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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 28 APR 91	3. REPORT TYPE AND DATES COVERED Final Report
4. TITLE AND SUBTITLE Review and Analysis of LAV-25 Detailed Test Plan.		5. FUNDING NUMBERS C - DLA900-86-C-2045 Task No. 106
6. AUTHOR(S) Robert D. Carpenter		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Wackenhut Applied Technologies Center 10530 Rosehaven Street, Suite 500 Fairfax, VA 22030		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Director, Live Fire Testing Defense Research and Engineering (Test and Evaluation) Washington, DC 20301-3110		10. SPONSORING, MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES		
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unlimited This document has been approved for public release and sale; its distribution is unlimited.		12b. DISTRIBUTION CODE U.S. Marine Corps
13. ABSTRACT (Maximum 200 words) This report provides a review and analysis of the Detailed Test Plan prepared for the live fire test of the LAV-25 by the USMC. Detailed evaluation criteria were used and specific comments provided. Short comings of the test plan were discussed to include the lack of reasonable employment scenarios which are necessary to evaluate the reasonableness of the threat.		
14. SUBJECT TERMS Live Fire Testing Light Armored Vehicle LAV-25		15. NUMBER OF PAGES 14

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FINAL REPORT

REVIEW AND ANALYSIS OF LAV-25 DETAILED TEST PLAN

1. In accordance with Task Order No. 2 (106) of subcontract R-5013(8937)-1178, the following comments are provided from the review and analysis of the "Test Plan for Selected Direct Fire Threats Against USMC Light Armored Vehicle (LAV-25) (DRAFT)," January 1989.

2. Evaluation Methodology. Pursuant to Task 105, MRC produced, in October 1988, an outline of the criteria to be used for evaluation of Detailed Test Plans (DTP) and an evaluation sheet which an evaluator could use to perform a critical review of these Live Fire Plans. These documents were used for the LAV-25 DTP and constitute the body of the critical comments provided. The Evaluation Criteria, together with applicable review comments, is at Enclosure 1, and the Evaluation Sheet, together with rationale supporting the ratings, is at Enclosure 2. Specific page-by-page comments are at Enclosure 3.

3. Conclusion.

a. Since the LAV-25 Live Fire Test is part of the Joint Live Fire Test Program, there is somewhat of a mismatch involved, since these evaluation sheets apply to the Live Fire Testing Process which is a hurdle all newly developing systems must overcome. Joint Live Fire Tests are for evaluation of established systems already in the government inventory. The go-ahead for full production decision has already been made and the purpose of Joint Live Fire Testing is to determine the vulnerability of these existing systems in their expected threat environment and to determine what reasonable survivability improvements may be considered.

b. In the context described, it appears that the tests described here are reasonable to determine the vulnerability of the LAV-25 and should point to possible improvements in survivability, either by altering the intended employment or making material alterations in the existing systems. However, it is not possible to judge either the reasonableness of exposure to the threat, or the reasonableness of intended LAV-25 employment scenarios, since these considerations are not discussed in this plan at all, nor are they referred to.

4. Recommendations.

a. Include development of threat exposure and likely employment scenarios in the introduction of this DTP.

b. Resolve specific carry-on ammunition and munitions questions for the LAV-25 4-man squad.

c. Show the relationships between the tests performed, measures of effectiveness developed and critical issues to be resolved by testing in sufficient detail that the vulnerability of the LAV-25 in its typical mission(s) and the value of possible improvements can be developed more easily.

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DETAILED TEST AND EVALUATION PLAN

EVALUATION CRITERIA

1. General Contents. Does the plan contain a sufficient description of:
 - a. Detailed test procedures.
 - b. Test conditions.
 - c. Data collection and analysis procedures used to evaluate data.

Comment: In view of the limited objective of the plan, i.e., to determine the vulnerability of the LAV-25 to specified threats (7.62 mm AP, 14.5 mm AP, 30 mm APDS, and RPG-18) and to gain insights into possible survivability enhancements, the plan appears to provide a sufficient description.

2. Specific Contents. Does the plan contain the following information?

- a. Administrative:

- (1) Cover page with name of system, responsible agency, date, classification, distribution statement.

Comment: Yes, no, yes, yes (unclassified), no.

- (2) Coordination sheet with signatures of service approval authorities.

Comment: No.

- (3) Information on key LFT&E personnel giving position, name, organization, telephone number, electronic mail address.

Comment: Some key personnel info given on p. D-4, and some organizational responsibilities on pp. 14-15, but no list is specifically provided.

- b. Test objectives in sufficient detail to show that evaluation procedures are appropriate and adequate. This section should also show how the test objectives relate to the critical issues from the TEMP.

Comment: Test objectives are given in sufficient detail. Issues are given, but TEMP provision is not applicable for JLFT (testing existing systems, not developmental systems).



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c. Threats/targets. This section discusses:

- (1) Key characteristics of threats/targets which affect vulnerability/lethality.

Comment: While not specifically stated, one can deduce them: penetration, spall, overpressure, heat, toxic fumes.

- (2) Threat definition document/authority.

Comment: Not given.

- (3) Rationale/criteria for threats/targets, basis used for number to be tested.

Comment: Not given.

- (4) Surrogates, if used, and rationale for their selection.

Comment: Surrogates given, rationale not provided.

- (5) Description of specific threats/targets and detailed configuration and stowage plan.

Comment: Given.

d. Constraints. Includes:

- (1) Test limitations and impact on test results.

Comment: Not discussed.

- (2) Differences between system tested and system to be fielded. Identify degree to which results are representative of vulnerability/lethality of the production system.

Comment: System tested is the fielded system.

- (3) Shot Selection Process. Thoroughly discusses random shots, how selected, exclusion rules, if any, and engineering shots, to include vulnerability/lethality issue examined and rationale for selection of specific conditions.

Comment: Shot selection process is adequately described.

e. Detailed Test Descriptions. Discusses:

- (1) Test approach.

Comment: Provided.

(2) Test setup.

Comment: Provided.

(3) Test conditions.

Comment: Provided.

(4) Firing procedures.

Comment: Provided.

(5) Damage assessment and repair process.

Comment: Provided.

(6) Test sequence.

Comment: Provided, depends on number of targets available.

(7) Instrumentation.

Comment: Provided.

(8) Data collection and analysis procedures.

Comment: Provided.

(9) Responsibilities for results collection and documentation.

Comment: Provided.

(10) Standard forms used, if any.

Comment: Provided.

f. Evaluation. Contains:

- (1) Detailed description of analysis/evaluation plan for the test, consistent with the test design and data to be collected. Indicates statistical test designs used for direct comparisons or for pass/fail criterion.

Comment: Covered. Statistical test designs not discussed, if used, no pass/fail criteria provided (nor intended).

- (2) Prediction of results for each shot, with detail consistent with damage prediction technique (computer models, engineering principles, or engineering judgement).

Comment: Not provided in DTP, but to be provided concurrent with testing, using SQUASH model.

- (3) Description of vulnerability/lethality models used to support shot line selection, pre-shot predictions, and/or analysis and evaluation. Discussion includes model input limitations as well as sources of key inputs.

Comment: SQUASH model described in Analysis Addendum. No discussion of model limitations or input sources provided.

DETAILED LIVE FIRE TEST PLAN

EVALUATION SHEET

The following items and the degree to which they are discussed will determine the adequacy of the Detailed Live Fire Test Plan. The ratings are established as E = Excellent; A = Adequate; and U = Unsatisfactory.

Rating

- N/A ■ Consistent with TEMP, e.g., test objectives, measures of effectiveness (MOE) related to critical issues, activities in this test phase, etc. Any differences are explained.
- A ■ Threat assessment. Threat source cited. Recent DIA-validated threat available to compare threat simulators/surrogates used in test.
- A/U ■ MOE's quantitatively or qualitatively expressed (if qualitative, pass/fail criteria is clearly stated).
- E ■ Test plan specifically states critical Live Fire Test issues.
- A ■ Planned test events specifically related to critical Live Fire Test issues and describes how they will be answered.
- E ■ Production articles used for testing or differences between test articles and production articles defined with probable impact on test results explained.
- A ■ All test support requirements met, e.g., number and location of test sites, facilities, special instrumentation, targets, expendables, support equipment, data and transmission security. Resources examined in detail.
- E ■ Test data collection processing and quality control procedures explained and adequate. Back-up procedures available and explained. Test data collection personnel and their relationships considered. Damage assessment team identified.
- E ■ Evaluation methodology is satisfactory. Method of applying results to MOE's is clearly described. Model predictions addressed and simulations described.
- A ■ Sufficient number of test events included to provide a level of confidence in the results. Includes discussion of statistical adequacy and judgemental factors. Evaluates static vs. dynamic shots and appropriateness.

E ■ Shot selection process thoroughly discussed. Discusses random shots and how selected, use of exclusion rules, if any, and treatment of excluded shots. If engineering shots are used, discusses specific vulnerability/lethality issue examined and rationale for selection of specific conditions. Balance between random and engineering shots is adequate.

UNK ■ Shots are representative of expected weather and terrain conditions, engagement velocities, obliquities, azimuths, visibilities, countermeasures, combat postures and regions of expected employment.

A ■ Target is combat configured with proper fuel, ammo and hydraulic fluids on board, at operating temperatures and pressures, and electrical systems, engines and hydraulic systems operating.

U ■ Identifies limitations of test and judgement of the effects of these limitations on validity of the test.

A ■ Test is sufficient to judge system adequacy for vulnerability/lethality confirmation prior to full scale production.

Any one of the following failures will make the test plan unsatisfactory.

N/A ■ Test plan not consistent with the TEMP.

E ■ No critical Live Fire Test issues defined.

UNK ■ Threat data not current and DIA-validated.

U ■ MOE's not given or not clearly defined.

A ■ Insufficient threat simulators and surrogates or other test assets to preclude adequate testing.

A ■ Data collection, processing and quality control not discussed.

EXPLANATION OF RATINGS

- Consistent with TEMP, e.g., test objectives, measures of effectiveness (MOE) related to critical issues, activities in this test phase, etc. Any differences are explained.

Rating: Not Applicable. For a system currently in use rather than in limited production, the TEMP was developed long before the need for LFT was established. The plan does, however, reflect objectives, issues, and describes the tests in detail. The provision of references 2 and 3 would permit a more detailed look at the context of this testing, however.

Reference 2: "JLF Test Armor/Anti-Armor System, Program Plan for USMC LAV," Sep. 87. Reference 3: T.R. Julian, "Final Report, Technical Feasibility Test of LAV-25."

- Threat assessment. Threat source cited. Recent DIA-validated threat available to compare threat simulators/surrogates used in test.

Rating: Adequate. No threat source is cited, nor is a recent DIA validated threat known to be used. However, since this item is an adaptation of an existing system, the threats chosen for testing appear to be reasonable. A detailed evaluation of reference 3 (T.R. Julian, "Final Report Technical Feasibility Test of LAV-25") would be helpful as this report probably has a threat evaluation in it.

- MOE's quantitatively or qualitatively expressed (if qualitative, pass/fail criteria is clearly stated).

Rating: Marginal. MOE are not stated. Further, the plan specifically states that the purpose of the test is not to meet pass/fail criteria, but to provide insights into survivability enhancements as well as establishing the vulnerability of the vehicle to these threats. The MOE used, however, are loss of function expressed as P_k, or its conjugate, combat utility (CU), measuring the functional characteristics of the vehicle: mobility, firepower, catastrophic failure.

- Test plan specifically states critical Live Fire Test issues.

Rating: Excellent. The plan identifies the issues being evaluated and these clearly relate to the purpose of live fire testing: crew vulnerability, ammunition vulnerability, vulnerabilities of critical components relating to mobility.

- Planned test events specifically related to critical Live Fire Test issues and describes how they will be answered.

Rating: Adequate. The test events are grouped to evaluate the vulnerability of stored ammunition to the threats, the vulnerability of the vehicle, its components and crew without live ammo to the threats (inert test), and vulnerability to the threats of vehicle with ready ammo as well as stored ammo. The issues are grouped to evaluate vulnerability to direct threat effects, secondary threat effects, and susceptibility of mobility, firepower and commo to kill by the threats. Grouped as they are, all three test events must be conducted to answer the issues.

- Production articles used for testing or differences between test articles and production articles defined with probable impact on test results explained.

Rating: Excellent. Production LAV used for two of three tests plus ballistic hull (production model) used for third test.

- All test support requirements met, e.g., number and location of test sites, facilities, special instrumentation, targets, expendables, support equipment, data and transmission security. Resources examined in detail.

Rating: Adequate. Although actual site of test facilities is not yet decided, negotiations are on-going with facilities that can adequately support the effort. The number of targets and the need to refurbish them are limiting to the rapid conduct of this test.

- Test data collection processing and quality control procedures explained and adequate. Back-up procedures available and explained. Test data collection personnel and their relationships considered. Damage assessment team identified.

Rating: Excellent. Data collection will use standardized forms for evaluation. All test shots are photographed and evaluation/assessment procedures will be standardized. Damage assessment team not fully identified, but discussed and some members identified.

- Evaluation methodology is satisfactory. Method of applying results to MOE's is clearly described. Model predictions addressed and simulations described.

Rating: Excellent. Method of applying results to MOE's is clearly described. Model predictions and simulations are somewhat described in analysis addendum. It appears that the pre-shot prediction will need the test results in order to validate/calibrate the model. Therefore, its primary value will be in prediction of enhancements that will reduce vulnerability/enhance survivability of the LAV-25, rather than in prediction of pre-shot damage.

- Sufficient number of test events included to provide a level of confidence in the results. Includes discussion of statistical adequacy and judgemental factors. Evaluates static vs. dynamic shots and appropriateness.

Rating: Adequate. Although there is no discussion of statistical adequacy/judgemental factors, the number of test events (108 shots) should provide a level of confidence in the results. All shots are dynamic, which appears to be appropriate with the possible exception of the RPG-18. Static shots would avoid launch errors and, since over 95% of the RPG energy is chemical and independent of terminal conditions, it would appear that avoiding possible launch errors is desirable.

- Shot selection process thoroughly discussed. Discusses random shots and how selected, use of exclusion rules, if any, and treatment of excluded shots. If engineering shots are used, discusses specific vulnerability/lethality issue examined and rationale for selection of specific conditions. Balance between random and engineering shots is adequate.

Rating: Excellent. Process is discussed adequately. BAST methodology is discussed elsewhere, but the balance between random and engineering shots is adequately treated.

- Shots are representative of expected weather and terrain conditions, engagement velocities, obliquities, azimuths, visibilities, countermeasures, combat postures and regions of expected employment.

Rating: Unknown. To answer for all these conditions requires an in-depth look at the representative scenarios which gave rise to the need for the test. They are not discussed in this plan at all. They may be in reference 2 or 3, cited above.

- Target is combat configured with proper fuel, ammo and hydraulic fluids on board, at operating temperatures and pressures, and electrical systems, engines and hydraulic systems operating.

Rating: Adequate. Combat configuration is good, with possible exception of HE ammo of the four-man squad, which can have a significant impact on possible results. Plan does not state whether hydraulic systems are operating or not, and this should be stated.

- Identifies limitations of test and judgement of the effects of these limitations on validity of the test.

Rating: Unsatisfactory. Limitations are not discussed, nor their effect on validity of the test.

- Test is sufficient to judge system adequacy for vulnerability/lethality confirmation prior to full scale production.

Rating: Adequate. Although this is a JLF test, and full production decision has been made, this test should give significant insight into the vulnerability of the LAV-25 and possible improvements to its survivability.

SPECIFIC PAGE COMMENTS ON LAV DTP

1. Table 3, p. 12. Unclear what is meant by use of * in second column (which means "hardware on hand") and then placing an entry in third column as a potential substitute. It would appear that, if the item is on hand, a substitute is unnecessary and, therefore, third column should be empty.

2. Stowed Ammo Test. Target configuration description (p. 23) refers to Appendix F for layout (Appendix F is LAV-25 stowage plan for First Light Armored Inf Bn, 1st MAR DIV). Appendix F, however, does not agree with planned test quantities of ammo for test, nor, in some cases, kinds of ammo. Table 1, below, shows discrepancies. These discrepancies should be resolved: specifically differing quantities of ammo, differing numbers of AT warheads containing HE (SMAW, LAW/AT-4), numbers and types of grenades, whether mines containing significant quantities of HE are to be loaded, and, if not, why not in face of USMC stated plans to carry. The DAL assessment of catastrophic loss due to squad-carried HE being hit shows the importance of this point. These same comments also apply to the live loaded LAV-25 test, since all the same loading occurs, plus all live ready rounds in turret.

3. P. 23, Target Configuration. This section describes operational configuration of LAV during the test. One of the conditions (item j, paragraph 2.2.2) calls for all hatches and/or openings in LAV to be closed (buttoned up). However, no mention is made of ventilation system as part of the critical systems to evaluate, nor of the possibility of operating in a chemical environment. This should be considered and included if this is a realistic condition that may be encountered in the scenario(s) under evaluation.

4. Damage Assessment List (Appendix D).

a. P. D-13, Fire Control. Loss of Combat Utility (CU) assessed for loss of day/night commander/gunner sights is 0.85, which is the full capability of the main gun and coax, implying complete loss of function. However, 2nd paragraph, 1st sentence, this page, states that some capability remains. Therefore, 0.85 is too high and should be reassessed to reflect the remaining capability mentioned.

b. P. D-13, Vision Devices (last 2 paragraphs). It is not clear how the vision devices help, or their loss hurts, firepower. If the weapon sights are unaffected, how can the loss of vision devices affect the firepower rating at all? Are the vision devices included in the original calculation of combat utility for firepower? This relationship needs further explanation, or reassessment of degree of CU lost.

c. P. D-14, 2nd sentence. Perhaps the word "effectively" should be added to this sentence since, as written, it is not strictly true. P. 67 of the Criticality Analysis states that the chain gun can be fired manually, but at a severely reduced rate of fire (9 hand-crank revolutions to fire a single round).

Table 1. Comparison of Test and USMC Stowage Plans.

AMMO TYPE		QUANTITIES		COMMENTS
		TEST	APPENDIX F	
25 mm	APDS-T HEI-T	500 (10 boxes of 50 ea)	120 (4 boxes of 30 ea) 300 (10 boxes of 30 ea)	500 rds versus 420 (Table 1 lists only 420 also)
7.62 mm		1200 (6 boxes of 200 ea)	1200 (6 boxes of 200 ea)	OK
5.56 mm	unlinked linked	4050 (5 boxes of 810 ea) 0	810 (1 box) 1600 (4 boxes of 400 ea)	for individual weapons for SAW(?)
Pop-up flares		1 box (10 ea)	1 box (10 ea)	App F cites hand-held illumination signal— is it the same thing?
SMAW (HE)		3	3	Alternates for SMAW (p. 24), but loaded <u>in addition</u> to SMAW
LAW/AT-4		3	0	
Grenades (WS Parachute & HEDP)		12	12	40 mm hand-held
	Smoke	0	6	
	Thermite	0	6	
	Frag	0	30	
Mines	M-16 M-15 M-18	0 0 0	4 3 2	AP AT Claymore (These all contain significant quantities of HE especially AT mines)

d. In connection with preceding comment, the P_k rating assessed for loss of electric power is the complete utility of the main gun and coax, again allowing nothing for the remaining manual capability. Something less than the full penalty should be considered in view of the retained manual capability to traverse, elevate and fire the guns when power is lost.

e. P. D-18. P_k rating for loss of hydraulic systems for firepower is 0.75, indicating a retention of 0.10 capability for the main gun and coax. Our understanding is that the loss of hydraulics will disable the main gun and coax elevation, but not traverse capability. It is unknown whether the loss of hydraulic systems disables the manual capability to fire the guns or not. Is the 0.10 capability retention a reflection of these considerations or something else? This, perhaps, should be better explained in the text.