as TECOM, LABCOM, BRL, PMs, etc. Not only must this planning be done earlier, but it will be necessary to develop the plan in some detail as this part of our independent evaluation process will have to be approved by the Deputy Under Secretary of the Army for Operations Research and the Asst Dep Under Sec of Defense (Live Fire Test). To facilitate this approval process, live fire testing and evaluation will be reviewed separately from our overall plan as a logical adjunct to the systems vulnerability/ survivability and effectiveness analysis in the basic plan. The TEMP must also include a section on Live Fire Test and Evaluation. Once the plan has been approved at the appropriate HQDA and OSD levels, it will not be changed without approval by these same levels. The tests and analyses must be executed exactly as approved. This is considerably different from other facets of our evaluation wherein we retain much greater latitude for last minute changes as conditions, emerging data and other factors suggest. This does not mean we cannot recommend changes that make sense or that we cannot delay testing until issues are resolved. But, we must do it in such a way that there is absolutely no basis for suspicion by congressional or other critics that we are doing so in an attempt to "rig" the tests. Precise and comprehensive documentation of recommended changes and approvals thereof in the test and evaluation procedures will ensure that our actions will be clearly understood and above reproach by critics. Thus, as a matter of course, we will, as a good technical practice, ensure rigorous documentation of deviations from approved test and evaluation plans made during the course of the technical testing processes. While the above discussion emphasizes development programs, we must be similarly concerned with NDI systems. Coincident with the live fire test and evaluation process, we are aware of and will pursue the unique opportunity to obtain critical data on parts consumption and combat damage repair, etc., to support our analyses to determine wartime provisioning and maintenance work load.

Planning, Briefing, and Reporting. AMSAA will prepare a comprehensive independent evaluation plan and a test design plan that includes live fire issues in time for TECOM to prepare the detailed test design plan required by law and live fire tests. Input must be sought from the technical, research, and test communities as well as the PM and PEOs and others as appropriate to assure development of a complete and executable plan.

AMSAA will prepare and publish a Live Fire Evaluation Report (stand alone volume to the overall Independent Evaluation Report) within 60 days after the Live Fire Test Report is published and BRL has provided the requested vulnerability/lethality calculations required to support the evaluations. AMSAA will also prepare stand alone Live Fire Evaluation briefings (if required and to the extent possible) before the Evaluation Report is published.

Monitoring Tests. AMSAA will monitor selected tests, but will not provide a damage assessor, relying upon the BRL/CSTA or other designated damage assessors.

Appendix E
Alternatives for Threat Tank and Helicopter Targets

This appendix is a verbatim extract from Director, AMSAA Memoranda, dated 14 March 1989 and 19 May 1989, subject: Live Fire Lethality Test Target Surrogates.

Tank Targets for Live Fire Lethality Testing

Live Fire Lethality testing of U.S. antitank munitions shall include, when feasible, the firing of that munition against threat targets. Since it is very unlikely that future threat tank targets (requirements for antitank munitions) will be available at the time they are needed for Live Fire Lethality testing, it is necessary to identify and evaluate alternatives for threat tank targets and recommend the preferred alternative(s).

The Army DCSINT has developed a classification scheme for threat tank range target (armor arrays) data. It is also applicable to tank target (reference target) data. The categories are:

a. An original or actual specimen.
b. A duplicate or replica created from original specification.
c. A surrogate or reasonable facsimile which is created from specific knowledge about original specifications.
d. A substitute which represents some general knowledge or performance characteristics of the original.
e. A postulated technology option derived from an intelligence assessment.

For Live Fire Lethality testing of antitank munitions, the threat tank target data are and will probably always be a postulated technology option derived from an intelligence assessment. The testing and evaluation alternatives are defined (Table E -1) in terms of the type of target fired at in Live Fire Lethality tests, whether the target functions (i.e., mobility, firepower, etc.), what the test addresses (armor perforation, damage mechanisms, components), and the basis for the overall lethality assessment (test, model). The eight lethality test and evaluation altenatives break logically into three groups:
a. Functioning tanks with an overall lethality assessment based upon test results (alternatives 1-4).
b. Ballistic hull and turret with the crew (alternative 6) or crew and components (alternative 5) represented by boxes with a limited overall lethality assessment based upon test results.
c. Ballistic hull and turret only (alternative 7) or range targets (alternative 8) with no overall lethality assessment based upon test results.

Regardless of the scope of lethality testing, the overall lethality assessment will be supplemented with model predictions.

Live fire and joint live fire lethality and vulnerability testing indicates that the dominant antitank damage mechanisms are the primary penetrator and spall. Lethality of antitank projectiles depends on whether the armor is perforated, the extent of spall damage (cone angle and amount of spall), the location of major vulnerable components (crew, ammo, fuel, etc.), and the specific way the tank design is implemented (e.g., do subsystems fail gracefully, location and distribution of hydraulic and electrical power lines, are there redundant systems). Spall damage varies as a function of the type of armor perforated (e.g., laminate ceramic versus reactive) because the penetrator is attacked differently by the different armor defeat mechanisms. A penetrator could have the same degree of overmatch against two different armor technologies and have different spall characteristics. In addition, the target structure and way the armor is integrated into the vehicle structure will affect collateral damage to components (e.g., damage due to ballistic shock) and affect multi hit performance of the vehicle. Technical projections of future tanks address armor and gross characteristics. However, the details on the components and vehicle design cannot be adequately projected.

Functioning tank alternatives are appealing because lethality can be assessed directly for each shot fired. The practical limits on numbers of shots fired dictates that an overall lethality assessment be based upon both test results and calculations for a broader spectrum of conditions. Ideally, the testing should confirm that the model predictions are accurate or provide the basis for modifying the model to permit an accurate set of predictions. Alternatives 1 and 2 have the highest level of perceived fidelity because the armor and the configuration are matching or trying to match the threat projections. Actual fidelity will probably be considerably less than perceived fidelity because there is little or no information on which to project component characteristics and vehicle design. It is very unlikely that the component vulnerability or the system loss of function for these targets will match the future threat. In addition, the configuration

projections for the future threat tanks are radically different than any available U.S. or older threat systems, and it is unlikely that these kinds of modifications could be made in a configuration with acceptable functioning or vulnerability characteristics. Therefore, neither alternatives 1 or 2 are recommended.

Armor on U.S. or available older threat tanks can be modified to represent a level of overmatch (residual penetrating capability) or can be replaced with a range target that represents the threat armor projections. Both options have potentially significant limitations. Modifying the armor to represent a level of overmatch probably would not represent spall accurately. Replacing the armor with a range target may alter significantly the collateral damage to components and, therefore, may give a misleading impression of system loss of function. Given these limitations and since the configurations of future threat tanks are significantly different than the U.S. or older available threat tanks, alternative 3 is not recommended.

Alternative 4 (U.S. or older threat tank without modifications) is not recommended because it does not match threat projections for armor, components, or configuration. However, firing against a U.S. or older available threat tank without modification can provide some useful supplemental insight into the overall lethality assessment against tank targets. In addition, it adds to the vulnerability data base on these tanks.

Ballistic hull and turret alternatives 5–7 built to threat armor projections can provide an accurate representation of the areas that can be perforated and the degree of behind-armor effects for areas perforated. If components (mannequins and boxes that represent components occupy the projected areas) are included, then a limited lethality assessment for shots fired based directly upon tests can be made. Alternative 5 is the most comprehensive of these alternatives, but it is not sufficient because the target does not function.

Alternative 8 is not recommended because it does not provide even a limited basis for assessing lethality against the threat tank for the shots fired directly from the test. In addition, firings against range targets have always been part of the standard development tests that contribute to the overall lethality assessment.

None of the alternatives by themselves is adequate for live fire lethality testing; however, it is possible to fire against three different targets to adequately demonstrate lethality in live fire tests. The three different targets and the type of tests recommended are as follows:

a. Threat tank range target tests with sufficient sample sizes to establish with high statistical confidence that the ability of the baseline and developmental anti-armor munition to perforate the range targets of interest and to characterize the behind-armor spall characteristics of both munitions.

b. Ballistic hull and turret targets constructed to threat armor projections and configured with crew and major component box representations to demonstrate major lethality differences between baseline and developmental anti-armor munitions.

c. U.S or older threat tank (without modifications) to provide a limited demonstration of lethality of the baseline and developmental munitions against a functioning vehicle. (Note: these tests may not demonstrate significant differences because both munitions may significantly overmatch these targets.)

Helicopter Targets for Live Fire Lethality Testing

Live fire testing of U.S. anti-helicopter munitions shall include, when feasible, the firing of that munition against threat targets. Since it is very unlikely that future threat helicopter targets (requirements for anti-helicopter munitions) will be available at the time they are needed for Live Fire Lethality testing, it is necessary to identify and evaluate alternatives for threat helicopter targets and recommend the preferred alternatives. Thus, for Live Fire Lethality testing of anti-helicopter munitions the threat helicopter target data are and will probably largely be postulated technologies and configurations derived from intelligence assessments.

Our anti-helicopter munitions will be largely smart munitions in that they will respond to target signatures to execute terminal maneuvers (optimizing accuracy and approach angles) or optimize fuzing/detonation points relative to the target by sensing target proximity. These complex interactions of our anti-helicopter munitions with a variety of signatures, countermeasures (false signatures or obscuration/suppression of signatures), and environmental conditions will require substantive laboratory, technical, and operational testing preceding any Live Fire testing so that Live Fire testers have sufficient basis to define shots about meaningful intercept conditions.

Lethality and vulnerability testing indicates that the dominant damage mechanisms against aircraft (including helicopters) are the warhead fragments and blast. The blast effects are significantly enhanced by warhead penetration of the aircraft skin. Munitions optimized for fragment kills use various forms or fuzing to detonate the warhead when in proximity of the threat aircraft. Munitions which depend on the blast kill mechanism may optimize their point of impact based on target signature to take advantage of vulnerability features of the aircraft. Hit-to-kill missiles can achieve bonus effects by the missile body continuing to fly into the aircraft target. There are also dual purpose munitions which are designed for both anti-armor and anti-aircraft roles. Typically these munitions have a point detonating shaped charge warhead matched to the armor threat of interest and for the air defense role a proximity fuze which senses if the munition is about to miss the target and detonates the warhead to generate lethal fragmentation. The shaped charge warhead effect is often so overmatched to the aircraft target that a direct hit is a virtual kill.

Live fire testing and evaluation alternatives are defined (Table E-2) in terms of the type of target fired at in Live Fire Lethality tests, whether the target is functional or flyable, what the test addresses, and the basis for the overall lethality assessment (test, model, or a combination of both). Alternatives 1 and 2 are certainly the most credible alternatives for addressing live fire objectives. The acquisition of actual threat targets in quantity for exploitation (Alternative 1) in live fire will not likely include the latest threat systems. It may be possible to acquire limited numbers of threat helicopters which have been fielded in quantity and exported widely. Also, commercial versions of some helicopter types may be available on the world market as the Soviets or others seek opportunities to gain hard currency. The construction of flyable surrogates based on technical threat projections (Alternative 2) is a very costly and risky approach to satisfying live fire target requirements. Development costs would be similar to the development of any new helicopter and the uncertainty of projections carries with it the risk of developing exactly the wrong surrogate. However, the development of non-flying/non-functioning surrogate targets based on threat projections is probably very reasonable. This approach might also allow the exploration of projected design alternatives at reasonable costs. The use of modified U.S. or older threat aircraft (Alternative 3) provides the most reasonable alternative for conducting Live Fire Tests of fully functioning helicopters. Use of helicopters which most closely conform to the projected threat design can assist in understanding the influence of dynamic effects on munitions lethality. Finally, the construction of a fuselage shell, major component boxes and mannequins (Alternative 4) based on technical threat projections, although significantly lacking in resolution, may be the solution to maximizing the utility of a limited number of more faithful but expensive target alternatives. This alternative should allow the exploration of expected effects through numerous live fire shots and permit "tuning" of our models to minimize the number of shots required against the more expensive and scarce alternatives.

The lethality test and evaluation target alternatives break logically

into four categories. None of these categories offer an entirely satisfactory technical solution and the costs associated with flying and functioning targets are very high. The categories for each alternative are:

a. Flyable-functioning helicopters with an overall lethality assessment primarily based upon observation of test results (collection of damage effects data frequently not possible).

b. Non-flyable/functioning helicopter targets (typically tower mounted) with an overall lethality assessment based upon a combination of modelling (principally to define intercept and fuzing/detonation points) and test results (collection of damage effects data).

c. Non-flyable/nonfunctioning helicopter targets (typically tower mounted) with an overall lethality assessment based upon a combination of modelling (defining intercept/fuzing and damage effects on nonfunctioning components) and test results (collection of damage effects data).

d. Fuselage or major subsystems representative of comparable threat helicopter components (i.e., engine, rotor system, etc.), with an overall lethality assessment based principally upon modelling.

The most realistic category for live fire lethality against threat helicopters would appear to be against the flying helicopter targets (drone kits installed and flown by a remote flight qualified operator). However, using flying targets alone is not a totally acceptable solution with regard to data collection. A lethal engagement of a flying drone threat helicopter or surrogate will most often result in a crash which causes other damage tending to mask damage effects created by the weapon fired at the aircraft. True lethality might also be masked by "lethal" damage to the drone control system resulting in a helicopter target crash. Diagnosis of which effects are munition related or crash related in determining lethality for live fire is costly and time consuming, and often not possible. Under these conditions, refurbishment of targets may frequently be out of the question. This target category may require nearly one target per engagement fired for live fire lethality (at possible millions of dollars per copy depending upon the fidelity of representing the threat).

The next most realistic category for live fire lethality testing would be against non-flying/functioning alternatives. Helicopters can be tied down on a tower and simulate a hovering or slow flying helicopter by running engines, rotor blades, and other subsystems to create conditions for obtaining fairly realistic lethality effects given that intercept and fuzing geometries are well understood. Although damage effects can be acquired from functioning tower mounted targets the true test of whether or not the helicopter would have crashed from some damage effects in dynamic flight may only be derived with absolute certainty by using a flying helicopter. For example, rotor blades hit while rotating on a tethered machine are subject to different dynamic loads than rotor blades on a real hovering helicopter and the effects on controlled flight may not be readily apparent in the tethered case. Functioning (flying or non-flying) helicopter alternatives are most appealing because nearly the entire range of damage effects may be assessed for each shot.

The non-flying/non-functioning category of threat target is a less realistic category for each alternative, but is probably one of the more practical and among the most affordable of the categories for each alternative. However, without engines running and rotor blades rotating, the realism of live fire lethality will be limited for some munition effects.

The least realistic category for each alternative is the use of the fuselage and/or major components for live fire testing. However, from a practical point of view the fuselage and component shots are an essential building block to gaining enough information to tune lethality modelling and decide on the nature of "full up" shots against more realistic target alternatives.

The major thesis to be derived from the preceding discussion is to proceed on a building block approach from the crudest representation of threat targets to build a vulnerability/lethality database and to minimize the use of scarce and costly threat target resources in the live fire program. It is probably not reasonable to expect a cookbook solution for all types of munitions. The preceding discussion may offer a hierarchy of solutions where we might enter the Table E-2 matrix at the component level in developing basic vulnerability assessments and then developing our live fire lethality data using helicopter targets which provide acceptable levels of realism and affordability.

A combination of Alternatives 2 (non-flyable/non-functioning and fuselage-major subsystem surrogates) and 3 (flyable-functioning and non-flyable/functioning older U.S. or threat surrogates) is probably the most practical and affordable approach for building a realistic matrix of live fire lethality tests against threat helicopters.

Table E–1
Tank LFT&E Alternatives

				Mechanisms		Target Component Vulnerability		Overall Lethality Assessment	
Alternative	Target	Target Functions	Armor Perforated	Pen/Spall	All Other	Crew	All Other	Test	Model
1	Prototype built based upon tech projections	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Modified U.S. or older threat tank: armor and components	Yes	Yes	Yes		Yes[2]	Limited	Yes	Yes
3	Modified U.S. or older threat tank: armor only	Yes	Yes	Yes	Yes	Yes[2]	No	Yes	Yes
4	U.S. or older threat tank without any modification	Yes	Yes	Yes	Yes	Yes[2]	No	Yes	Yes

Table E–1
Tank LFT&E Alternatives—Continued

				Mechanisms		Target Component Vulnerability		Overall Lethality Assessment	
Alternative	Target	Target Functions	Armor Perforated	Pen/Spall	All Other	Crew	All Other	Test	Model
5	BHT[1] with mannequins and major component boxes	No	Yes	Yes[2]	No	Yes[2]	Limited	Limited	Yes
6	BHT[1] with mannequins only	No	Yes	Yes	No	Yes	No	Limited	Yes
7	BHT[1] (armor shell only)	No		Yes	No	No	No	No	Yes
8	Range targets	No	Yes	Yes	No	No	No	No	Yes

Notes:
[1] Ballistic hull and turret built to threat projections
[2] Accuracy depends on the extent to which the crew locations and shielding by components represents the threat projection.

Table E–2
Helicopter LFT&E Alternatives

					Damage Mechanisms			Target Component Vulnerability				Overall Lethality Assessment	
Alt	Target	Target Flying/Tower		Target Signature	Blast	Frag	All Other	Crew	Fuel Fire	Engine	All Other	Test	Model
1	**Actual target exploitation**												
	Flying-Functioning	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	N/A
	Non-Flyable/Functioning	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N\A
	Non-Flyable/Non-Functioning	No	Yes	No	Yes	Yes	No	Yes	Part	No	No	N\A	Yes
	Fuselage/Components	No	No	No	Part	Part	No	Yes	No	No	No	N\A	Yes
2	**Prototype built based on technical projection**												
	Flying-Functioning	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	N\A
	Non-Flyable/Functioning	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N\A
	Non-Flyable/Non-Functioning	No	Yes	No	Yes	Yes	No	Yes	Part	No	No	N\A	Yes
	Fuselage/Components	No	No	No	Part	Part	No	Yes	No	No	No	N\A	Yes
3	**Modified U.S. or older threat aircraft**												
	Flying-Functioning	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	N\A
	Non-Flyable/Functioning	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N\A
	Non-Flyable/Non-Functioning	No	Yes	No	Yes	Yes	No	Yes	Part	No	No	N\A	Yes
	Fuselage/Components	No	No	No	Part	Part	No	Yes	No	No	No	N\A	Yes
4	**Fuselage constructed with major component boxes and mannequins**	N/A	NA	N\A	Part	Part	No	Yes	No	No	No	No	Yes

Glossary

Section I
Abbreviations

AAEitle>
Army Acquisition Executive

ACAT
acquisition category

AMC
United States Army Materiel Command

AMSAA
United States Army Materiel Systems Analysis Activity

AR
Army Regulation

ARL
United States Army Research Laboratory (formerly U.S. Army Ballistic Research Laboratory)

ASARC
Army Systems Acquisition Review Council

ASA(RDA)
Assistant Secretary of the Army (Research, Development, and Acquisition)

ATC
United States Army Aberdeen Test Center (formerly U.S. Army Combat Systems Test Activity)

BRL
United States Army Ballistic Research Laboratory

BVLD
Ballistic Vulnerability/Lethality Division

CCM
counter-countermeasure

CM
countermeasure

COEA
Cost and Operational Effectiveness Analysis

CSTA
United States Army Combat Systems Test Activity

DA
Department of the Army

DCSINT
Deputy Chief of Staff for Intelligence

DIA
Defense Intelligence Agency

DOT&E
Director of Operational Test and Evaluation

DoD
Department of Defense

DoDI
Department of Defense Instruction

DT
developmental test

DTP
Detailed Test Plan

DTR
Detailed Test Report

DUSA(OR)
Deputy Under Secretary of the Army (Operations Research)

EMD
Engineering and Manufacturing Development

FSD
Full-Scale Development

HQDA
Headquarters, Department of the Army

IEP
Independent Evaluation Plan

IEP/TDP
Independent Evaluation Plan/Test Design Plan

IER
Independent Evaluation Report

IPR
In-Process Review

LFT&E
Live Fire Test and Evaluation

LRIP
low-rate initial production

MAA
Mission Area Analysis

MC
Materiel change

MOA
Memorandum of Agreement

MOU
Memorandum of Understanding

NDI
Non-developmental item

OMB
Office of Management and Budget

OPSEC
Operations Security

OPTEC
Operational Test and Evaluation Command

O&S
Operation and support

OSD
Office of the Secretary of Defense

PEO
Program Executive Officer

PIP
Product Improvement Program

PM
Program/Product Manager

PM ITTS
Project Manager for Instrumentation, Targets, and Threat Simulators

PMO
Program Manager's Office

PQT
production qualification test

PVT
production verification test

RAM
reliability, availability, and maintainability

RHA
rolled homogeneous armor

SLAD
Survivability/Lethality Analysis Directorate

SSEB
Source Selection Evaluation Board

STAR
System Threat Assessment Report

Sub-sys
Sub-system

TDP
test design plan

T&E
Test and Evaluation

TECOM
United States Army Test and Evaluation Command

TEMP
Test and Evaluation Master Plan

TIWG
Test Integration Working Group

TRADOC
United States Army Training and Doctrine Command

USC
United States Code

VLAMO
United States Army Vulnerability/Lethality Assessment Management Office

WRAIR
Walter Reed Army Institute of Research

Section II
Terms

Army live fire
Live fire testing of the Bradley, the Abrams, and the M113 Family of Vehicles; program completed in 1988.

Ballistic hull and turret
An armored structure representative of a system without powerpack or component subsystems.

Building-block approach
An approach to vulnerability/lethality testing beginning with component level testing and progressing through sub-system, system, BH&T testing, and culminating in a full-up, system-level LFT.

Catastrophic kill
The damage an armored vehicle sustains when both an M-kill and an F-kill occur and it is not economically repairable, usually called a k-kill.

Compartment model
A low-resolution vulnerability/lethality assessment computer model used to predict the vulnerability of armored vehicles and the lethality of anti-armor munitions (see chap 6, table 6–1).

Conventional weapon
Those weapons which are neither nuclear, chemical, or biological.

Covered Product Improvement Program
A covered system and/or major munition or missile program for which a planned modification or upgrade is likely to produce a significant effect on the vulnerability and/or lethality of that system/munition or missile.

Covered system
Any vehicle, weapon platform, or conventional weapon system that includes features designed to provide some degree of protection to users in combat and is a major system.

Depot level support
The level of repair performed by depot mechanics with depot tools and procedures.

Engineering and Manufacturing Development
The acquisition phase between Milestone II and Milestone III (formerly, Full-Scale Development).

Firepower kill
The damage an armored vehicle suffers if it becomes incapable of delivering accurate, controlled firepower and cannot be repaired by the crew (within approximately 10 minutes) on the battlefield, usually called an F-kill.

Full-up testing
Firings against full-scale targets containing all of the dangerous materials (for example, ammunition, fuel, hydraulic fluids, or similar items), system parts (for example, electrical lines with operating voltages and currents applied, hydraulic lines containing appropriate fluids at operating pressures, and so forth), and stowage items normally found on that target when operating in combat. Full-up testing includes firings against full-up components, full-up sub-systems, full-up subassemblies, or full-up systems. The term "full-up, system-level testing" is synonymous with "realistic survivability testing" or"realistic lethality testing" as defined in the legislation covering LFT.

Lethality
The ability of a munition to cause damage that will cause the loss of, or a degradation in, the ability of a target system to complete its designated mission(s).

Live fire test
A test event within an overall LFT&E strategy which involves the firing of actual munitions at target components, target subsystems, target sub-assemblies, and/or subscale or full-scale targets to examine personnel casualty, vulnerability, and/or lethality issues.

Major munitions program
A conventional munitions program that is a major system within the definition given below or for which more than 1,000,000 rounds are planned to be acquired.

Major system
As specified in Title 10, United States Code, Section 2302(5), a system is a combination of elements that will function together to produce the capabilities required to fulfill a mission need. The elements may include hardware, equipment, software, or any combination thereof, but excludes construction or other improvements to real property. A system shall be considered a major system if:

a. The DoD is responsible for the system and the total expenditures for research, development, and test and evaluation for the system are estimated to be more than 75 million dollars (based on fiscal year 1980 constant dollars), or the eventual total expenditure for procurement of more than 300 million dollars (based on fiscal year 1980 constant dollars).

b. A civilian agency is responsible for the system and the total expenditures for the system are estimated to exceed 750,000 dollars (based on fiscal year 1980 constant dollars) or the dollar threshold for a "major system" established by the agency pursuant to Office of Management and Budget, Circular A–109, entitled "Major Systems Acquisitions," whichever is greater.

c. The system is designated a "major system" by the Secretary of the Army.

Note. Per DoDI 5000.2, fiscal year 1990 constant dollars are 115 million dollars for research, development, and test and evaluation and 540 million dollars for procurement.

Milestone IIIB
In the OSD LFT&E Guidelines, the full-rate production decision milestone (always follows an LRIP) before which LFT&E must be completed and reported upon to Congress. Under the current DoD policy (reference DoDI 5000.2), there is no Milestone IIIB. LFT&E must be completed and reported before Milestone III (Production Approval); LRIP will now be conducted during the EMD phase prior to Milestone III.

Mobility kill
The damage a vehicle suffers if it becomes incapable of executing controlled movement and cannot be repaired by the crew (within approximately 10 minutes) on the battlefield, usually called an M-kill.

Model/Modeling
A vulnerability/lethality assessment tool used to predict one or more aspects of a given munition/target interaction. A model may be anything from a sophisticated computer code (employing many individual algorithms to assess total system vulnerability/lethality) to a simple mathematical expression or empirical relationship used to predict a single element of a munition/target interaction (for example, the penetration performance of a given munition).

Pk
Not a probability in the pure sense, but a fractional estimate of a systems loss of function.

Pk/h
Not a probability in the pure sense, but a fractional estimate of a systems loss of function given an impact on the system of interest.

Pre-shot prediction
An priori prediction of the expected outcomes of a Live Fire shot. The prediction might, in special circumstances, be a quantified value of the probability of kill given a hit and/or the expected number of casualties. Most often, the pre-shot prediction will be in the form of quantitative or qualitative expectations of the ability of the attacking munition to defeat the armor or other protective design features of the target and inflict damage to components or personnel; or conversely, the ability of the target to defeat or mitigate the effects of the attacking munition. These predictions can be either absolute expectations of performance or comparative expectations of the relative performance of two or more munitions or targets. The pre-shot predictions may be based on computer models, engineering principles, or engineering judgments.

Realistic lethality testing
Testing for lethality by firing the munition or missile concerned at appropriate targets configured for combat.

Realistic survivability testing
Testing for vulnerability and survivability of a system in combat by firing weapons likely to be encountered in combat (or munitions with a capability similar to such munitions) at the system configured for combat, with the primary emphasis on testing vulnerability with respect to potential user casualties and taking into account equal consideration for the operational requirements and combat performance of the system.

Realistic testing
For vulnerability testing: the firing of munitions, likely to be encountered in combat, at the weapon system configured for combat. For lethality testing: the firing of the munition or missile concerned at appropriate targets configured for combat.

Stochastic
Involving or containing random variables; the interaction between the munition and the target is stochastic.

Survivability
The capability of a system to avoid or withstand a man-made hostile environment without suffering an abortive impairment of its ability to accomplish its designated mission.

Test issues
Questions which must be answered in operational and developmental testing. Test issues are not necessarily stated in the same form as the system evaluation issues or system test and evaluation critical issues from which they are derived, but test issues must be stated in a manner that ensures those evaluation issues amenable to test can be answered. The emphasis of test issues is on producing data in support of the operational and developmental evaluations. Test issues have criteria when needed. Test issues and their criteria are identified by the independent evaluators and published in Independent Evaluation Plans (IEPs) and Test Design Plans (TDPs).

Vulnerability
The characteristics of a system that cause it to suffer a definite degradation (loss or reduction of capability to perform its designated missions as a result of having been subjected to a certain level of effects in a man-made hostile environment.

Section III
Special Abbreviations and Terms

AAL
additional authorization list

BAD
behind-armor debris

BAST
Board on Army Science and Technology

BDAR
battlefield damage assessment and repair

BH&T
ballistic hull and turret

BII
basic issue items

DAL
damage assessment list

DAT
damage assessment team

F-kill
firepower kill

frag
fragment

K-kill
catastrophic kill

JLF
Joint Live Fire

LFT
Live Fire test

LOF
loss of function

M-kill
mobility kill

Pen
penetration

Pk
probability of kill

Pk/h
probability of kill given a hit

SLV
survivability/lethality and vulnerability

SPARC
Sustainability predictions for Army requirements for combat

V/L
vulnerability/lethality

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