ARI Research Note 88-12

HUMAN FACTORS ASSESSMENT: M9 ARMORED COMBAT EARTHMOVER (ACE)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The human factors assessment for the M9 Armored Combat Earthmover (ACE) was conducted in response to a requirement for a follow-on evaluation (FOE) of the system. The FOE was conducted at Fort Hood, Texas, from March through June 1985, by the Combined Arms Test Activity (TCATA) of the Army Training and Doctrine Command (TRADOC), working for the Army Operational Test and Evaluation Agency (OTEA). Nine M9 ACEs performed construction tasks, and on-site performance observations, structured interviews, and weekly meetings with the (OVER)

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20. Abstract (continued)

operators and mechanics were conducted by human factors engineers. Questionnaires were also filled out by the personnel being tested when the FOE was finished.

Measurements included vibration, noise levels, temperature, and humidity. Forty human factors deficiencies and safety hazards were found during the assessment. Many of the deficiencies and hazards can be corrected without major modifications to the vehicle components, and using existing hardware.

FOREWORD

The Fort Hood Field Unit of the US Army Research Institute for the Behavioral and Social Sciences (ARI) provided support to the TRADOC Combined Arms Test Activity (TCATA) conduct of the Follow-On Evaluation (FOE) of the M9 ACE. The FOE was conducted at Fort Hood, Texas, over a 15-week period from March through June 1985, by TCATA for the US Army Operational Test and Evaluation Agency (USAOTEA). The report describes the human factors assessment support and findings provided to the evaluation by ARI. The primary objective of the assessment was to identify human factors engineering (man-machine) deficiences that distract from M9 operational effectiveness and maintainability. Questionnaires, interviews, and direct observation of the equipment and environment by human factors specialists were employed. The results of this research were integrated into the TCATA Test Report, OT 1208, M9 Armored Combat Earthmover (ACE) Follow-On Evaluation (FOE), August 1985.

The effort is responsive to RDTE Project "Human Factors and Training Research in Operational Effectiveness," FY 1985 Work Program.

HUMAN FACTORS ASSESSMENT: M9 ARMORED COMBAT EARTHMOVER (ACE)

EXECUTIVE SUMMARY

Requirement:

The M9 ACE human factors assessment was conducted in response to a requirement for a Follow-On Evaluation (FOE) of the system. The FOE was conducted at Fort Hood, Texas, over a 15 week period from March through June 1985, by the US Army Training and Doctrine Command (TRADOC) Combined Arms Test Activity (TCATA) for the US Army Operational Test and Evaluation Agency (USAOTEA). This report describes the human factors assessment support and findings provided to the evaluation by the US Army Research Institute for the Behavioral and Social Sciences (ARI).

Procedure:

FOE subjects consisted of nine operators, nine mechanics, and nine M9 vehicles performing engineering construction tasks and vehicle maintenance. On-site performance observations by human factors engineers were documented and supplemented by structured interviews and weekly meetings were conducted with the operators and mechanics during the FOE. Questionnaires were administered to the personnel at the end of the FOE. Measurements included data for vibration, noise levels, temperature and humidity.

Findings:

Forty human factors deficiencies and safety hazards were found during the assessment. Many of the deficiencies and hazards can be corrected without major modifications to the vehicle components and by using existing hardware. The deficiencies and hazards include:

1. Vehicle noise levels as high as 115 dB(A).

2. Air temperatures in the driver's station 20°F higher than the ambient air temperatures.

3. Vehicle vibration exposure limits as low as 1 hour and causing the dozer blade to strike the ground and the operators to experience nausea when they use the night vision devices.

4. Inappropriate location of the radio at the rear of the vehicle, making changing frequencies difficult and exposing it to high exhaust temperatures that burn its wires.

5. Insufficient stowage space and insecure locations for stowage.

6. Flood and operating lights that do not conform to the Army Secure Lighting Program and indicator lights that interfere with night operations.

7. Drive shaft failures due to a combination of operator driving behavior and the lack of a torque converter in the drive train.

8. Hazardous procedures for roadwheel removal and replacement.

9. The lack of quick disconnect couplings on fluid lines and identification codes on the numerous fluid lines for rapid reattachment.

10. Numerous deficiencies concerning the driver's station involving: the weight of the hatch, controls and displays that are difficult to use, slippery walking surfaces, and hindered MOPP operations.

Utilization of Findings:

The findings of this research were used by the M9 ACE FOE test directorate as an input to recommendations for future M9 ACE improvements. The findings that addressed the M9ACE FOE data requirements have been integrated into the TCATA final test report: M9 Armored Combat Earthmover (ACE), Follow-On Evaluation (FOE), Final Report, August 1985.

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M9 ARMORED COMBAT EARTHMOVER (ACE)

INTRODUCTION

General

This report describes the human factors assessment of the M9 Armored Combat Earthmover (ACE). The assessment was part of the M9 ACE Follow-On Evaluation (FOE) conducted at Fort Hood, Texas, over a 15-week period from March through June 1985. The FOE was conducted by the US Army Training and Doctrine Command (TRADOC) Combined Arms Test Activity (TCATA) for the US Army Operational Test and Evaluation Agency (USAOTEA). The human factors assessment support was provided to USAOTEA by the US Army Research Institute for the Behavioral and Social Sciences (ARI), Fort Hood Field Unit.

Description

Figures 1 and 2 show the M9 ACE. The M9 is a tracked, armored, and amphibious earthmover designed to perform engineering construction tasks. The M9 will be used to support light or heavy forces on an integrated battlefield. The M9 is designed to provide light armor protection for the operator and key vehicle components in addition to chemical agent protection for the operator. It is designed to negotiate cross-country terrain, to travel at 30 mph on level terrain, and to swim at 3 mph. Like other combat vehicles, the M9 was designed to perform mobility, countermobility, and survivability tasks.

The M9 ACE has a unique suspension system that raises (sprung) for travel and lowers (unsprung) for earthmoving. The suspension can also be adjusted to tilt forward for dozing or to one side or the other for specialized digging. The M9 can be used for bulldozing, rough grading, scraping, and hauling (earth or cargo). The specialized engineering tasks it was designed to perform include: constructing tank ditches, combat vehicle fighting positions, combat roads, POL berms, and for breaching obstacles. Moreover, the vehicle was designed to be operated by a single operator.

The specialized features of the vehicle include:

1. Cummins V903C, 4-stroke cycle diesel engine,
2. PACAR planetary winch having 30,000 pounds of capacity,
3. Front cargo bowl with ejector blade to eject earth from the bowl,
4. Raisable dozer blade and apron to expose a scraper blade and to provide access to the bowl,
5. Clark transmission with six forward and two reverse speeds,
6. Radio, model AN/VRC-64,
7. Driver station heater and NBC gas particulate filter,
8. Smoke grenade launcher,
9. Removable canvas canopy over the driver's station.

Figure 1. Two M9 vehicles, side view.

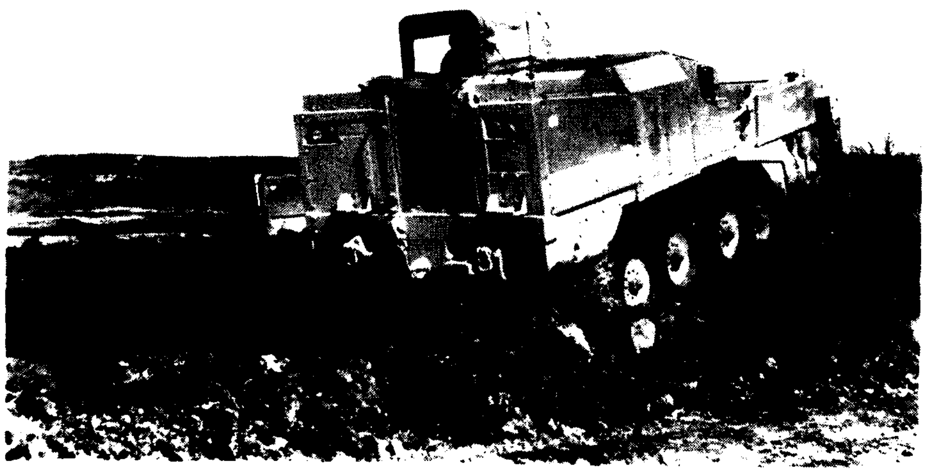


Figure 2. The M9 ACE, rear view.

Table 1 lists selected vehicle specifications for the operator's manual (TM 5-2350-262-10).

Table 1

Selected Vehicle Specifications

EQUIPMENT DATA

GENERAL

Weight, Combat Loaded	34,8000 pounds (15,785 kilograms)
Weight (less driver, fuel and OVE)	33,800 pounds (15,332 kilograms)
Length	20 feet, 6 inches (6.15 meters)
Height (windshield stowed)	8 feet, 11 inches (2.72 meters)
Width (blade extensions removed)	9 feet, 2 inches (2.79 meters)
Ground Pressure	9.0 psi (62.1 kPa)

LAND PERFORMANCE

Maximum speed	30 mph (48 km/h)
Trench Width	5 feet, 2 inches (1.57 meters)
Vertical Wall	1 foot, 6 inches (45.7 centimeters)
Tilt Dozing	5 degrees
Side Slope Limit (curb weight)	20%
Side Slope Limit - with 4000 pound (1.814 kilograms) load	30%
Drawbar Pull	30,000 pounds (13,608 kilograms)
Bowl Capacity	8.7 cubic yards (6.7 cubic meters)
Fording Depth	36 inches (91.4 centimeters)
Turning Radius (geared steer model)	45 feet (13.72 meters)
Turning Radius (clutch brake model)	pivots
Angle of Approach and Departure (maximum)	28 degrees

WATER PERFORMANCE

Speed	3 mph (4.8 km/h)
Bilge pump	345 gpm (1,305.963 lpm)

CAPACITIES

Fuel tank	146 gallons (552.668 liters)
Engine Oil, Dry	38 quarts (35.961 liters)
Radiator Capacity	79 quarts (74.815 liters)
Transmission, Steer Unit, Transfer Case, Oil Cooler and Lines:	
Dry	78 quarts (73.815 liters)
Final Drives	4 quarts (3.785 liters)
Hydraulic Oil Tank	
Dry	128 quarts (121.133 liters)

Objective

The objective of the human factors assessment was to identify man-machine interface, safety, task performance, and operator literature deficiencies requiring attention or correction. The outcome of the assessment is to document human factors engineering deficiencies in order to improve the M9 ACE and its components. The assessment found several deficiencies on the M9 ACE. Most deficiencies may be corrected without unreasonable expense and may remain within the vehicle's configuration constraints. Deficiencies, such as the extremely high temperatures found in the operator's compartment and the need for an NBC microclimate system, may involve expensive modifications. However, eliminating the deficiencies will prevent the severe deterioration of the vehicle's performance that results from the incapacitation of the operator.

Background

Early prototypes of the M9 ACE underwent engineering and service tests during the 1960s. The Development Acceptance In-Process Review referred the program to an Army scientific advisory panel ad hoc commmittee in 1969 due to numerous reliability problems found in the early prototypes. The committee recommended that satisfacatory reliability be demonstrated prior to accepting the vehicle for production. At the completion of a design evaluation, an advanced production engineering contract was awarded in December 1971 for the fabrication of four vehicles and corrections of the reliability problems. The contractor, Pacific Car and Foundry Company (PACAR) completed the fabrication and each vehicle completed a 100-hour shakedown test at the contractor's plant in January 1975. From September through December 1975, two vehicles underwent a field evaluation at Fort Hood, Texas. Testing by the US Army Test and Evaluation Command (TECOM) was completed in August 1976. The prototype vehicles had not yet demonstrated sufficient reliability and performance for procurement by the Army.

A First Article - Initial Production Test (FA-IPT) was conducted from April through September 1984. The purpose of the FA-IPT was to verify whether deficiencies on the M9 had been corrected by production changes when it was manufactured according to the production technical data package. Testing was done on four vehicles. One vehicle was subjected to performance tests, the remaining three vehicles were subjected to 600 hours each of endurance operation. The final report of the FA-IPT (TECOM, 1984) was the first test report concerning the M9 that contained extensive human factors engineering and safety data. The findings of the FA-IPT are referenced in this report for the appropriate deficiencies identified during the present FOE. The topic of the major human engineering deficiencies from the FA-IPT included:

1. high vehicle noise levels up to 115 dBA,
2. high vehicle vibration,
3. poor visual coverage of terrain features,
4. poor ventilation,
5. poor ingress to and egress from the driver's station,
6. excessive force required to close the hatch,
7. inappropritе separation of the control handles,
8. poor lighting for night operations,
9. poor access to several PMCS maintenance checkpoints.

METHOD

Operators and Vehicles

Table 2 summarizes the operators' and mechanics' biographical data. Nine operators, nine mechanics, and M9 ACE vehicles were tested. Two of the nine operators were alternates and operated vehicles when any of the other seven operators were unavailable. Likewise, two of the nine M9 vehicles were designated as extras for spare parts or to be used if any M9 became completely inoperable. All operators and mechanics had completed the new equipment training (NET). Data provided by the two alternate operators were included in the assessment. The alternate operators had completed the NET and had completed at least three weeks of M9 operations before the end of the test.

Ten mechanics were used to support the M9 vehicles. However, one mechanic was unavailable when the questionnaires were administered. All mechanics had previous experience at maintaining D7 earthmovers.

Table 2

Summary of Biographical Data

	Operators	Mechanics
Number assigned to test	9	9
Sex		
Male	9	8
Female	0	1
Age		
Mean	20.7 years	26.2 years
Range	19 to 25 years	20 to 35 years
Time in service		
Mean	1.3 years	7.1 years
Range	10 to 30 months	1 to 14 years
Rank (number of)		
E2	2	0
E3	5	2
E4	2	3
E5	0	2
E6	0	2

Assessment Materials

Questionnaires and structured interviews were developed for the M9 ACE FOE and are contained in Appendix A. The M9 operators' questionnaire was designed to investigate human factors considerations pertaining to the features of the M9 ACE. The structured interviews, however, were designed to investigate considerations pertaining to controls and displays, safety hazards, and the tasks performed by the M9 ACE. The M9 mechanics' questionnaire was designed to investigate human factors considerations pertaining to the maintainability of the vehicle. Interviews were conducted with mechanics; however, the interviews were unstructured due to the unpredictability of required maintenance.

The operators' questionnaire contained 43 questions and many questions required responses to several sub-items to respond to. The mechanics' questionnaire contained 113 questions with many fewer sub-items than the operators' questionnaire. Two 5-point rating scales and a Yes/No checklist were used. One scale had descriptors and scale values ranging from "very easy" (5) to "very difficult" (1), while the other scale had values ranging from "very adequate" (5) to "very inadequate" (1). The Yes/No checklist was used to identify hazards and maintenance difficulties associated with vehicle components. All items had sections for respondent comments or to indicate that a question was not applicable to them or not observed by them. The types of scales used were limited to two similar scales requiring the same type of response in order to:

1. simplify and limit the required length of the questionnaire instructions,
2. simplify and limit the type of required responses,
3. eliminate the need to display a scale for each question and to decrease the page space required to display several scales,
4. simplify and standardize page format.

The structured interviews were developed using a Yes/No checklist format with space to record interviewee comments. The checklists were used to guide the interviews and also allowed the interviewees to make any other comments that they desired. Because of the variety of engineering construction tasks performed by the M9, a separate structured interview was conducted for each type of major task performed during the FOE. (The interviews focused on the procedures specific to the tasks performed and the equipment used.) The major engineering construction tasks performed during the FOE were:

1. constructing tank ditches,
2. constructing combat vehicle fighting positions,
3. constructing combat roads,
4. constructing POL berms,
5. reducing craters,
6. breaching tank ditches,
7. breaching wire obstacles,
8. amphibious operations,
9. safety hazards,
10. controls and displays,
11. PMCS maintenance.

Assessment Procedures

Figure 3 shows the sequence of M9 ACE human factors assessment activities. Initial coordination meetings were conducted with the TCATA test officer and data manager in February 1985. The initial scope of the test was discussed and it was recognized that the design of the data collection materials would have to account for the variety of combat engineering tasks to be conducted. The human factors assessment data collection efforts were then coordinated with the on-site test data collectors. A "spot-safety report" was developed and used by the on-site test data collector assigned to record data for each of the M9 vehicles.

Observations of the M9 ACE and the operators performing combat engineering tasks during the NET began in February 1985. Operator PMCS maintenance was also observed during the NET. Once phase II of the test began and actual test operations were being conducted, M9 ACE operations were observed three out of five days and for special events such as amphibious maneuvers.

Weekly meetings of the performance Data Analysis Group (DAG) were attended. The purpose of attending the meeting was to inform the eight member group of significant findings of the human factors assessment, to act as an advisor to the group, and to review data that may have been pertinent to the human factors assessment. Several performance DAG members also met with the Reliability, Availability and Maintainability (RAM) DAG. Thus, by informing the performance DAG members of significant findings, the information was disseminated to members of the RAM DAG.

Weekly health and safety meetings were conducted with the M9 ACE operators. The meetings were used to monitor for the effects of safety hazards identified in the FA-IPT and reported by the operators early in the test. Medical surveillance urology tests were conducted for hematuria and dehydration. The operators also discussed the construction tasks performed during the week and stated whether they had noticed any potential hazards.

Twice during the test, serious potential health and safety problems were identified as a result of meetings with the operators. Immediate health and safety reviews were conducted with key test personnel and Army specialists trained in the problem area. The potential health and safety problems were excessive vibration and noise. Medical surveillance testing was initiated and conducted by MEDDAC personnel in order to detect injury to the operators from vibration. Additional training by a specialist from the Army Chemical School was provided to the operators concerning the proper donning of personal protective clothing and head gear to reduce noise. Vehicle vibration and noise are discussed in the Results section of this report.

Structured interviews were conducted on site following the completion of the engineering construction tasks. Operators were interviewed individually on their M9 vehicles. Each interview lasted approximately 15 minutes.

Questionnaires were administered during the last week of the test in June 1985. The questionnaires were administered to the nine operators and nine mechanics in a classroom. A human factors engineering specialist was present throughout the session to answer any questions from the respondents. The questionnaire session lasted one hour.

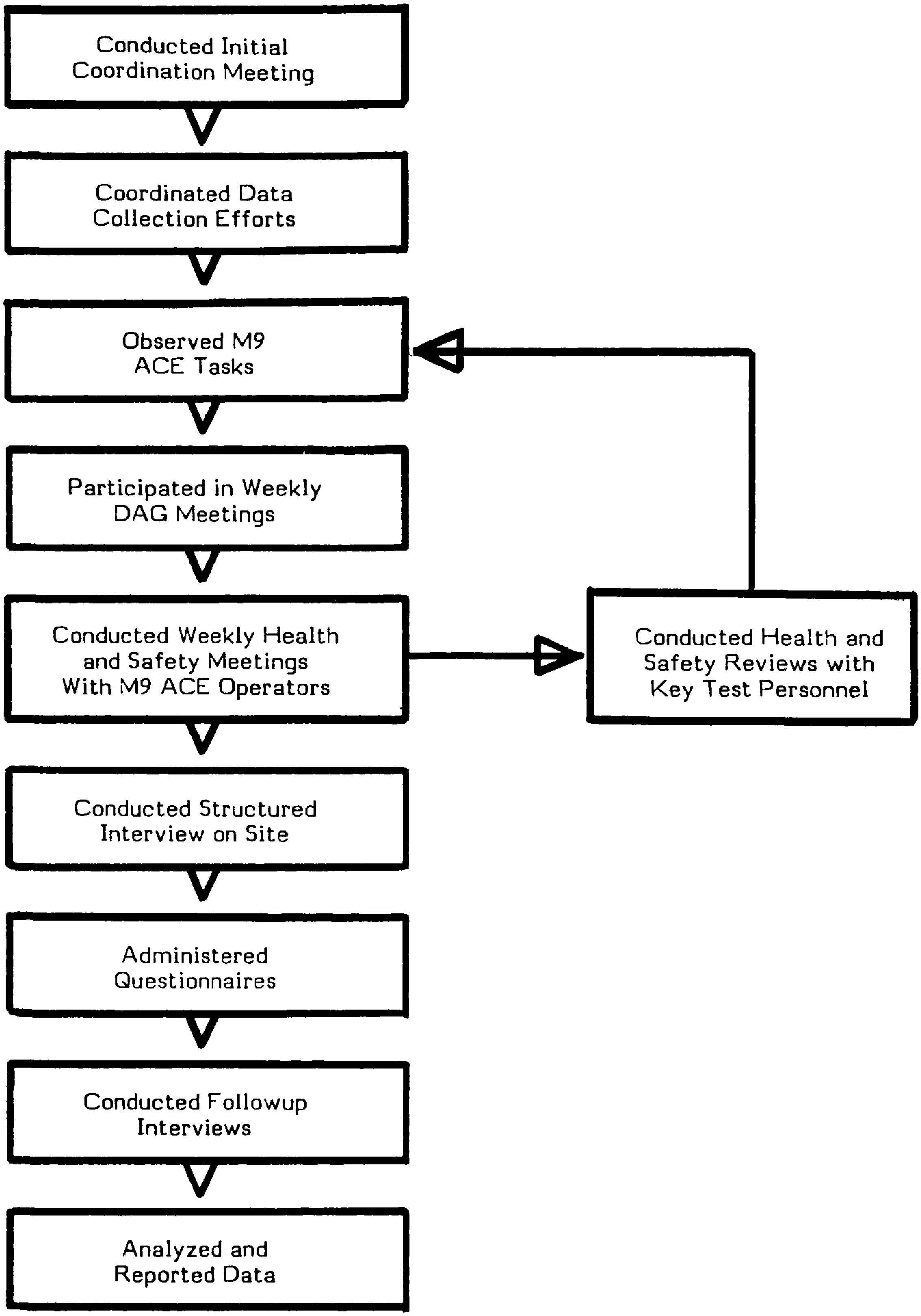


Figure 3. Sequence of the M9 ACE human factors assessment activities.

Followup interviews were conducted during the week of vehicle technical inspections after a preliminary analysis of the questionnaire data was performed. The interviews were used to:

1. pursue information leads suggested by the data,
2. assure proper interpretation of the questionnaire data,
3. assure that no issues of concern were omitted.

Data were analyzed and reported upon completion of the site visits. Since the purpose of the assessment was to find human factors deficiencies and safety hazards, only deficiencies and hazards are reported. Findings of the human factors assessment contained in the Results sections of this report also were presented in the human factors and safety sections of the FOE final report (TCATA, 1985).

A deficiency was reported if:

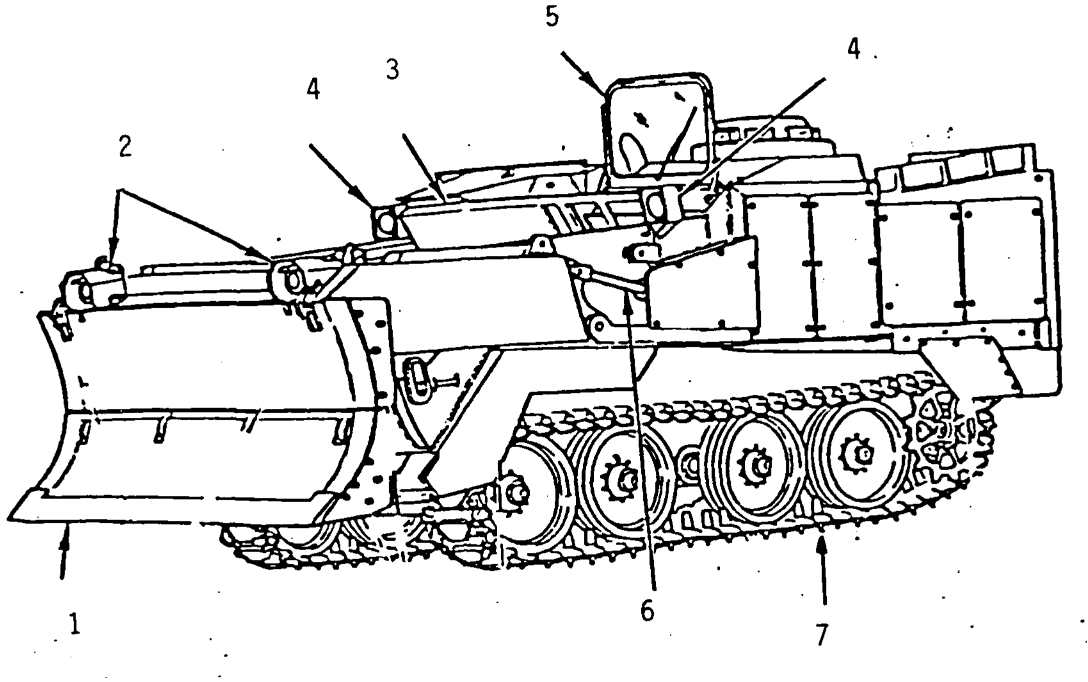
1. Questionnaire items received a mean (M) rating of 3.5 or less (the rating intervals were: very inadequate, 1 to 1.5; inadequate, 1.6 to 2.5; borderline, 2.6 to 3.5; adequate, 3.6 to 4.5; very adequate, 4.6 to 5.0. Rating intervals for very difficult to very easy were similar). Omitted responses or responses indicating that the item was not applicable or not observed by the respondent are not included in the tabled data as these responses do not contribute much to understanding the data. The number of omitted and not applicable or not observed responses can be determined from the number of responses for other scale categories.

2. Human factors problems were judged by the human factors specialist to significantly degrade system performance if it:

a. increased times to perform tasks,
b. contributed to operator error.
c. contributed to operational delays,
d. caused injury,
e. caused equipment damage.

RESULTS

Figure 4 shows the location of the major human factors engineering deficiencies and safety hazards found on the M9 ACE. The deficiencies and hazards are described in the sections that follow for M9 operations and M9 maintenance. Categories such as a description of the deficiency (or safety hazard), the implications for the operator and the equipment, other affected tasks and equipment functions, and potential solutions are used to organize the information.



1. APRON AND DOZER ASSEMBLY. The operator must unsafely crawl beneath the dozer blade in order to prepare it for folding.
2. HEADLIGHTS. The lights do not conform to the Army Secure Lighting Program.
3. EJECTOR. There is no ejector blade lockout device to prevent its being retracted when personnel work in the bowl. The ejector cylinder (not shown) must be removed before other major components can be removed.
4. FLOODLIGHTS. The lights are frequently broken by collisions with trees.
5. WINDSHIELD. The windshield is frequently broken by collisions with trees.
6. APRON CYLINDER. The lubrication points are blocked by an armor panel.
7. TRACK. The track pads frequently wore out and may have increased vehicle vibration.

Figure 4. Locations of the major human factors engineering deficiencies and safety hazards found on the M9 ACE. The drawings are from the Operator's Manual, Armored Combat Earthmover (ACE), M9 (TM 5-2350-262-10), Headquarters, Department of the Army, February 1984.

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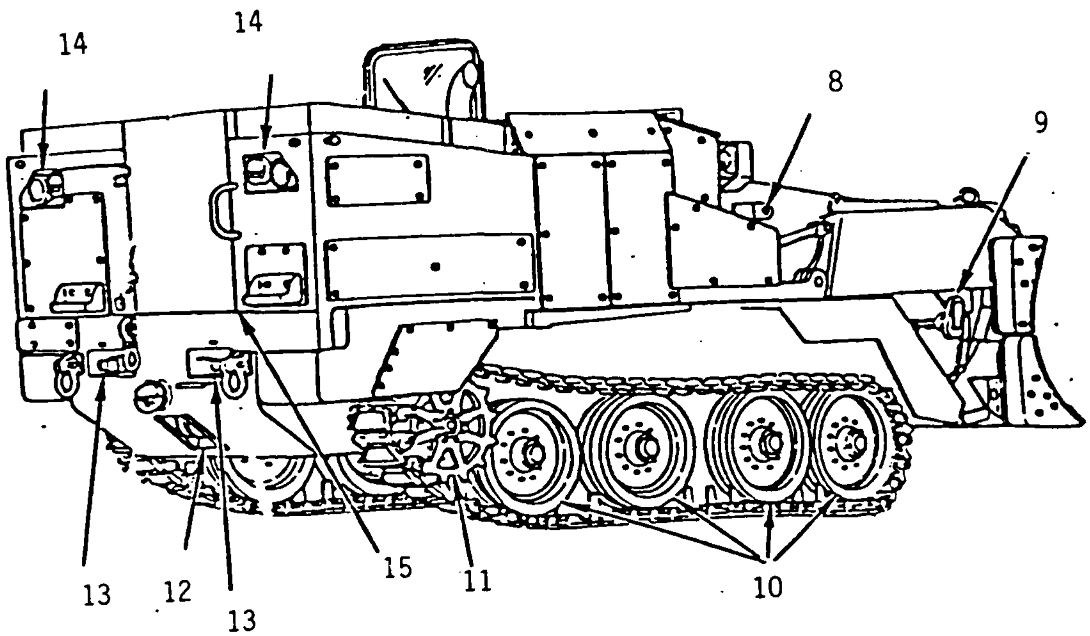
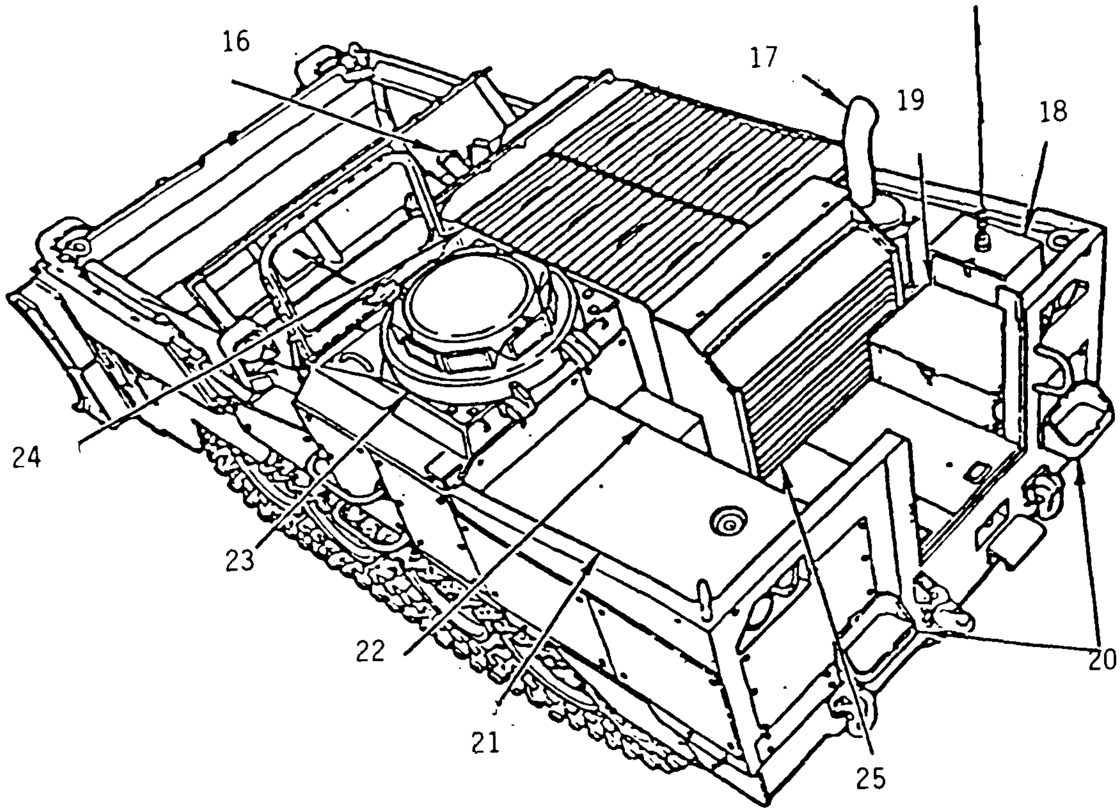


8. UPPER APRON LOCK PINS. Pin openings must be perfectly aligned in order to insert the pin. Two people are required to perform the task.
9. LOWER APRON LOCK PIN. The pins were difficult to remove due to the tightness of their fit. The pins were deformed by operators hammering them in and out of position.
10. ROADWHEELS. Rubber broke off the roadwheels and may have increased vehicle vibration. Roadwheels are hazardous to remove and replace.
11. FINAL DRIVES. The final drives must be drained in order to check the fluid levels.
12. WINCH ASSEMBLY. The winch is under capacity. The wire rope broke frequently. The wire rope wraps unevenly on the drum. There is no winch brake.
13. REAR STEP. The step was crushed in collisions.
14. TAILLIGHTS. The lights do not conform to the Army Secure Lighting Program.
15. REAR DOOR. The door is difficult to lift when installing or stowing it.

(Figure 4, cont'd)



16. SMOKE GRENADE LAUNCHERS. The launchers are difficult to load from the sloped roof of the engine housing.
17. MUFFLER. Debris trapped in the muffler well was caught on fire. The radio cables were burned by heat generated from the muffler.
18. RADIO. The radio is located too far from the operator. The radio frequencies cannot be changed by the operator in the driver's station.
19. BATTERY BOX. The battery, beneath the radio, is difficult to inspect for low fluid levels and loose cables. The heat generated by the radiator and muffler reduced the battery fluid levels.
20. JERRY CAN BRACKETS. The brackets were crushed by collisions with objects to the rear of the vehicle.
21. UNSECURE STOWAGE AREA. Items were frequently stacked on the fuel tank.
22. HYDRAULIC OIL TANK. The hydraulic fluid used in the vehicle is flammable oil rather than unflammable oil.
23. DRIVER'S STATION. The hatch cannot be safely opened or closed. Vehicle noise ranges as high as 115 dB. Station air temperatures were 20°F greater than ambient air temperatures. Vision block position resulted in blindspots. Night vision devices caused nausea. Ingress and egress of the station is difficult due to slippery walking surfaces and a lack of steps and handholds above the rear deck.
24. & 25. INTAKE AND EXHAUST GRILLES. The upper intake grilles are heavy and there is no place for the operators to stand when removing them. The rear exhaust grilles exhaust heat that burns items stowed on the rear deck.

(Figure 4, cont'd)

M9 Operations

Deficiency: Vehicle Noise.

Description of the Deficiency: Vehicle noise levels were measured and documented in the First Article-Initial Production Test (FA-IPT, November 1984, Report No. USACSTA-6102). The final report concluded that:

> Test item operators were exposed to noise levels above the safe limit for unprotected ears during all phases of moving and stationary testing. Several octave band noise levels exceeded the protective limits of the DH-132 helmet. The maximum design limits of Category A (table 2 of MIL-STD-1474B(MI) for steady-state noise and the maximum design levels of Category B (table 2 MIL-STD-1474B(MI) for electrically aided communications are exceeded. The noise levels at the operator's position are judged to cause a Category II A safety hazard resulting in a deficiency.

Table 3 lists the maximum A-weighted, steady-state noise levels measured during the FA-IPT. The noise levels exceeded the 85 dB(A) criterion for safe unprotected hearing and the upper limit 105 dB(A) at 1000 Hz criterion for safe protected hearing (MIL-STD-1474B(MI), paragraph 5.1.1.2e). The FA-IPT report recommended that "a complete analysis of the problem involved and the possible hearing damage that may result from the vehicle operation must be evaluated." Moreover, MIL-STD-1474B (paragraph 5.1.1.2e) states that: "...in no case will a project proceed beyond the prototype stage until such a decision has been made on this basis." However, a complete analysis of the noise levels for all centerband frequencies and the potential for hearing damage has not been conducted.

Table 3

M9 Steady-State Noise Levels

Vehicle operation	Hatch	dB(A)
Box filling	Open	114
Dozing	Open	110
Backdragging	Open	115
Paved highway	Open	113
Travel (43 km/hr)	Closed	112

Six operators reported in a preliminary health and safety questionnaire that the vehicle noise was causing ringing in their ears and their heads to ache. Moreover, six operators reported that the noise was loudest when they wore their MOPP mask (M25) and hood. The MOPP hood interfered with the protection offered by the CVC helmet by:

1. Bunching above the helmet chin strap and causing the strap to unsnap when the operator turned his head to look to the rear.

2. Keeping the helmet earcups from forming a seal around the operator's ear.

Figure 5 shows the MOPP hood bunching above the CVC helmet chin strap. The test directorate took several steps to correct and monitor the problem, including:

1. Providing additional training to the operators by an Army Chemical School specialist. The training included the proper methods for donning the MOPP mask and hood.

2. Changing the operator's earplugs from the issued hard rubber plugs to soft foam plugs.

3. Performing audiograms of the operators' hearing.

Figure 5. The MOPP mask bunching beneath the CVC helmet chin strap.

Table 4 lists the hearing losses suffered by the operators during the second half of the test. Baseline audiograms, performed by Army MEDDAC personnel, were not measured prior to the start of the test, but were measured at the beginning and end of a 54 day period of time after the operators complained of ringing ears and headaches. End-of-test audiograms were measured after the last week of the test, during the week of vehicle technical inspections. Data from the two audiograms indicated that one operator suffered a significant hearing loss and five operators suffered mild hearing losses. Whether the hearing loss is permanent or a temporary threshold shift has not been determined by MEDDAC. Three operators experienced no hearing loss. However, the three operators had little exposure to the vehicle noise during the second half of the test because their vehicles were undergoing lengthy repairs.

Table 4

Audiogram Results Indicating a Hearing Loss

	Audiometry*											
Freq.	Left ear						Right ear					
Hz	500	1K	2K	3K	4K	6K	500	1K	2K	3K	4K	6K
Operator's vehicle number**	Hearing loss in dB											
M903	20	0	0	10	20	0	15	0	0	5	5	0
M905	5	5	0	5	0	0	10	10	0	0	15	0
M906	5	10	0	0	0	5	5	10	5	0	5	0
M901	0	0	0	5	5	0	0	0	0	5	10	0
M902	0	5	0	0	0	0	0	0	5	0	0	0
M907	0	0	5	5	10	0	0	0	0	0	10	0

*A hearing loss of 20dB or greater was defined on form DD-2216 as significant.
**The operators' names were kept confidential for reporting purposes.

Implications for the Operator and the Equipment: Short term exposure to the operating vehicle for approximately 60 days is likely to cause hearing injury. The operators were required to wear double hearing protection and they wore it correctly during the latter half of the test. However, the operators still suffered hearing losses.

The amount of hearing loss among the operators varied. This may have been a result of the frequent number of vehicle breakdowns during the second half of the test which reduced exposure to the equipment for some of the operators. The amount of hearing loss the operators may have suffered during the first half of the test cannot be determined. Yet, the hearing loss may have been significant due to the high levels of noise, the problems with the CVC helmet, and the type of earplugs used. This unknown amount of hearing loss should be considered when estimating the full extent of the injury caused by vehicle noise.

The M9 has a distinct noise signature which can be heard when it travels with an armored unit. Well prepared enemy obstacles usually will be defended by a threat force. Detection of the approach of the M9 in an armor unit may unfavorably influence the tactical positioning of the threat force. The M9 may become a high priority target for the enemy.

Potential Solutions: The specific vehicle components contributing to the greatest amounts of noise should be identified and means of reducing the noise should be directed primarily at the noisier vehicle components. A variety of solutions to the noise problem should be used. However, modifications that reduce only a small portion of the noise since the total level of noise is a composite of noise from many components. Several approaches might be used, including:

1. Adding insulation (heat and sound absorbing material) between the engine and operator's compartment (see Deficiency: Driver Station Temperature and Ventilation, pg 17).

2. Directing the engine air intake grilles to the right and away from the driver's station in order to deflect engine noise.

3. Adding insulation (sound absorbing material) close to noisy components including the engine, transmission, and hydraulic valve banks.

4. Improving the efficiency of the muffler and placing the exhaust pipe farther from the driver's station.

Deficiency: Driver Station Temperature and Ventilation.

Description of the Deficiency: Table 5 lists the driver station air temperatures averaged for three of the vehicles. The air temperatures averaged as high as 107.3°F (41.9°C) during a day with an ambient temperature of 85.3°F (29.6°C) and a completely overcast sky. All temperatures and humidities measured in the driver's station exceed the exposure limits described as intolerable in the ASHRAE effective temperature scale (ASHRAE Handbook, 47, chap 7, fig. 16, 1972) and are in the exposure limits of 30 to 60 minutes for the limited tolerances found in MIL-STD-1472C (section 5.8, fig 39, 1981). Moreover, medical surveillance tests found the operators to be dehydrated; an effect of exposure to high temperatures.

Table 5

Temperature and Humidity Measurements of the Driver's Station

Condition	Mean F°	Wet Bulb (C°)	SD*	Mean F°	Dry Bulb (C°)	SD*	Humidity Mean %
Ambient**	76.3	(24.6)	0.58	85.3	(29.6)	0.57	68
Hatch open, vehicle standing	83.0	(28.3)	4.35	98.0	(36.6)	0.00	55
Hatch open, vehicle moving	81.0	(27.2)	2.64	98.0	(36.6)	2.00	59
Hatch closed, vehicle standing	85.0	(29.4)	0.00	101.0	(38.3)	3.60	52
Hatch closed, vehicle moving, ventilation on	84.6	(29.2)	0.57	105.3	(40.7)	0.57	46
Hatch closed, vehicle moving, ventilation off	86.0	(30.0)	1.73	107.3	(41.9)	3.05	38

*SD, standard deviation.
**Weather factors included: 10 to 15 mph variable wind speed, SE wind direction and complete overcast (no direct sunlight).

Table 6 lists the operators' responses concerning the adequacy of the driver station ventilation. Table 7 shows the operators' responses concerning the adequacy of the driver station temperature and ventilation while they wore MOPP IV uniforms. In hot weather without MOPP gear, the operators rated the ventilation as marginal (Means 3.1 and 2.8) when the hatch was open. However, when the hatch was closed, and ventilation was provided by the ventilation ports, the operators rated the ventilation as inadequate (Means 2.3 and 1.95). Moreover, the operators rated the temperature and ventilation as inadequate (Means 2.3 and 2.1) during MOPP IV conditions. The ventilation is provided through two 2 in (4.8 cm) diameter, circular openings. The openings are positioned in the cab walls on the driver's right and left. The circular ports can be closed. Additional air flow can be provided by turning on the heater fan, with or without heat (the fan was on when temperatures were measured in the driver's station with the hatch closed and ventilation ports open).

Table 6

Responses From M9 ACE Operators Concerning
Adequacy of Ventilation (Air Flow)

Condition	Number of responses: Very adeq 5	Adeq 4	Marginal 3	Inadeq 2	Very inadeq 1	Mean	SD
Cool Weather							
Hatch open, vehicle moving	2	6	0	0	0	4.2	0.46
Hatch open, vehicle standing	1	7	0	0	0	4.1	0.35
Hatch closed, vehicle moving	1	4	2	1	0	3.5	1.20
Hatch closed, vehicle standing	1	3	3	1	0	3.5	0.92
Hot Weather							
Hatch open vehicle moving	1	3	2	1	1	3.1	1.45
Hatch open, vehicle standing	1	0	4	2	1	2.8	1.16
Hatch closed, vehicle moving	0	1	2	3	2	2.3	1.03
Hatch closed, vehicle standing	0	0	2	2	3	1.95	0.89

Table 7

Adequacy of Cab Temperature and Ventilation for Comfort During MOPP IV Conditions

	Number of responses						
Condition	Very adeq 5	Adeq 4	Mar-ginal 3	Inadeq 2	Very inadeq 1	Mean	SD
Hatch open, vehicle moving	0	0	4	2	2	2.3	0.89
Hatch open, vehicle standing	0	0	3	2	2	2.1	0.89

Implications for the Operator and the Equipment: Exposure to high temperatures for periods of more than one hour may severely affect the operator's health and performance. Exposure to high temperatures and stress such as in combat, NBC conditions, or during hasty defense preparations, may have synergistic effects causing the operator to become ill quickly. Heat stress alone can lead to impaired mental judgment, deteriorated physical work performance, hyperplexia, and heat stroke. The productivity of the vehicle will decrease as the operator's work performance deteriorates.

Other Affected Tasks and Equipment Functions: Figure 6 shows an operator dressed in his MOPP IV uniform. Operators are likely to suffer heat stroke during NBC conditions while they are wearing their MOPP uniforms in hot weather. The MOPP mask gas particulate filter blows air on the operator's face. However, the air from the gas particulate filter is not cooled or controlled for temperature. The MOPP mask (M25) has no provision for drinking water.

The human need for drinking water during periods of high temperatures and heavy work can be as high as three gallons per person per day. The M9 had no secure stowage area or containers for water. The M9 should include stowage for 10 to 15 gallons (38 to 57 l) of water in order to supply the operator during extended operations. A portion of the stowage for water should be provided in the driver's station.

Potential Solutions: Add an NBC microclimate system to the vehicle which includes the cooling vest and controlled air temperatures. A positive air pressure should be maintained in the driver's station during closed hatch operations. The positive pressure should be provided by fans and filtered air drawn from outside of the vehicle. The current ventilation ports draw air from inside of the bowl and ejector blade roller guide housing. This air is often filled with dust and radiated heat from the engine. The ventilation ports should provide air from outside of the vehicle.

Figure 6. The operator dressed in MOPP IV uniform.

Deficiency: Vehicle Vibration.

Description of the Deficiency: Table 8 lists the whole body vibration exposure times for M9 operators. The exposure times were reported in the Final Report, First Article-Initial Production Test (November 1984, Report No. USACSTA-6102). The vibration was measured for the centerband frequencies corresponding to those specified by MIL-STD-1472C beginning at 1 Hz. The table indicates that the exposure limits (to avoid injury to the operator) were four hours or less for over 50 percent of the 41 trials. The fatigue and decreased proficiency limits (to avoid deteriorating system performance) were less than 2.5 hours for over 70 percent of the trials. The M9 ACE mission will include extended travel with armored units. Thus, the low exposure limits of one hour for cross-country travel (bowl empty) and four hours or less for secondary road travel (bowl empty) should indicate that vehicle vibration could seriously impact on the operator during travel. The medical surveillance tests found no significant findings of hematuria (blood in the urine) for the operators. However, several other problems developed during the test which could increase the effects of vehicle vibration or may have resulted from vehicle vibration.

Figures 7 and 8 show the rubber worn off of the roadwheels and track pads. As many as 187 roadwheels and over 200 track pads (an average of 27 roadwheels and 38 track pads per vehicle) were replaced during the test. As large portions of rubber are worn away, creating an uneven surface, vibration may have increased significantly. Moreover, during extended operations, repair and replacement of these components are less likely to occur.

Table 9 lists the operators' responses concerning the adequacy of the driver's seat for protection from vibration. The operators rated the seat as marginal (Mean 3.1). Moreover, four operators reported that the vinyl on the operator's seat cracked and the foam cushion deteriorated. The operators reported that the damaged seats irritated their backs as the vehicle bounced.

The effect of the vehicle vibration in decreasing the operators' proficiency appeared when the operators used night vision devices (see Deficiency: Night Vision Devices, pg 31). The operators reported experiencing nausea and occasionally vomitting when using the devices. The operators reported that their heads bounced continuously and the bouncing also resulted in image smear in the night vision device. A representative of the Night Vision Laboratories reported that this problem has not been reported for any other military vehicles when the night vision devices were used.

Table 10 lists the number of operators reporting that the vehicle bounced forcibly while traveling. The low frequency bouncing created a safety problem when the dozer blade struck the ground, jarring or throwing the operator forward (see Deficiency: Dozer Blade Clearance, pg 90). The vehicle rocks backs and forth as it travels across rough terrain at all speeds. The rocking is a result of the weight of the rear of the vehicle and a suspension system that appears to have difficulty compensating for the rearward center of gravity. Thus, the vehicle must slow its rate of travel and avoid uneven terrain. The operators reported traveling with the ejector blade forward or with dirt in the bowl in order to smooth out the ride.

Table 8

Whole Body Vibration Exposure Times*

Run No.	Speed (mph)	Course[a]	Bowl	Exposure Limit[b]	Fatigue-Decreased Proficiency	Reduced Comfort	Data Validity Check	
001	5	XC No. 3	Empty[c]	8	2.5	16 min	-	
002	10	XC No. 3	Empty	1	25 min	<1 min	Shock present in data (V,L)	
003	15	XC No. 3	Empty	1	1 min	<1 min	Data noisy (V)	
004	20	XC No. 3	Empty	1	25 min	<1 min	Shock present in data (V,L)	
005	5	SA	Empty	4	1	<1 min		
006	10	SA	Empty	4	2.5	1 min		
007	15	SA	Empty	2.5	1	<1 min		
008	20	SA	Empty	4	2.5	1 min		
009	25	SA	Empty	4	1	<1 min		
010	30	SA	Empty	1	25 min	<1 min		
011	32	SA	Empty	2.5	1	<1 min		
012	6	Paved	Empty	16	4	1 hour		
013	8	Paved	Empty	4	1	1 min		
014	10	Paved	Empty	4	1	1 min		
015	12	Paved	Empty	8	2.5	25 min		
016	14	Paved	Empty	16	4	1 hour		
017	16	Paved	Empty	16	4	25 min		
018	18	Paved	Empty	8	4	25 min		
019	20	Paved	Empty	16	4	1 hour		
020	22	Paved	Empty	16	4	1 hour		
021	24	Paved	Empty	4	2.5	16 min		
022	26	Paved	Empty	4	2.5	16 min		
023	28	Paved	Empty	16	4	25 min		
024	30	Paved	Empty	8	2.5	16 min		
025	6	Paved	Full	8	2.5	25 min		
026	8	Paved	Full	8	2.5	25 min		
027	10	Paved	Full	4	2.5	16 min		
028	12	Paved	Full	8	2.5	25 min		
029	14	Paved	Full	16	4	25 min		
030	16	Paved	Full	16	4	1 hour		
031	18	Paved	Full	16	4	1 hour		
032	20	Paved	Full	16	4	1 hour		
033	22	Paved	Full	8	4	25 min		
034	24	Paved	Full	8	2.5	25 min		
035	5	XC No. 3	Full	8	2.5	25 min		
036	10	XC No. 3	Full	4	2.5	1 min		
037	15	XC No. 3	Full	1	16 min	<1 min	Shock present in data (V, L, T)	Data Questionabl
038	18	XC No. 3	Full	1	1 min	<1 min	Shock present in data (V, L, T)	
039	5	SA	Full	2.5	1	<1 min		
040	10	SA	Full	4	1	1 min		
041	15	SA	Full	4	2.5	1 min		

*Data from Final Report, First Article-Initial Production Test (FA-IPT) of M9, Armored Combat Earthmover (ACE). US Army Combat Systems Test Activity, November 1984, Report No. USACSTA-6102.

Figure 7. Deterioration of the rubber on the roadwheels.

Figure 8. Deterioration of the rubber on the track pads.

Table 9

Adequacy of the M9 ACE Driver's Seat for Protection From Vibration

Condition	Number of responses					Mean	SD
	Very adeq 5	Adeq 4	Mar-ginal 3	Inadeq 2	Very inadeq 1		
Seat protection from vibration	0	2	6	1	0	3.1	0.60

Table 10

Number of M9 Operators Reporting Earthmover Forcible Rocking and Bouncing While Traveling

Condition	Number of responses
Cross country	6
On secondary roads	3
On paved roads	0

Implications for the Operator and the Equipment: The M9 ACE seldom traveled for an extended length of time. Most travel occurred on short routes (approximately 5 to 10 miles (8 to 16.1 km)) to and from the assembly area. Thus, the effects of vibration from prolonged travel could not be measured during the FOE. However, the evidence indicates that vehicle vibration may be a serious problem for the operator. Injury to the operators from whole body vibration has not occurred during testing. However, safety problems involving the night vision devices and the dozer blade striking the ground were directly related to vehicle vibration in the ranges of 1.5 Hz or less. The unique M9 ACE suspension and the distribution of its weight are the probable causes of the vibration.

Other Affected Tasks or Equipment Functions: The mission profiles developed for the M9 ACE stated that travel does not exceed 35 minutes for any continuous period and totals approximately two-and-a-half hours for a 10 hour period of operation. However, the mission profiles were arbitrary and developed from an engineering construction point of view. It is unlikely that travel will be limited to 35 minutes when the M9 travels with armored units in peace or in war. In fact, under combat conditions, travel and operation times may easily exceed 10 hours for several days. During combat, night operations and the construction of hasty obstacles and fighting positions, work cannot be stoppped while operators recover from nausea. Nausea is debilitating and will rapidly slow or halt the operator's performance.

Potential Solutions: The full extent of the vehicle and whole body vibration problems have not been determined. The roadwheel and track pad rubber deterioration may increase the vibration levels. Whole body vibration levels of less than 1 Hz have not been measured and the lower levels are most likely to cause motion sickness. However, reducing vehicle vibration would require substantial modification to the vehicle's suspension. Whole body vibration can be partially reduced by adding a suspension device to the driver's seat and adding rubber dampening pads in the frame attachment points to the compartment walls.

Deficiency: Drive Shaft Failures.

Description of the Deficiency: Table 11 shows the M9 ACE operator responses to questions concerning the operation of the transmissions attached to the drive shafts. Six drive shafts broke down during the test, accounting for 40 percent of the maintenance man-hours expended during the FOE. Arguments concerning the causes of the breakdowns include operator abuse and inappropriate design of the equipment. Operators may have abused the equipment, according to some people, if they did not reduce engine RPM before shifting and brake to a stop before shifting into and out of reverse gear. Operators apparently did not reduce the engine RPM before shifting between higher gears and also shifted from forward gear to reverse gear while the vehicle was still moving. However, when the M9 was dozing fighting positions and tank ditches, the vehicle's speed is very slow (estimated by the operators to be 0.5 to 1.0 mph (0.8 to 1.6 kph)) and the resistance of the material being dozed stopped the vehicle quickly without it having to be braked to a stop. Moreover, the operators reported that they did reduce the engine RPM before shifting into and out of reverse gear (note that this is a typical operating method for the D7 and other earthmovers). The transmission and drive shafts on the D7 are assisted by a torque converter that allows the vehicle to be shifted from forward to reverse while the vehicle is moving without damaging either component. The torque converter also increases the vehicle productivity by decreasing the time spent braking.

Table 11

M9 ACE Operators' Responses to Questions Concerning the Operation of the Transmission

Driving behavior when preparing tank ditches or fighting positions	Number of operator responses		
	Yes	No	Sometimes
Shift from forward to reverse while the vehicle is moving?	5	2	1
Have the hand throttle advanced?	0	8	0
Use the footbrake to stop the vehicle?	5	2	1
"Let up on the gas" when shifting gears?	1	7	0
"Let up on the gas" when shifting from forward to reverse and reverse to forward?	8	0	0
Which do you prefer:			
Shifting in and out of reverse without braking?	8	0	0
Braking to a stop before shifting in and out of reverse?	0	8	0

Implications for the Operator, the Mechanic, and the Equipment: The operators will drive the M9 ACE according to their driving preferences and habits. The operators' driving preferences give an indication of the requirements for the design of the transmission and drive shaft.

The M9 operators reported preferring to shift into and out of reverse without braking to a stop for several reasons, including:

1. The abrupt change of direction causes the earth spoil remaining on the dozer blade to drop off at the end of the cut. The operators estimated that the earth spoil remaining in the curve of the blade accounted for as much productivity as 20 percent of the cut.

2. Shifting without braking to a stop allowed the vehicles to dig more rapidly.

3. Braking was fatiguing due to its repetition and the position of the brake pedal.

4. Repeated braking increased the wear of the brakes. One operator felt that this was the reason the brakes on his M9 needed to be replaced during the test.

Removing transmissions to repair drive shafts was a time consuming and complicated task for mechanics. The engine and a large number of hydraulic lines had to be removed in order to gain access to the transmission.

Potential Solutions: Modify the transmission by adding a torque converter. Other less desirable alternatives include:

1. Add a locknut device to the shifting mechanism to prevent the operator from shifting into and out of reverse without braking. (It is predicted that personnel will find a way to modify this solution and make it ineffective.)

2. Train the operators to brake appropriately. (It is predicted that driving behavior learned from the operation of other vehicles will make this solution ineffective.)

Deficiency: Communications.

Description of the Deficiency: Table 12 shows the operators' responses concerning the adequacy of the communications net and radio. Figure 9 shows the position of the radio at the rear of the vehicle. The radio was located above the battery box and behind the muffler and radiator exhaust grilles. The operators rated the radio (Model AN/VRC-64) as marginal to inadequate as a result of several problems, including:

1. The radio is close to the muffler and radiator exhaust grilles, resulting in burned radio wiring.

2. The distance the radio is from the driver's station makes changing frequencies difficult.

3. Using the CVC helmet selector switch jammed the radio.

Table 12

Adequacy of the Communication Net and Radio

Communications from the vehicle	Number of responses: Very adeq 5	Adeq 4	Marginal 3	Inadeq 2	Very inadeq 1	Mean	SD
Using the AN/VRC-64 short range radio	0	1	2	0	2	2.4	1.34
With platoon commander	0	1	2	0	2	2.4	1.34
With company commander	0	1	0	1	1	2.3	1.53
When working alone	0	1	2	1	1	2.6	1.14
When working with combined arms operations	0	2	2	1	1	2.8	1.17
When working at squad or company tasks	0	3	2	1	0	3.3	0.81
When changes in missions are required	0	1	4	1	0	3.0	0.63

Figure 9. The location of the radio box above the battery box and behind the radiator grille.

Operators accidentally jammed the communications net by moving the three-position selector switch on the earcup forward from the OFF position (1) to the transmit position (3). After the operators finished communicating, they would release the switch which snapped back to the intercom position (2). The intercom position on the M9, with its single operator, serves no purpose. The operators did not realize that when the switch was in the intercom position, the vehicle noise and other sounds were transmitted on the communications net. Thus, the net was jammed with vehicle noise.

Implications for the Operator and the Equipment: During combat the operators may need to change and scan radio frequencies. The operator must turn off the vehicle engine (due to the high temperatures behind the radiator housing) and leave the driver's station to access the radio. Moreover, the radio cable, mounted beneath the rear deck and close to the exhaust system, was burned or damaged during repairs.

Other Affected Tasks and Equipment Functions: The vehicle batteries are positioned beneath the radio. There is approximately 12 in (30 cm) between the radio mount and battery box. The operator cannot see into the battery fill ports or inspect the connecting cables due to the small size of the opening. The battery fluid levels needed to be checked daily during the test due to the drying effect of the high temperatures behind the radiator housing.

Potential Solutions: The radio should be mounted in the driver's station. Additional space in the driver's station might be provided by removing the housing for the ejector blade roller guides which is positioned in the lower left side of the station. Removing the housing would be possible by using dual cylinders for the ejector blade (see Deficiency: Inspecting the Ejector Blade Guide Rollers, pg 107). The length of the driver's station might be increased if the hatch was reconfigured and the massive hinge behind the station was eliminated.

Deficiency: Night Vision Devices.

Description of the Deficiency: Six of the M9 operators reported nausea while they used the night vision devices. The night vision periscope (Model AN/VVS-2) and goggles (Model AN/PVS-5) were used at different times during the FOE. The night vision periscope was mounted in the driver's hatch in front of the operator. The night vision goggles were worn on the head and face of the operators. The operators complained of nausea and occasional vomiting while using the night vision periscope throughout the test. However, operators stopped feeling nausea while wearing the goggles during the second week of night operations and reported having become accustomed to the sensations.

The cause of the nausea may result from a complex set of factors. One factor may be the improper focusing of the night vision goggles and its effect on the operator's depth perception. However, M9 operators have reported that their goggles were correctly focused and that the problem also exists when they use the night vision periscope. Another, more complex cause of nausea, may be a combined result of vibration and the position of the operator's cab. The cab is positioned on the left side of the vehicle rather than in the center. This may expose the operator to more "side-to-side" vibration on the operator's y axis than would occur if the cab was centered on the vehicle. The operators complained that the bouncing of their heads made the focusing of their eyes on the image in the periscope difficult. In this case, the operators' heads vibrated out of phase with the persicope which was firmly attached to the hatch.

Table 13 shows the M9 ACE operator responses concerning the adequacy of the night vision goggles and periscope. The M9 ACE operators rated the goggles as adequate and the periscope as inadequate. The operators did not prefer the night vision periscope for several reasons, including:

Table 13

Adequacy of the Night Vision Goggles (Model AN/PVS-5) and Periscope (Model AN/VVS-2)

	Number of responses						
Night Vision Device	Very adeq 5	Adeq 4	Marginal 3	Inadeq 2	Very inadeq 1	Mean	SD
Goggles	1	4	4	0	0	3.6	0.71
Periscope	0	0	4	1	3	2.1	0.99

1. The operator's head vibrated at one frequency while the periscope, firmly attached to the M9 ACE, vibrated at a different frequency. This resulted in an image smear and nausea.

2. The periscope does not provide a field of view to the right, left or rear.

3. The periscope can only be used with the hatch closed.

4. The position of the periscope, approximately 4 in. (10 cm) in front of the operator's face, does not allow enough room between the periscope and rear vision blocks for the operator to turn his head.

The goggles were preferred by the M9 ACE operators for several reasons, including:

1. The operators accommodated to the goggles and did not feel the sensations of nausea after the first week of use.

2. The goggles provided a full field of view as the operators turned their heads.

3. The goggles could be used with the hatch open or closed.

The major benefits of using a periscope in the vehicle for the operator are:

1. It can be used while the operator wears the NBC MOPP mask and hood.

2. It can be locked into the hatch preventing its theft.

The major benefits of using the goggles for the operator are:

1. They can be used with the hatch open or closed.

2. They can provide 360° of visual coverage.

3. The operator can exit the vehicle while wearing the goggles in order to perform other tasks.

Implications for the Operator and the Equipment: Sensations of nausea will decrease the operator's ability to perform tasks. Many times during night operations, operators needed to stop working until they recovered from the nausea. Often they continued their work without using the night vision device.

Other Affected Tasks and Equipment Functions: The night vision periscope presented several difficulties when the operator drove his vehicle. The periscope was locked into a fixed position in the hatch and provided a forward view. Thus, the operator had no view to the rear of the vehicle when it traveled in reverse. Many earthmoving tasks required almost equal amounts of forward and rearward travel. Moreover, as the vehicle turned the operators had difficulty finding the correct direction of travel as their views of where they have been and where they are going are limited and changing. Thus, they lost sight of the visual cues they had been using to direct their driving.

Potential Solutions: The operators preferred to use the goggles rather than the periscope because the goggles, when worn, were part of the operators' visual system. The goggles are probably the night vision device that should be used, especially since nausea must be avoided. A new model of night vision goggles is being developed by the Night Vision Laboratories. The new version of the goggles has a single tube for the objective lenses that extends 3 to 4 in (7.6 to 10.2 cm) from the operator's face. (The new version is approximately 1 to 2 inches (2.5 to 5.0 cm) longer than the current goggles, AN/PVS-5.) If the new model of the goggles is used on the M9, the single tube should not interfere with the use of the vision blocks or strike the vision blocks.

If the hatch configuration is changed (see Deficiency: Driver's Station Hatch, pg 70), and the periscope is used, provide a periscope and mount that:

1. Can be adjusted in height for open and closed hatch operation.

2. Can be adjusted side to side for a greater field of view. (It may be difficult to provide a rearward view.)

3. Is positioned farther away from the operator's face.

The operator may need a head support on the seat to reduce the difference in motion between his head and the periscope.

Deficiency: Ground Surface Visibility.

Description of the Deficiency: The visual coverage of terrain features surrounding the M9 was found to be poor. The Final Report, First Article-Initial Production Test (FA-IPT, November 1984, reported that the operators' visual coverage was obstructed by vehicle components in all directions, except to the left. The driver's station is positioned on the left side and middle of the vehicle. The position of the driver's station and the height of the vehicle combine to create large blindspots surrounding the vehicle.

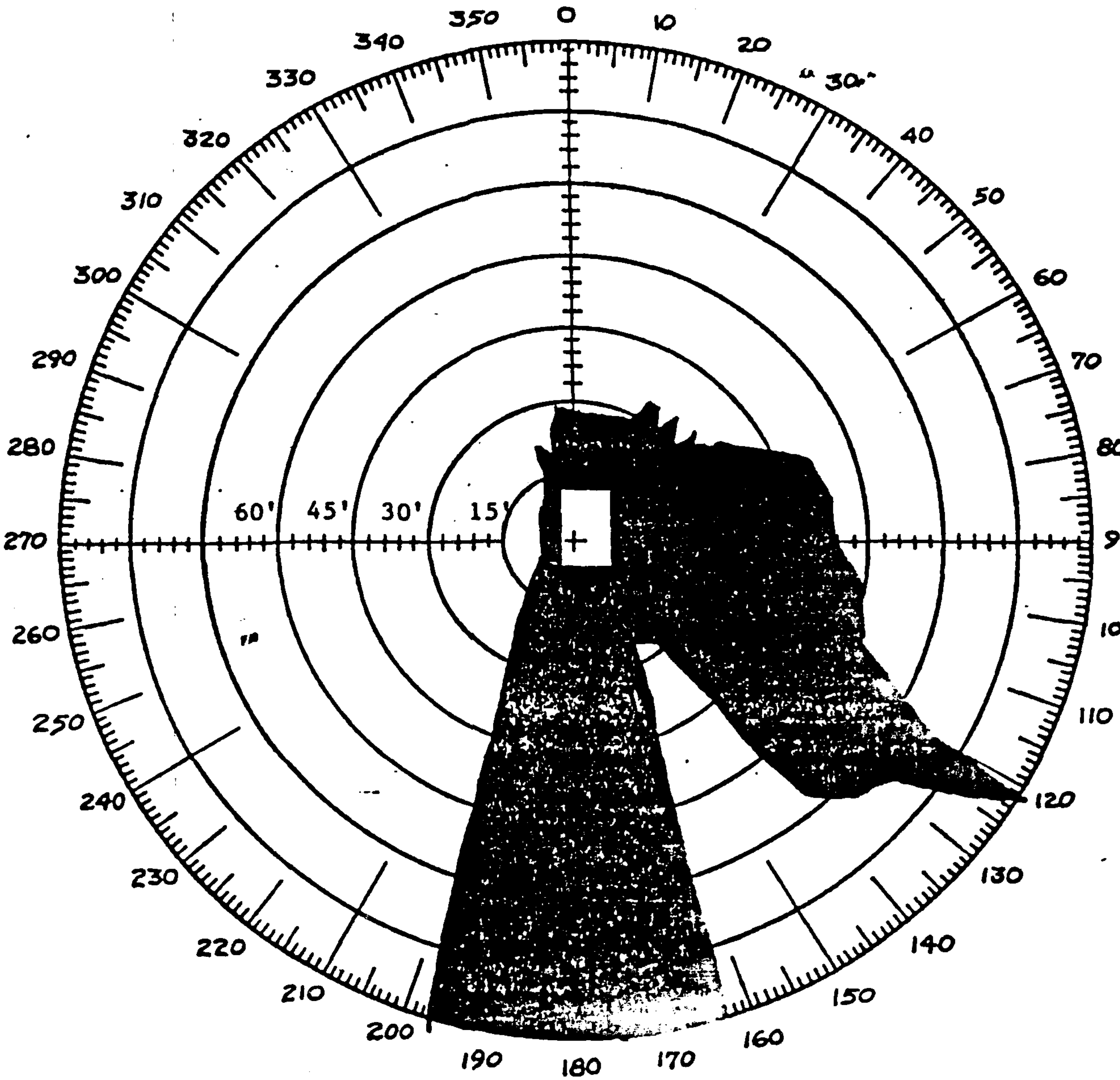
Table 14 lists Figures 10, 11, 12, 13, and 14 from the FA-IPT and describes the visibility test conditions for each figure.

Several comments can be made about the visual coverage from the vehicle based on the data from the FA-IPT and operator comments during the FOE.

Table 14

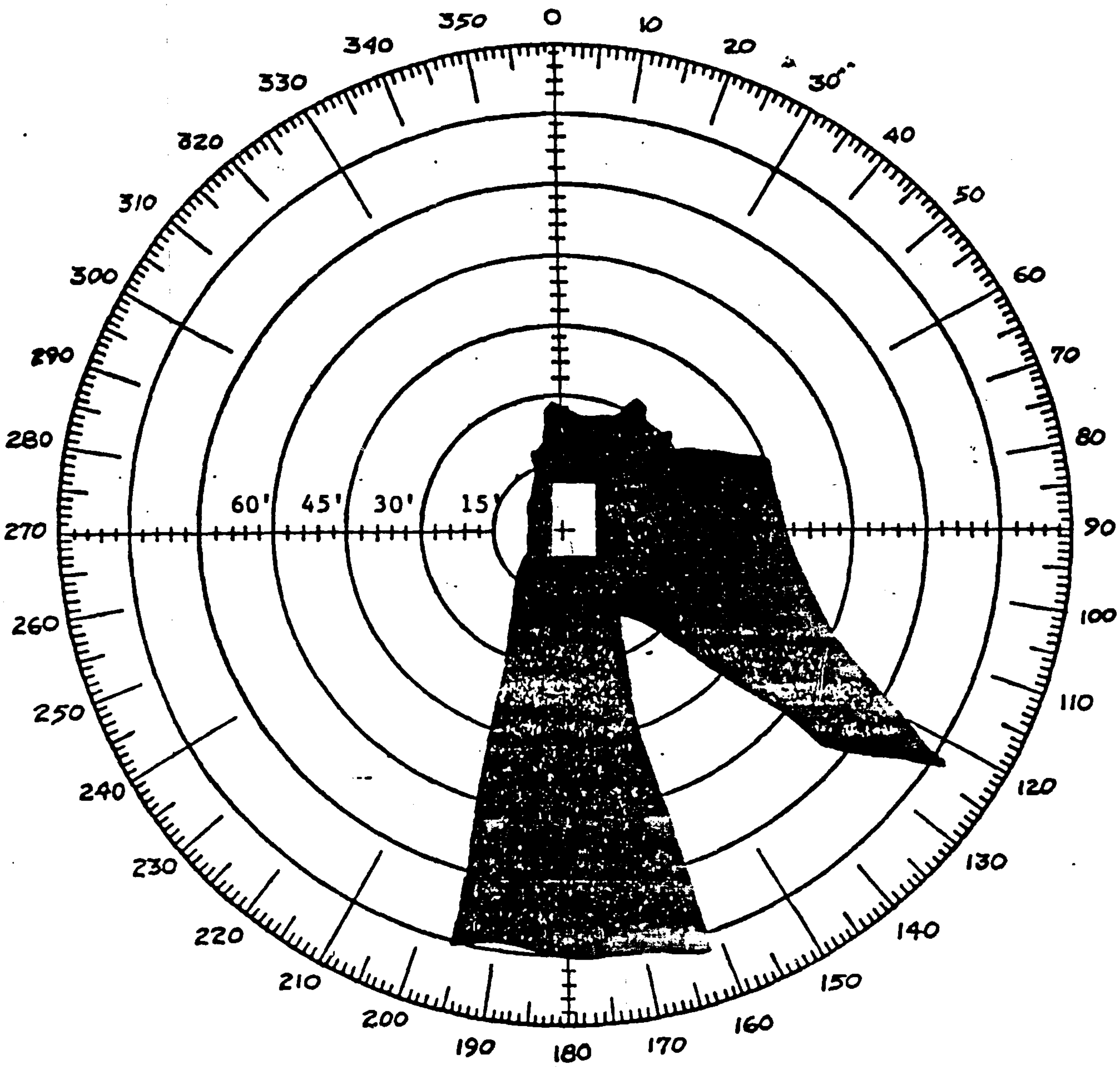
Visibility Test Conditions for Figures 10, 11, 12, 13, and 14

Vehicle conditions	Measurement location
Fig. 10; Blade in work position. Suspension lowered and tilted forward. Hatch open.	5th percentile operator, seated, measured at eye height.
Fig. 11; Blade in work position. Suspension lowered and tilted forward. Hatch open.	95th percentile operator, seated, measured at eye height.
Fig. 12; Blade in travel position. Suspension raised and level. Hatch open.	5th percentile operator, seated, measured at eye height.
Fig. 13; Blade in travel position. Suspension raised and level. Hatch open.	95th percentile operator, seated measured at eye height.
Fig. 14; Blade in travel position. Hatch closed.	5th and 95th percentile operators, measured at the same eye height.



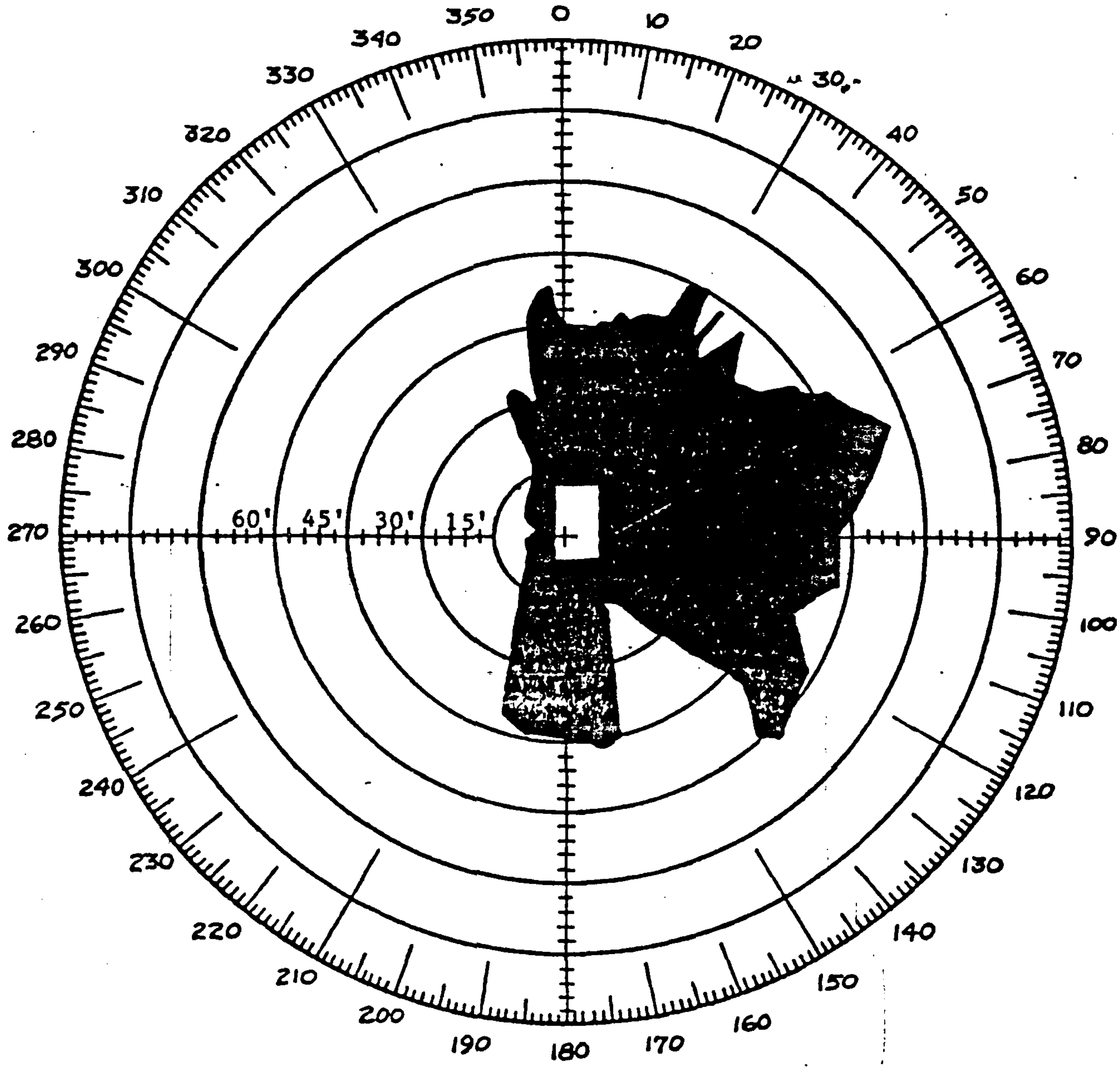
TEST ITEM: M9 ACE	DATE: July 2, 1984
STATION: Operator	TESTER: Beran, Ekquist
TOTAL UNOBSTRUCTED VIEW: 180^{0}	MINIMUM DISTANCE @ 0°: 28 feet
REMARKS: BLADE IN WORK POSITION - 5th percentile sitting eye height	
■ = OBSTRUCTED VIEW	

Figure 10. Blade in work position, suspension lowered and tilted forward, hatch open; 5th percentile operator, seated, measured at eye height.



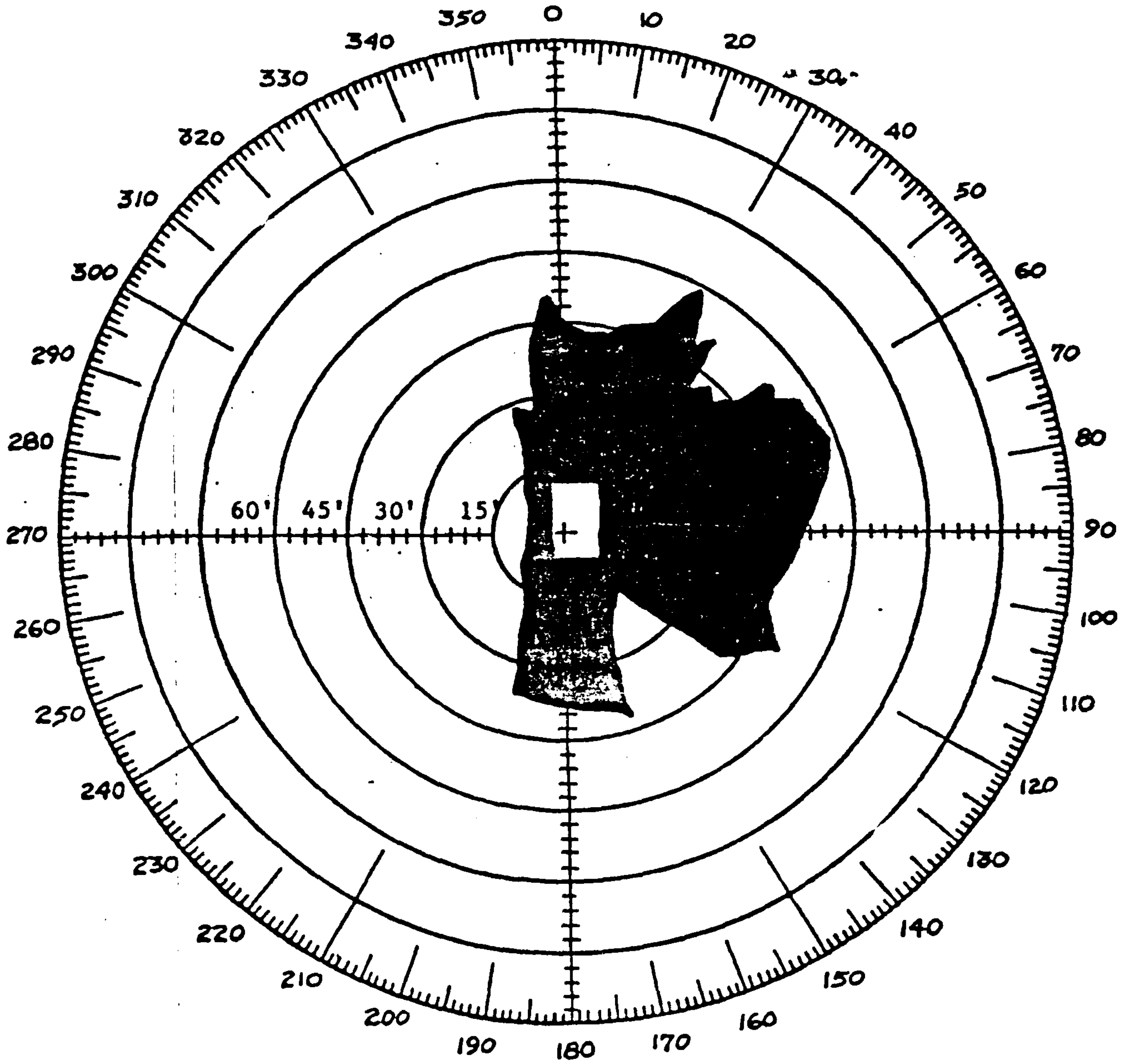
TEST ITEM: M9 ACE	DATE: July 2, 1984
STATION: Operator	TESTER: Beran, Ekquist
TOTAL UNOBSTRUCTED VIEW: 180°	MINIMUM DISTANCE @ 0° 28 feet
REMARKS: BLADE IN WORK POSITION - 95th percentile sitting eye height	
■ = OBSTRUCTED VIEW	

Figure 11. Blade in work position, suspension lowered and tilted forward, hatch open; 95th percentile operator, seated, measured at eye height.



TEST ITEM: M9 ACE	DATE: July 2, 1984
STATION: Operator	TESTER: Beran, Ekquist
TOTAL UNOBSTRUCTED VIEW: 180°	MINIMUM DISTANCE @ 0°: 46 feet
REMARKS: BLADE IN TRAVEL POSITION - 5th percentile sitting eye height	
■ - OBSTRUCTED VIEW	

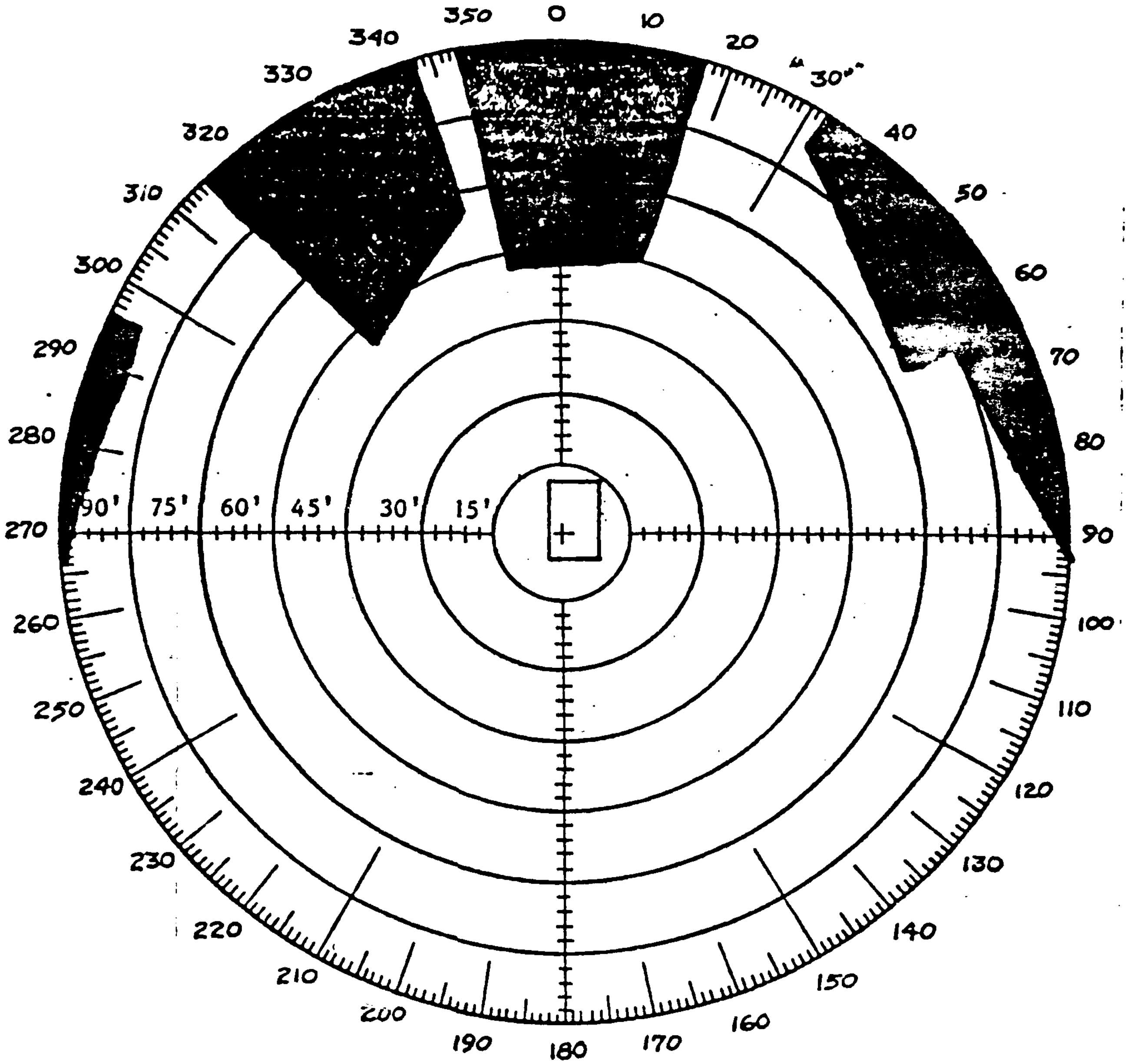
Figure 12. Blade in travel position, suspension lowered and tilted forward, hatch open; 5th percentile operator, seated, measured at eye height.



TEST ITEM: M9 ACE	DATE: July 2, 1984
STATION: Operator	TESTER: Beran, Ekquist
TOTAL UNOBSTRUCTED VIEW: 180°	MINIMUM DISTANCE @ 0°: 44 feet
REMARKS: BLADE IN WORK POSITION - 95th percentile sitting eye height	
■ = OBSTRUCTED VIEW	

Figure 13. Blade in travel position, suspension raised and level, hatch open, 95th percentile operator, seated, measured at eye height.

■ = GROUND SURFACE VISIBLE TO OPERATOR



TEST ITEM: M9 ACE	DATE: July 2, 1984
STATION: Operator	TESTER: Beran, Ekquist
TOTAL UNOBSTRUCTED VIEW: THROUGH VISION BLOCKS 157°	MINIMUM DISTANCE @ 0° 56 feet
REMARKS: HATCH CLOSED	

Figure 14. Blade in travel position, hatch closed; 5th and 95th percentile operators, measured at the same eye height.

1. The operator cannot see ground features in front of the vehicle for a distance of 45 ft (17.3 m) when traveling and 30 ft (9.1 m) when dozing or scraping.

2. The operators cannot see ground features behind the rear of the vehicle for distances of 90 to 105 ft (27.4 to 32.0 m) when dozing. However, after a cut is made the suspension can be leveled and then "blind" distance to the rear of the vehicle is reduced to 40 ft (12.2 m).

3. The operators cannot see ground features to the right of the vehicle for distances of 45 to 60 ft (13.7 to 18.2 m) during tasks when the suspension is lowered (unsprung) or raised (sprung).

4. The operators have severely restricted visual coverage when the hatch is closed and they view through the vision blocks. Moreover, there are wide "blind" gaps in the field of view provided by the vision blocks.

Implications for the Operator and the Equipment: Figure 15 shows a curved tank ditch which was dug during the last month of the FOE. Operators reported that they controlled the vehicle by driving based on the machine's reponse because they often could not see the dozer blade making a cut and how much spoil (earth) was being removed due to the presence of the blindspots. For example, when the vehicle pulled to the right, the operator had to assume that the dozer blade was cutting into the right bank of the tank ditch or fighting position. The tank ditch shown in Figure 15 was curved to the left because the operator assumed more spoil (earth) was being removed on the right bank than actually was. Combat construction generally does not need to be to precision specifications. However, digging in less than a straight line requires more time.

Figure 15. A curved tank ditch. The M9 is finishing a cut at the end of the ditch.

The operators could not see people or small obstacles moving in close proximity to the M9. The operators could not see obstacles close to the vehicle and frequently collided with them. The problem contributed to much of the damage done to the rear of the vehicle (see Deficiency: Insufficient Stowage Space and Secure Locations for Stowage, pg 49). The lack of visual coverage, increasing the possibility of a collision, is a safety hazard.

Individuals serving as ground guides were needed frequently to direct the operator during the FOE. The platoon leader often directed the operator during initial cuts to insure that the cuts were straight. Ground guides may not be available during combat operations.

Other Affected Tasks and Equipment Functions: Table 15 lists the operators' responses concerning the vision blocks. Driving with the hatch closed severely restricts the driver's visual coverage. Moreover, the visual coverage worsens in foul weather as indicated by the operators' ratings of the vision blocks. The operators cannot see through the rear vision blocks as they cannot turn around to look due to the tight confines of the hatch. This may be a critical deficiency, as the M9 must travel in reverse 50 percent of the time during earth moving tasks.

Table 15

The Adequacy of the View Through the Vision Blocks

Condition	Very adeq 5	Adeq 4	Marginal 3	Inadeq 2	Very inadeq 1	Mean	SD
Daylight	1	1	4	2	0	3.1	0.99
Darkness	0	0	2	2	4	1.8	0.88
Rain/splashing water	0	0	1	2	1	2.0	0.82
Fog	0	0	1	1	1	2.0	1.00
Smoke	0	0	1	1	2	1.8	0.96
Mud	0	0	1	2	2	1.8	0.84

Potential Solutions: If the hatch is reconfigured, the position of the vision blocks and the visual coverage should be studied and improved.

1. Add rear view mirrors that are adjustable and shielded to prevent glare and detection by threat forces. The mirrors might have to be removable to meet the vehicle's height requirements.

2. Add a wiper blade to the front vision block.

Deficiency: Indicator Lights; Interference with Night Operations, Application, and Location.

Description of the Deficiency: Four problems with the indicator lights in the operator's cab were reported by operators and include:

1. The brightness of the indicator lights temporarily blind the operators if the lights come on during night operations (reported by four operators).

   a. The operator's eyes must re-accommodate to the darkness.
   b. The night vision devices momentarily white out and cannot be used.
   c. The vision blocks light up revealing the location of the vehicle.
   d. The lights do not conform to the low energy lighting required by the Army Secure Lighting Program.

2. The low air pressure indicator light should be a gauge that the operators can monitor (reported by two operators).

3. The low transmission fluid pressure indicator light should be a gauge that the operators can monitor (reported by two operators).

4. The bilge pump operation indicator light is located just below and behind the hatch rim. The light cannot be seen during open hatch operations in this location (reported by four operators).

Implications for the Operator and the Equipment: The operators experienced a momentary blindness after the indicator lights flashed or remained on. After the indicator lights were turned off, several minutes were required for the operator's eyes to accommodate to the dark. During this period of time the operators had difficulties seeing the details of the terrain surrounding their vehicles. This will affect the operator's ability to control his vehicle and to be productive. Moreover, flashing lights from the vision blocks may be detected by the enemy during combat. The problem was very noticeable when the operators shifted the transmission from first gear to reverse gear while they were digging fighting positions. The low transmission fluid pressure light would flash on approximately every 45 seconds during the task.

The low air pressure and low transmission fluid pressure indicator lights should be gauges. The operators need to know when the pressures are reduced in order to avoid equipment damage. The gauges would allow developing low pressures to be detected and corrected before equipment damage occurred.

The bilge pump "ON" indicator light represents a critical equipment function during amphibious operations. It is the only indication operators have that the bilge pump is operating when they are looking forward. If the bilge pump fails during amphibious operations, the vehicle could sink rapidly. The bilge pump indicator light should be placed in a location the operators can see when they are in the open and closed hatch modes.

Potential Solutions: The M9 ACE should have a built-in test equipment (BITE) unit installed in the operator's cab. An audio signal should be sounded if any of the gauges are not indicating normal operating ranges, or if any indicator lights flash on the BITE panel. Ideally, the light system should have a dimmer switch that allows the operators to adjust the brightness of the displays and the indicator lights during night and day operations.

The bilge pump indicator light should be located on the BITE panel. The BITE should be located in front of the operator in a position that is easily viewed by the operator when he sits with the seat fully adjusted up or down.

Deficiency: MOPP IV Mask, Hood, and Hose.

Description of the Deficiency: Operators reported several deficiencies concerning the MOPP mask (M25), the hood, and the gas particulate filter hose. The deficiencies include:

1. Six operators reported that the MOPP mask straps and hood prevented the earcups of the CVC helmet from sealing around the operator's ears (Figure 16). This defeated the effectiveness of the double hearing protection the operators were required to wear and exposed them to high levels of vehicle noise (see Deficiency: Vehicle Noise, pg 13).

2. Figure 5 shown previously (see Deficiency: Vehicle Noise, pg 13) shows the MOPP hood bunching above the CVC helmet chin strap. The bunched material of the hood caused the CVC helmet chin strap to unsnap as the operator turned his head. This also defeated the effectiveness of the double hearing protection.

3. Table 16 lists the operators' ratings of the ease of performing major tasks while wearing fatigue and MOPP IV uniforms. Mean ratings decreased for tasks performed by operators wearing MOPP uniforms. Task performances affected by wearing the MOPP IV mask were given the lowest ratings, such as viewing through the night vision periscope (Mean 2.2), seeing gauges and displays under white or blue light (Mean 2.8), and viewing with the hatches open (Mean 2.9). The operators reported their vision was affected by scratches and glare on the mask lens and fogging in hot weather or from temperature fluctuations.

4. Figure 17 shows an operator looking to the right and rear of the vehicle. The gas particulate filter is positioned to the left of the operator and the hose connected to it is not long enough to allow the operator to turn around to view the right rear areas behind the vehicle.

5. The M25 mask has no features for drinking water during MOPP operations. Two operators reported being extremely thirsty during MOPP operations. However, operators were allowed to take frequent rest breaks during the test. An insufficient supply of drinking water for M9 operators is hazardous due to the high temperatures found in the operator's station (see Deficiency: Driver's Station Temperature and Ventilation, pg 17).

Implications for the Operator and the Equipment: Controls, and especially displays, were difficult to use and read during night operations. Color coding the normal, caution, and danger operating ranges on the displays is recommended as intergers are difficult to read through the mask lens.

Visual coverage of the terrain features behind the vehicle was extremely limited except when the rear door (for amphibious operations) was removed. The operator must be able to look over his right shoulder to see through the door opening and could not do it due to the short length of the gas particulate hose.

Figure 16. The operator trying to fit the earcups of the CVC helmet while wearing the MOPP mask and hood.

Figure 17. The operator trying to look to the rear but is restricted by the length of the gas particulate filter hose.

Table 16

Ease of Performing Major M9 ACE Operator Tasks When Wearing Fatigue and MOPP IV Uniforms

Task	Very easy 5	Easy 4	Neither easy nor diff 3	Diff 2	Very diff 1	Mean	SD
			Number of responses				
			Fatigue uniforms				
Mounting or dismounting the vehicle	2	5	2	0	0	4.0	0.70
Speaking into the radio	1	5	1	0	0	4.0	0.58
Listening to the radio	1	5	1	0	0	4.0	0.58
Performing maintenance service to the vehicle	1	7	1	0	0	4.0	0.50
Using towing equipment	1	5	1	0	0	4.0	0.58
Refueling the vehicle	2	6	1	0	0	4.1	0.60
Viewing through the vision blocks	1	2	3	2	0	3.3	1.04
Viewing through the night vision devices	0	2	3	1	1	2.9	1.07
Viewing with the hatches open	3	5	1	0	0	4.2	0.66
Using handtools	3	5	1	0	0	4.2	0.66
Seeing gauges and displays under white light	1	6	2	0	0	3.9	0.60
Seeing gauges and displays under blue light	1	5	2	0	0	3.9	0.64
Manipulating vehicle and equipment controls	1	8	0	0	0	4.1	0.33

Table 16 (cont'd)

Task	Number of responses: Very easy 5	Easy 4	Neither easy nor diff 3	Diff 2	Very diff 1	Mean	SD
			MOPP IV uniforms				
Mounting or dismounting the vehicle	0	4	5	0	0	3.4	0.53
Speaking into the radio	1	2	1	1	1	3.2	1.47
Listening to the radio	1	1	2	1	1	3.0	1.41
Performing maintenance service to the vehicle	0	0	3	2	1	2.3	0.82
Using towing equipment	0	0	2	0	0	3.0	0.00
Refueling the vehicle	0	0	2	0	0	3.0	0.00
Viewing through the vision blocks	0	0	3	3	1	2.3	0.82
Viewing through the night vision periscope	0	2	0	0	3	2.2	1.64
Viewing with the hatches open	1	1	3	2	1	2.9	1.25
Using handtools	0	1	2	1	1	2.6	1.14
Seeing gauges and displays under white light	1	1	2	4	0	2.8	1.13
Seeing gauges and displays under blue light	1	1	2	3	1	2.8	1.28
Manipulating vehicle and equipment controls	1	2	6	0	0	3.4	0.73

Other Affected Tasks and Equipment Functions: The operator's ability to drive in reverse was limited by not being able to see through the rear door opening due to the length of the mask hose. Moreover, operators hesitated to look to the rear because doing so caused the CVC helmet to unsnap. The operator's view to the rear is extremely important because 50 percent of the vehicle's travel during earthmoving tasks is in reverse.

Potential Solutions:

1. Add an NBC microclimate system to the M9. The adjustable temperature control and air blower will reduce the fogging of the MOPP mask.

2. Add a feature to the M25 mask that allow operators to drink water from a canteen.

3. Change the snap arrangement on the CVC helmet strap so that it cannot pop open when operators wear the MOPP hood and turn their heads.

4. Lengthen the gas particulate filter (or microclimate system) hose at least 12 inches so that the operator can view to the rear.

5. Place covers over objects that snag the longer mask hose (ie., the fire extinguisher handle) and remove other objects that cannot be covered.

6. Use color codes and bold print on the displays so they can be read easily through the MOPP mask and when wearing the night vision goggles.

Other Problems with MOPP IV Uniforms.

Description of the Problems: Table 16 shown previously indicated that operators found it difficult to perform maintenance service to the vehicle (Mean 2.3). The operators reported that they had difficulty manipulating small latches, devices and tools (Mean 2.6) while wearing the MOPP gloves. The MOPP gloves reduced the user's dexterity.

Operators also reported that performing maintenance was difficult when they wore the MOPP boots. The MOPP boots slip over the operator's combat boots and have a minimal tread surface for use in wet or muddy environments.

Two operators reported that the MOPP hood, earplugs, and vehicle noise masked the CVC helmet radio reception. Four operators reported, early in the test, that not being able to hear the radio reception well was one of the reasons that they were not wearing earplugs (see Deficiency: Communications, pg 28).

Deficiency: Insufficient Stowage Space and Secure Locations for Stowage.

Description of the Deficiency: Table 17 lists the number of operators responding to questions concerning the space provided for stowage and its locations. Figure 18 shows damage to jerry can holders and other objects on the rear of the vehicle. Table 18 lists the specific stowage deficiencies for basic issue items (BII) and other equipment.

Table 17

Adequacy of Stowage Space and Location

	Number of responses						
Stowed items	Very adeq 5	Adeq 4	Mar-ginal 3	Inadeq 2	Very inadeq 1	Mean	SD
			Space provided				
Smoke grenades	0	3	2	1	1	3.0	1.15
Chains	0	4	4	0	1	4.1	1.27
Common tools	0	0	6	2	1	2.5	0.72
NBC gear	0	0	2	4	2	2.0	0.75
Personal combat gear	0	1	1	5	2	2.1	0.93
Water	0	1	3	2	2	2.4	1.06
Oils/lubricants	0	0	2	4	2	2.0	0.75
Hydraulic fluid	0	0	1	2	2	1.8	0.84
Repair parts	0	0	1	2	2	1.8	0.84
Manuals	1	7	0	0	1	3.8	1.09
				Location			
Smoke grenades	0	1	0	5	3	1.4	0.73
Chains	1	4	4	0	0	3.6	0.71
Common tools	1	3	4	1	0	3.4	0.88
NBC gear	0	0	2	3	2	2.0	0.86
Personal combat gear	0	0	2	3	3	1.9	0.83
Water	0	1	2	4	1	2.4	0.92
Oils/lubricants	0	0	2	2	1	2.2	0.83
Hydraulic fluid	0	0	0	2	1	1.6	0.58
Repair parts	0	1	0	2	1	2.3	1.25
Manuals	2	6	1	0	0	4.1	0.60

Implications for the Operator and the Equipment: Stowed equipment on the rear of the vehicle was frequently damaged by collisions with objects to the rear of the vehicle. Stowed equipment on the rear deck of the vehicle was affected by the high engine temperature. The stowed equipment blocked the air flow and affected the efficiency of the cooling system. Stowage locations that are difficult to access increase the time it

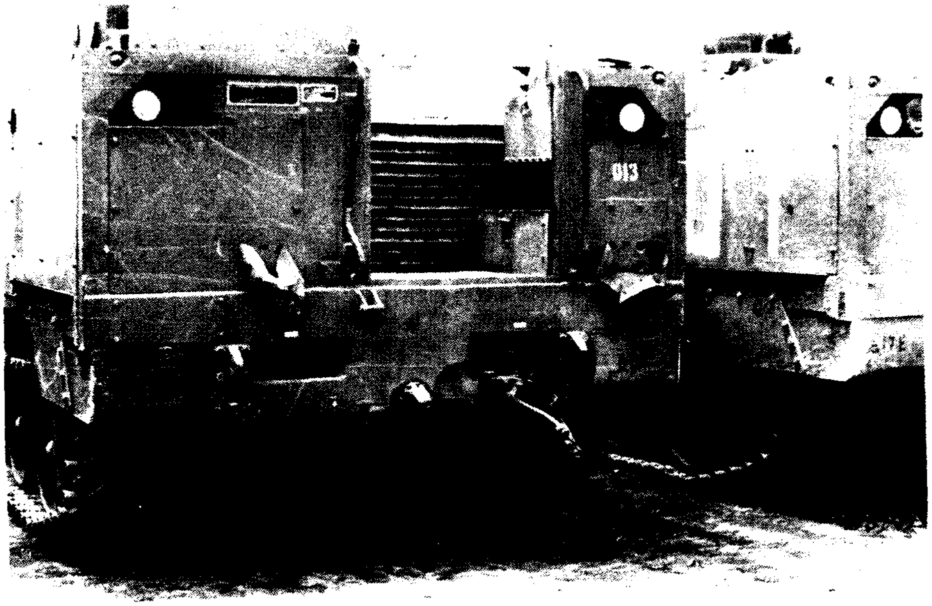


Figure 18. The damage to the rear of the vehicle. (The winch cable, the rear steps, the jerry can holders, and the handrails are broken.)

Table 18

Stowage Space Deficiencies

Stowage area	Problem
Rear mounted racks for jerry cans	Easily damaged by collisions between the vehicle and objects to its rear.
Tie down area over dozer blade	Stored items obstruct operator's view.
OVM tool box inside bowl	Too small for the tanker bar and additional items. Difficult location to access.
Combat and personal gear stowage on rear deck	Heated or burned by engine heat from cooling system.
Canvas canopy cover and frame Unsecured and placed across fuel tank	Interferes with ingress and egress from the operator's cab and opening and closing the hatch. A possible tripping hazard.
Hydraulic fluid, oils & lubricants	No stowage space for the quantities of fluids required for extended operation. If stored on the rear deck, they may be heated or burned by engine heat.

takes for operators to obtain tools and perform tasks. Insufficient stowage space results in the operators improvising stowage areas which may inadvertently create hazards. For example, all seven of the M9 operators reported stowing combat gear and personal equipment in the open and upside down hatch. During a combat emergency, the operators would have to unload the hatch before closing it. This exposes the operator to enemy fire and the displaced, loose, combat gear may be lost.

Potential Solutions: The Final Report of the First Article-Initial Production Test (1984) recommended a complete review of the stowage space provided on the M9 ACE and its load plan. In addition to a complete review, several specific recommendations include:

1. Add a rear bumper that extends along the lower rear of the M9 and up both of the outside edges. The bumper should be wider than any of the stowed items kept at the rear of the vehicle and the outside edges should be wide enough to deflect tree limbs. The rear bumper could also include an improved rear step and mount for the winch.

2. Increase the length and depth of the OMV tool box to accommodate the additional equipment (ie., the tanker bar, life jacket, canvas canopy, etc.).

3. Add steps and handholds to assist operators when climbing into the bowl in order to make access to the tool box easier and safer.

4. Add a mechanism on the tool box lid to lock it open and to avoid having it fall on the operator.

5. Add stowage compartments on the rear of the vehicle and protect them from being crushed.

6. By moving the radio from its present location, the battery box could be raised to improve access to the batteries and a stowage box could be located under the batteries (see Deficiency: Communications, pg 28).

Deficiency: Insufficient Basic Issue Items (BII) and Support Supplies.

Description of the Deficiency: Table 19 lists items that should be added to the M9 BII and the test events that indicated the items were needed. Moreover, events during the field training exercise (FTX) portion of the test indicated the need for additional support supplies.

Table 19

Additional BII and Support Supplies

Needed items	Test event indicating the requirement
Water, 5 to 15 gallons	The medical surveillance tests indicated that all operators were significantly dehydrated during the FOE. No water was stowed on the vehicle. Five quarts of water per day is the minimum requirement for human consumption. Occasionally, M9s overheated during continued road marches with armor units. Additional radiator water was needed.
Food	During the FTX the M9s traveled with armored units and ahead of engineer support units. Operators were not supplied with hot or cold food.
Five gal. cans of hydraulic fluid	During the FTX the M9s were delayed waiting for additional hydraulic fluid. Contact trucks may not be able to travel as rapidly or into the same terrain as the M9. The M9 has a complex hydraulic system requiring large quantities of fluid.
Spare roadwheels	Frequent roadwheel changes were required throughout the test. Many roadwheels fractured as well as lost rubber.
Dog bone jacks	At least one dog bone jack will be needed for roadwheel changes (see Deficiency: Roadwheel Changes, pg 105).
Spare track pads	Frequent track pad changes were required throughout the test.
Spare blade seals	Blade seals for amphibious operations were easily damaged or lost.
Quart cans of engine oil	Additional engine oil was required throughout the test. No engine oil was stowed on the vehicle.

Implications for the Operator and the Equipment: The mission requirement for the M9 is to travel with and support forward armor units. However, the vehicle lacked the BII and additional supplies required by the mission. The M9 should not be more dependent on supply and support units during extended operations than the other armored vehicles of the unit.

Other Affected Tasks and Equipment Functions: Stowage space and containers will be required for the additional BII and supplies. The present stowage space is deficient (see Deficiency: Insufficient Stowage Space and Secure Locations for Stowage, pg 49). Vehicle modifications may be affected by increased or decreased BII requirements.

Potential Solutions: A complete review of the required BII, supplies, and stowage load plan should be conducted. The required BII, supplies, and stowage space should be added to the M9.

Deficiency: Inappropriate Controls and Displays.

Description of the Deficiency: Table 20 lists the M9 controls and displays having human engineering deficiencies. The table describes the deficiencies and the implications for the operator of the vehicle.

MIL-STD-1472C, paragraphs 5.1 to 5.5.6 discuss the requirements for vehicle controls and displays. The controls and displays having deficiencies should be modified to correct the deficiencies. Many of the deficiencies could be solved by adding color markings to the displays indicating normal, caution, and dangerous operating ranges, and by adding a built-in test equipment (BITE) unit in the driver's station (see Deficiency: Indicator Lights, pg 42).

Potential Solutions: Activation of a single hydraulic control dominated the entire hydraulic system, allowing only one hydraulic function to be operated. This deficiency reduces the productivity of the M9 and may jeopardize its safety. For example, the ejector blade cannot begin to eject dirt from the bowl as the dozer blade is being raised. The task of emptying the ejector bowl or adjusting its load takes twice the time it would take if multiple hydraulic functions could be operated simultaneously. During amphibious operations, when the operation of the bilge pump is critical, the height of the suspension must be adjusted in order to dig egress ramps, yet the bilge pump must be turned off in order to lower (unsprung) the suspension. The hydraulic system should be modified to allow multiple control functions to operate. One potential solution would be to add proportional hydraulic control valves that allow hydraulic pressure to be distributed evenly to more than one hydraulic function.

Table 20

Controls and Displays Having Human Engineering Deficiencies

Control or Display	Problem Reported by	Deficiency	Implications for Operation of the Vehicle
M9 ACE CONTROLS			
Suspension control levers (see Fig. 19)	2 operators	The suspension on the right side of the vehicle responds more rapidly than the suspension on the left side. (See Fig. 20)	Time is lost adjusting the tilt of the dozer and scraper blades. The lowest corner of the blade causes the vehicle to steer to that side during dozing, usually affecting initial cuts.
		The knobs of the control levers are only 1/4 in (6.4mm) apart, causing MOPP gloves to be pinched.	Time is lost adjusting the levers to the proper positions.
Winch controls	2 operators	Winch does not have a brake control.	The winch must be turning in order to shift. In many situations it is undesirable to have the winch turning before shifting.
			The holding capacity of the winch in low gear and the directional valve in neutral (34.8 kN, 8920 lb) is insufficient to hold a vehicle on a slope.
Bilge pump lever (see Fig. 21)	Human factors engineer	To activate the bilge pump the lever must be pushed down and vice versa to deactivate it. This is opposite of the operator's expectations.	The bilge pump may be accidentally deactivated when in operation or if the operator if panicked.
All hydraulic controls	7 operators	Activation of a single hydraulic control dominates the entire system, allowing only one hydraulic function to operate.	Rapid operation of two or more functions simultaneously is impossible. For example, the ejector cannot operate as the dozer blade is raised. The vehicle suspension cannot be adjusted while the bilge pump is operating.
Brake pedal (see Fig. 22)	2 operators	Located too far to the left and too close to the accelerator pedal.	Operators experience muscle fatigue in their legs and are less likely to use the brake. Not using the brake to come to a complete stop may have contributed to the vehicle's transmission failures.
			MOPP boots get caught on the pedals.
Brake and accelerator pedals (see Fig. 23)	Human factors engineer	The upright position of the brake and accelerator pedals are steeply angled and uncomfortable to operate.	Sustained operation is fatiguing and may result in operation at slower speeds.
Accelerator pedal and heater unit	Human factors engineer	Heater unit next to pedal bumps and rubs operator's leg. The heater unit catches on MOPP boots.	Sustained operation is fatiguing and may result in operation at slower speeds.
M9 ACE DISPLAYS AND INDICATORS			
All indicator lights	7 operators	Lighted indicator lights blank the image seen through the night vision devices during night operations.	The operator momentarily loses his sight. His eyes must accommodate to the dark and the details of the terrain become more difficult to see.
		A flash of light can be seen from the vision blocks outside of the vehicle.	Possible detection of the M9 ACE by enemy combat units.
Gauges a. Engine oil pressure b. Water temperature c. Hydraulic oil temperature d. Transmission oil temperature (see Fig. 24)	Human factors engineer	Gauges do not have color markings indicating normal, caution, and dangerous operating ranges.	Operator may incorrectly read the gauges or may not know or remember the appropriate operating ranges. Color markings are less difficult to see than printed numbers wearing the MOPP mask.

Table 20 (cont'd

Control or Display	Problem Reported by	Deficiency	Implications for Operation of the Vehicle
Low oil and low air pressure indicator lights	2 operators	The indicator lights light too late to help prevent system failure.	Operator is not aware of decreasing pressures and cannot avoid pressure failures.
Clogged air filter indicator (see Fig. 25)	2 operators	The clogged filter indicator is located on the air filter in the engine compartment and not on the operator's display panel.	Operator may not detect a clogged air filter problem. The air filter may not be cleaned often enough.
Bilge pump "ON" indicator light (see Fig. 21, previously shown)	2 operators	The operator cannot see the bilge pump indicator light when the seat is raised for the open hatch position.	Operator may not detect a bilge pump failure to operate.
Left and right display panels	Human factors engineer	The gauge labels are above the gauges on the left panel and below the gauges on the right panel.	Operator may read the wrong gauge.
ADDITIONAL M9 ACE CONTROLS NEEDED			
Emergency engine shutdown	Human factors engineer	Vehicle not equipped with an emergency engine shutdown.	The operator should have a manual fuel shutoff control in the driver's station that is readily accessible. Safety hazard.
Ejector blade control lever lockout	Human factors engineer	The ejector blade control lever cannot be locked to prevent accidental activation.	The engine must be running in order to check the hydraulic lines behind the ejector. The ejector blade can be accidentally activated and retracted when personnel are working the bowl. Safety hazard.

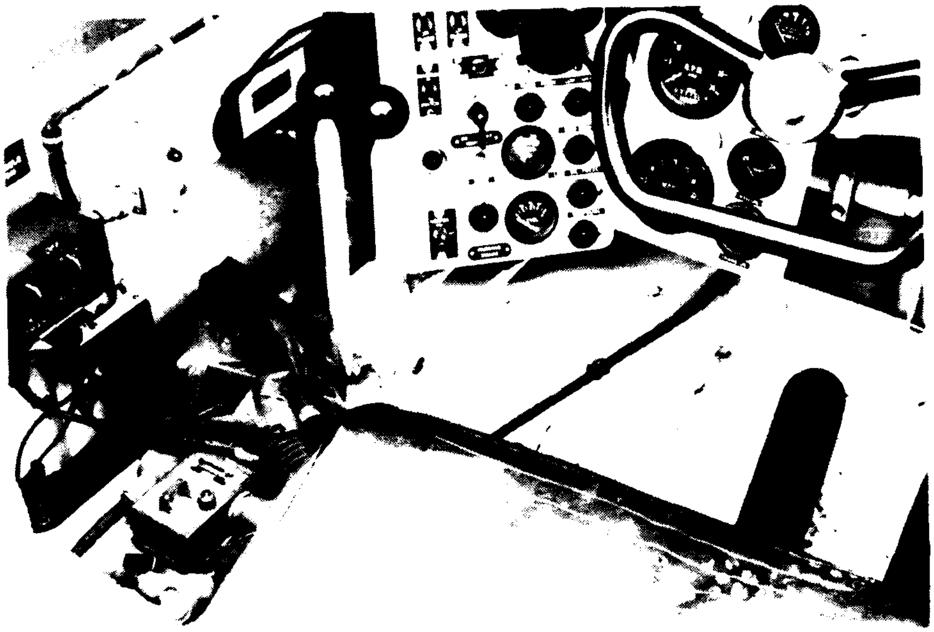


Figure 19. The suspension control levers (center left) that are too close together.

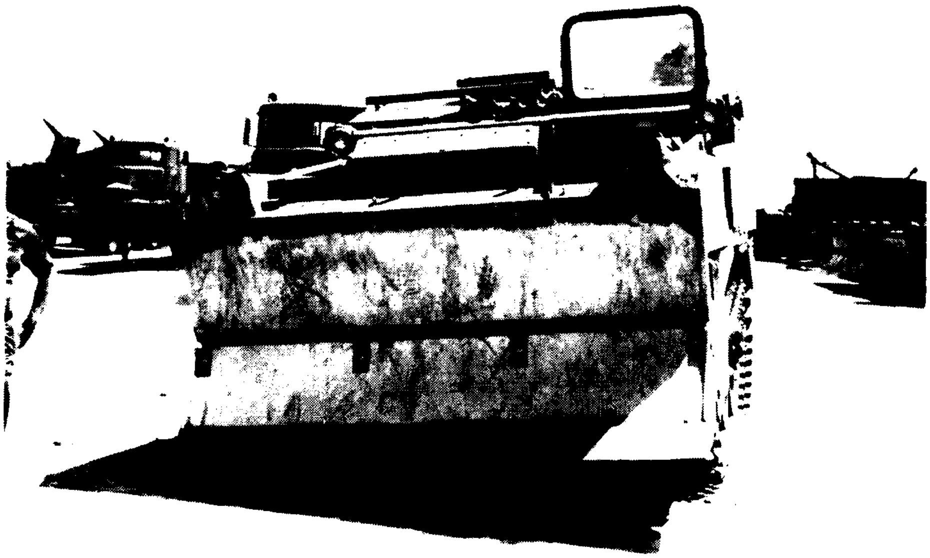


Figure 20. The operator lowering the suspension (unsprung) with one side responding more rapidly than the other.

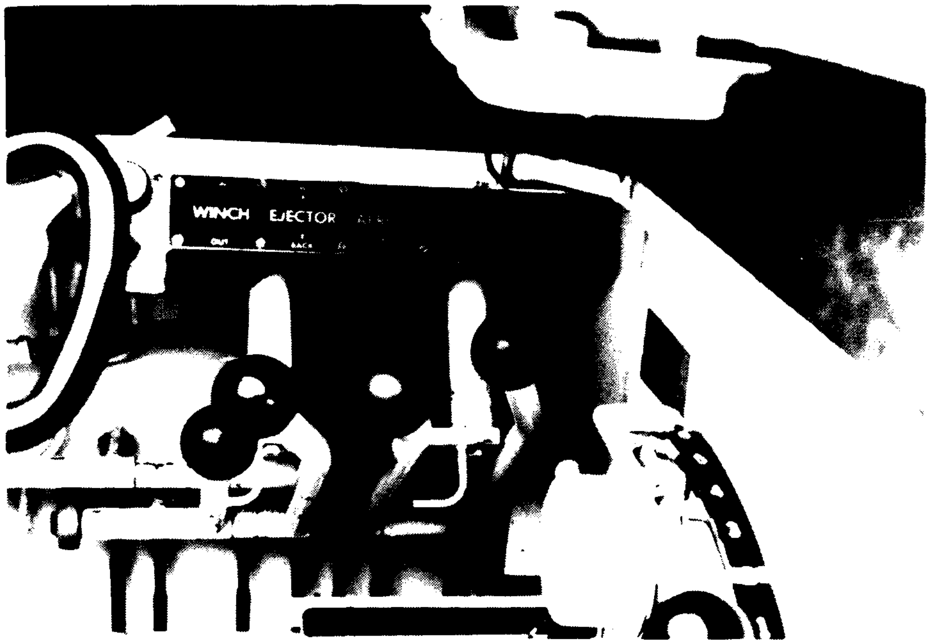


Figure 21. The bilge pump lever (furthest to the right) and the bilge pump light was above the lever but cannot be seen.

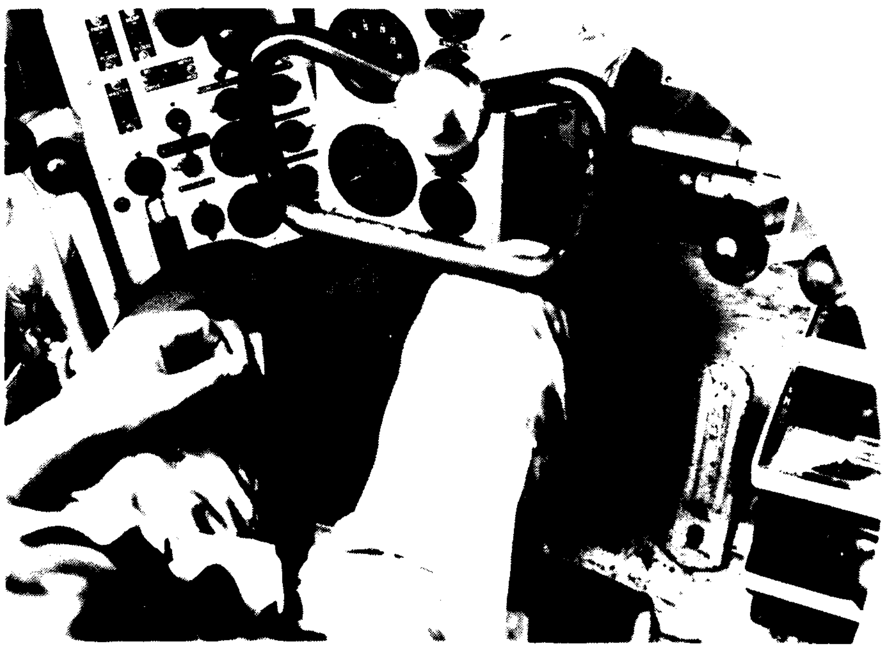


Figure 22. The operator's foot and leg position when using the brake pedal.

Figure 23. The position of the operator's leg against the heater box when using the accelerator pedal.

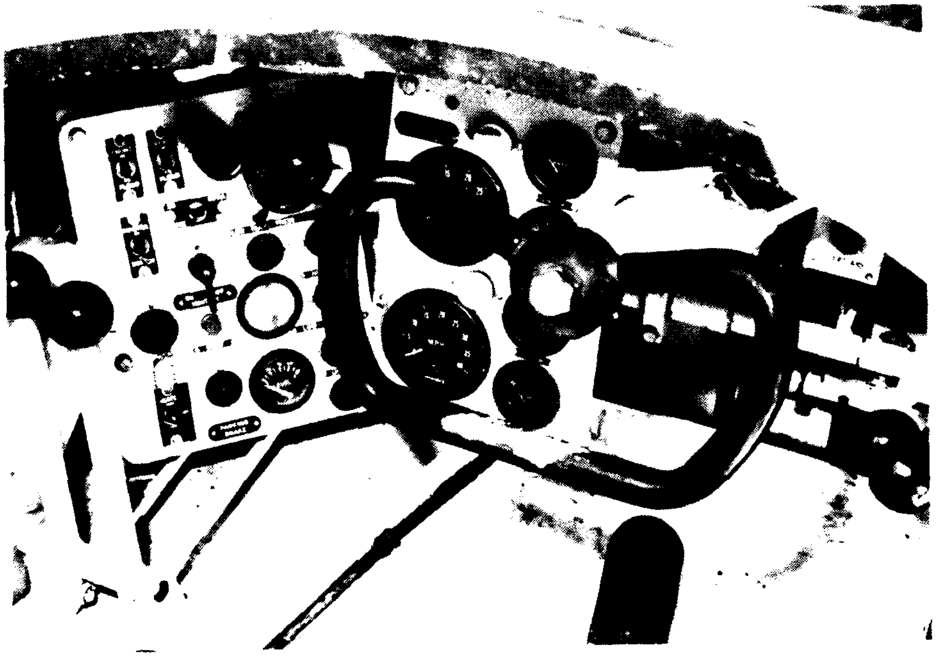


Figure 24. The operator's displays without colored operating ranges.

Figure 25. The clogged air filter indicator (the small dark knob on the filter canister).

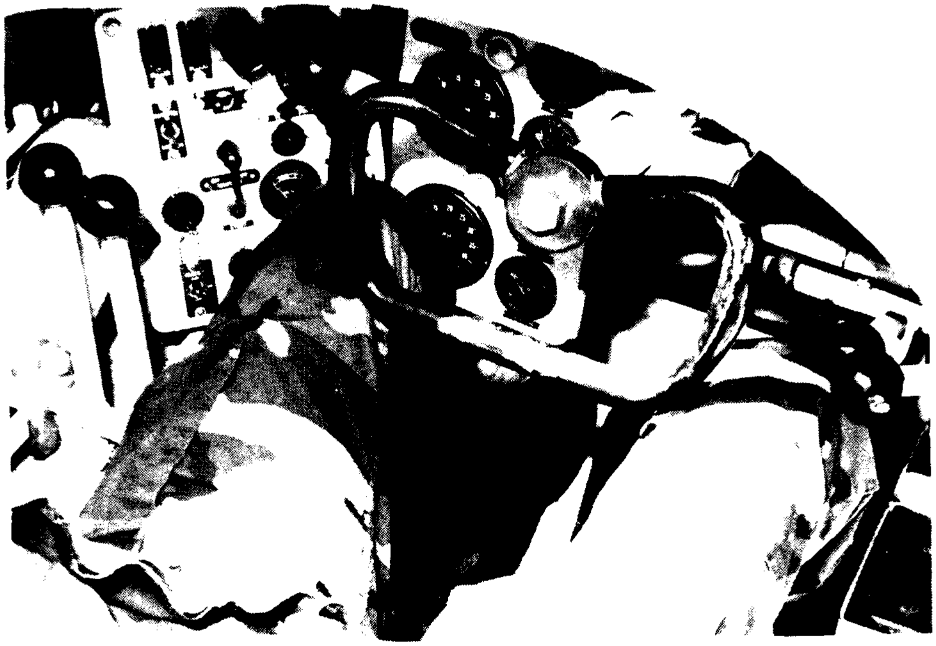


Figure 26. The operator's legs interfering with the steering control.

Deficiency: Driver's Seat Vinyl.

Description of the Deficiency: The seat vinyl began to tear and split during the second half of the test. Four operators reported that the deteriorating seat vinyl and foam resulted in the operator's back being irritated by the seat frame. The seat bottom is repeatedly stepped on when operators enter or exit the driver's station.

Implications for the Operator and the Equipment: The seat vinyl may not be durable enough for continued use, especially since the seat is used as a step. Once the vinyl and foam deteriorate, the operator will be exposed to high levels of vibration and jarring (see Deficiency: Vehicle Vibration, pg 21).

Potential Solutions: Use vinyl having more durability. Add a foldup seat bottom that has a spring-loaded hinge which automatically folds the seat bottom up when it is not being sat on. Beneath the seat bottom, add a stepping platform similar to that used in the M1 Main Battle Tank's commander's station.

Deficiency: Apron and Dozer Blade Lock Pins.

Description of the Deficiency: Figure 27 shows the apron lock pin with marks from hammering on the lower portion of the oval plate. All of the operators reported that the two apron pins, securing the left and right apron to the hull, were driven in and out of place using hammers. The fit of the lock pins into the openings was too tight for easy removal. Continued hammering deformed the pins adding to the problem.

Figure 27. The oval plate of the apron lock pin and hammering marks.

Figure 28 shows the dozer blade lock pin at the point of the ball point pin. All of the operators reported that removing the left and right lock pins using an allen wrench was time consuming and difficult due to mud caked on the pins. The left and right lock pins are positioned behind the lower corners of the dozer blade. The lower areas behind the dozer blade often collect caked mud. This made uncovering the lock pins and clearing the allen wrench opening a time consuming task.

Figure 28. The top of the dozer blade lock pin next to the point of the ball point pin.

Figure 29 shows a mechanic inserting the apron safety pin while the operator adjusts the height of the apron. Inserting and removing the apron lock and safety pins required two people to perform the task in order to align the pin openings and quicken the procedure. Otherwise, without two people, the one operator must mount and dismount the vehicle repeatedly attempting to align the pin openings until the pins can be inserted. This task may violate the vehicle's design criteria emphasizing that one operator must be able to perform all tasks alone.

Figure 29. A mechanic assisting the operator in inserting the apron safety pin.

Implications for the Operator and the Equipment: The operator may not have help removing and installing pins when the M9 travels with armored units. Locking the dozer blade, using the dozer blade lock pins, may be omitted as a procedure and equipment damage or injury may result. The apron lock pins may be rapidly deformed by hammering, increasing the time required to insert or move the pins. The apron lock pins may also be deformed to the extent that they are unusable.

Other Affected Tasks and Equipment Functions: All lock and safety pins on the M9 are removed frequently for a variety of tasks, such as traveling, filling the bowl, maintenance service, and amphibious operations. Inserting the lock and safety pins may require as much as 45 minutes during preparations for amphibious operations and it is one reason the preparations require two to three hours (see Safety Hazard: Amphibious Operations, pg 83).

Potential Solutions:

1. Taper or reduce the diameter of the apron lock and safety pins. The slight amount of water that enters the bowl through the pin opening during amphibious operations may be worth the reduction in time used to remove and install the pins.

2. The dozer blade lock pins should have a quick release mechanism. The lock pin should also be protected from mud.

3. The operator should have a method to determine when the pin openings are aligned to the point that a pin can be inserted easily.

Deficiency: Flood and Operating Lights.

Description of the Deficiency: Figure 30 shows a damaged protective shield for a floodlight mounted on the side of the vehicle. The side mounted floodlights were frequently damaged by collisions with trees.

Figure 31 shows the operating lights at the rear of the vehicle. The operating white lights and red filtered lights do not conform to the Army Secure Lighting Program. The program requires blue-green low energy lights in addition to other requirements.

Implications for the Operator and the Equipment: Floodlights were frequently broken and unusable during night operations. High energy white lights and red filtered lights can be detected more easily by threat forces than the lights required by the Army Secure Lighting Program.

Potential Solutions:

1. Place the side mounted floodlights in protected locations more inboard on the vehicle than the present locations. Perhaps, floodlights could be located inboard at a greater height on a removable stand or fixture.

2. Add lights meeting the requirements of the Army Secure Lighting Program.

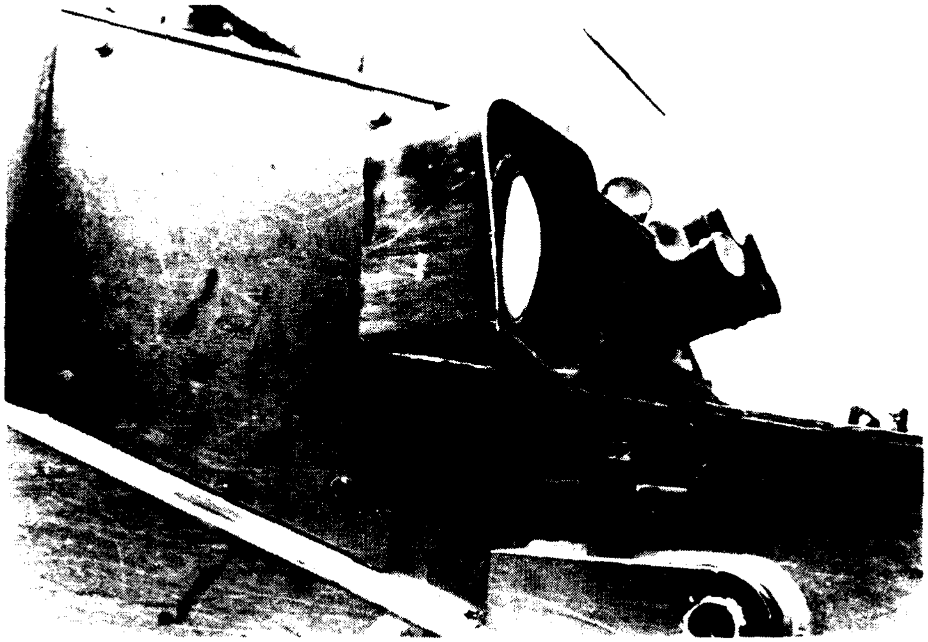


Figure 30. Damage to the floodlight guard

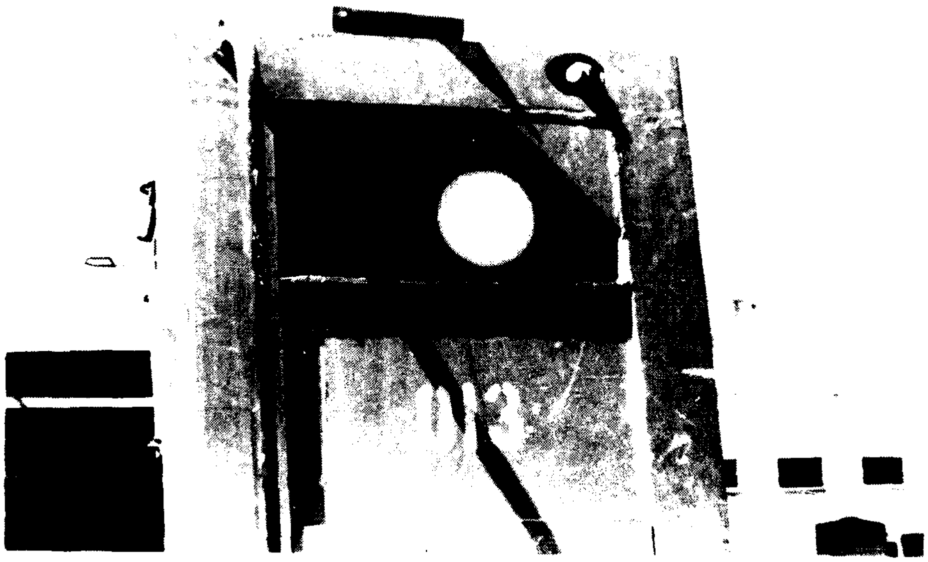


Figure 31. The red filtered and high intensity white filament lights at the rear of the vheicle.

Safety Hazard: Driver's Station Hatch.

Description of the Safety Hazard: Four operators and three mechanics reported that the driver's hatch is unsafe to use. Safety deficiencies concerning the hatch include:

1. The weight of the hatch. The force required to close the hatch is 100 lbs (440 N). The maximum acceptable force is 50 lbs (220 N) (MIL-STD-1472C, paragraph 5.7.8.2.2).

2. Figure 32 shows that the operator cannot close the hatch from the driver's seat. The operator must stand to close the hatch, exposing him to hostile weapons fire. This problem is a result of the weight of the hatch, its position behind the driver's station when it is open, and the multiple hand motions required to manipulate the hatch lock release lever (a violation of MIL-STD-1472C, paragraphs 5.7.8.2.1 and 5.7.8.2.2).

3. The hatch is difficult to open without forcibly dropping it on the fuel tank or onto anyone and anything close to the fuel tank. The hatch must also be closed in order to fill the fuel tank.

4. Figure 33 shows a mechanic grasping the bracket of the hatch paddle lock. There is no easy way to grasp the hatch in order to open it.

5. Figure 34 shows personal combat gear stowed in the driver's hatch (see Deficiency: Insufficient Stowage Space and Secure Locations for Stowage, pg 49). Using the hatch for stowage adds to the time required to close the hatch in a combat emergency or before firing the smoke grenade launcher.

6. The hatch cannot be opened rapidly in order to evacuate the vehicle and it is unlikely that a wounded operator could open it at all.

7. The position of the night vision periscope in the hatch is approximately 4 in (10 cm) from the the driver's face (see Deficiency: Night Vision Devices, pg 31). The driver may strike his face on the periscope if the vehicle bounces or if the dozer blade strikes an object (see Deficiency: Dozer Blade Clearance, pg 90).

8. The hatch does not seal (nor is the cab ventilation a positive pressure system) and may leak water and NBC contaminants (see Deficiency: Driver's Station Temperature and Ventilation, pg 17).

Implications for the Operator and the Equipment: Back injuries are likely, especially when operators are opening or closing the hatch rapidly. Factors such as the time required to close the hatch and the operators having to expose themselves to hostile weapons fire in order to do it, make the hatch useless as a protection device. Operators will realize that they will be trapped in the vehicle when they are wounded and the hatch is closed. The operators' willingness to work may be diminished when there is the threat of hostile weapons fire.

Other Affected Tasks and Equipment Functions: The smoke grenade launcher cannot be fired safely until the hatch is closed. Because the hatch is so difficult to close, it is unlikely that the operator will attempt to close the hatch or launch the smoke grenades before withdrawing from a position under enemy fire.

Potential Solutions: The driver's hatch needs to be studied and redesigned. The design criteria should include:

1. The weight of the hatch should be reduced, or opening and closing the hatch should be mechanically assisted, so that the force exerted by the operator to perform the task is within the limits required by MIL-STD-1472C.

2. The hatch should be opened with a single motion of the hand and arm (MIL-STD-1472C).

3. The vision blocks and other structures in the hatch, or the roof surrounding the hatch, should be positioned far enough from the operators so that their faces cannot strike the objects when they are seated and wearing their seat belts properly.

4. Handholds should be added inside and outside of the hatch to facilitate opening and closing the hatch.

5. The hatch should be sealed when closed to prevent leaks of water or NBC contaminants.

A pivot hatch arrangement may be a partial solution. If the height of the hatch interferes with loading onto the C-130 aircraft, then a hatch within a hatch may be required. The smaller upper hatch could be provided for operational use, while the entire top of the operator's compartment can be hinged to fully open (like the hatch presently opens) for loading the M9 onto aircraft.

Figure 32. The operator trying to close the driver's hatch.

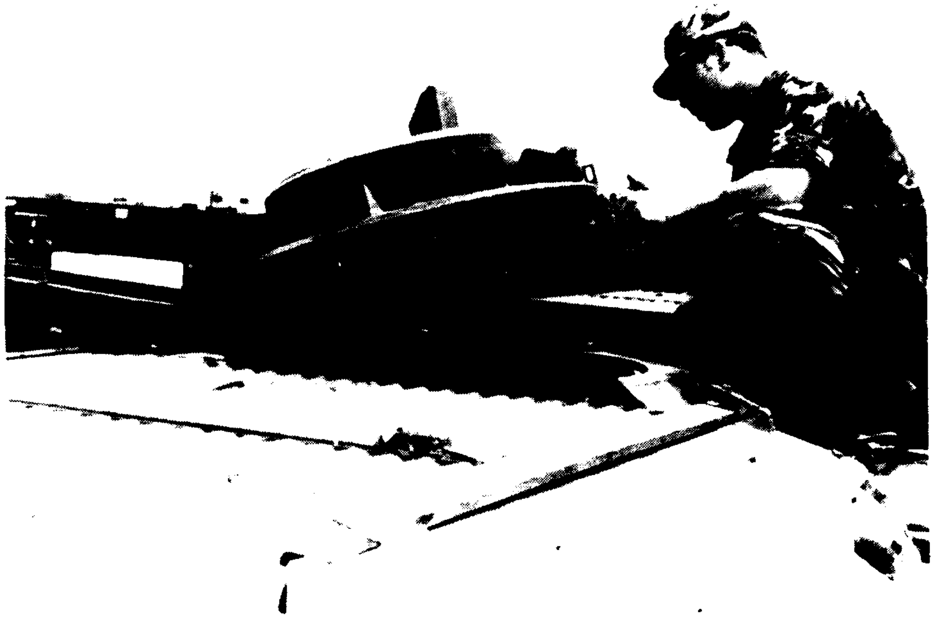


Figure 33. Mechanic grasping the paddle lock bracket to open the hatch. (The night vision periscope is in place above the driver's hatch.)

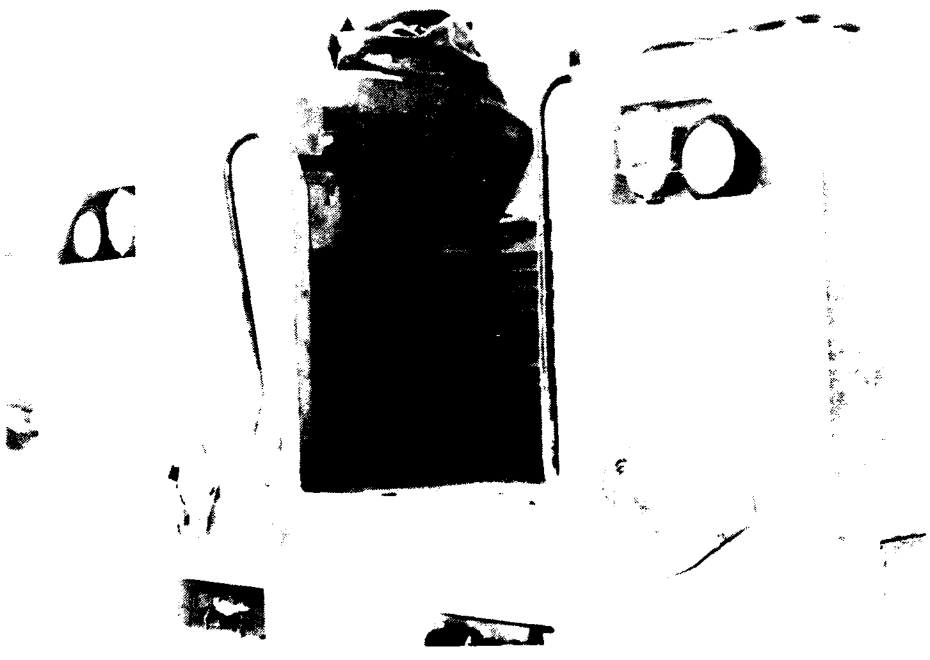


Figure 34. Gear stowed in the open hatch and the damaged jerry can holders.

Safety Hazard: Driver's Station Location and Windshields.

Description of the Safety Hazard: Figure 35 shows a shattered windshield and dented frame on an M9. Windshields were broken on all of the M9 vehicles during the test. The windshields were struck by tree limbs. The broken windshields resulted from having the driver's station located on the far left side of the vehicle. In this position, the operator is seated very close to objects along the side of the vehicle that may strike him or the windshield.

Implications for the Operator and the Equipment: The operator has the greatest probability of being struck when the vehicle is driven in reverse during darkness. The operator is unprotected from the rear and tree limbs extending over the top of the vehicle are difficult to see.

All of the operators reported preferring to have the windshields in place on the vehicles rather than folded down. The windshields were preferred because they offered protection from dust, airborne debris, and tree limbs.

Potential Solutions: Add protective structures to deflect tree limbs and other objects in several locations, including:

1. The left side and forward of the windshield.
2. The left side and along the side of the driver's station.
3. The left side and behind the driver's station.

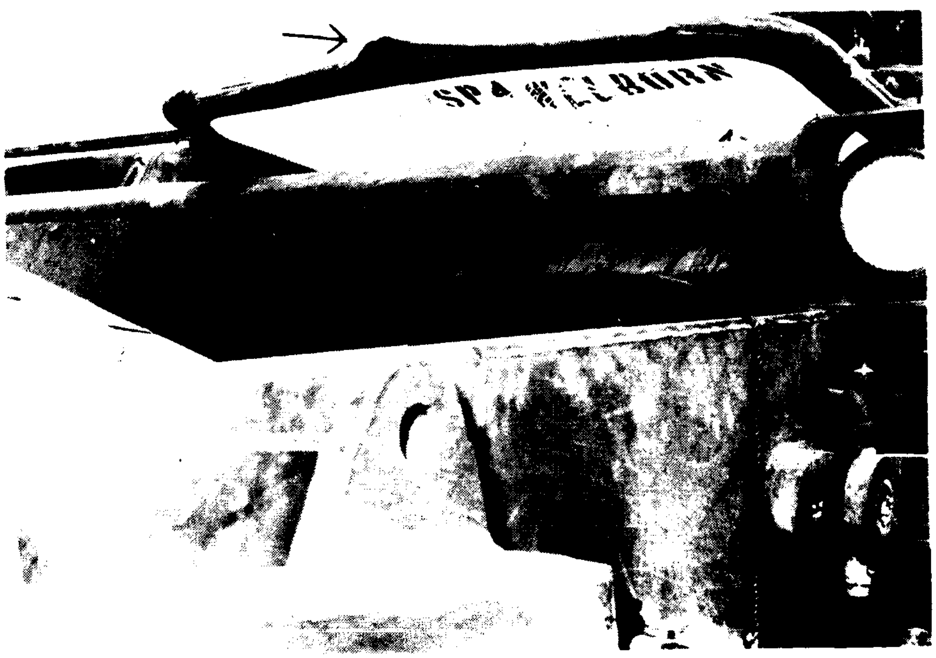


Figure 35. A shattered windshield and damaged windshield frame.

Safety Hazard: Folding the Dozer Blade.

Description of the Safety Hazard: Two operators reported that folding the dozer blade was hazardous. Figure 36 shows an operator crawling beneath the dozer blade in order to attach a chain to a shackle beneath the blade. The vehicle suspension must be raised (sprung) and supported with blocks in order to prevent the dozer blade from descending on the operator as a result of pressure changes in the hydraulic system. The support blocks were unavailable in the field and earth berms, which could collapse, were used to support the dozer blade.

The procedures used to fold the dozer blade include:

1. positioning blocks beneath the dozer blade
2. removing the dozer blade lock pins
3. extending the ejector blade.
4. attaching a chain to the top of the ejector blade and positioning the chain down the center of the dozer blade (Fig. 37)
5. attaching the chain to the shackle beneath the dozer blade
6. retracting the ejector blade which pulls the chain and folds the lower dozer blade up (Fig. 38)
7. locking the dozer blade latches that secure the lower dozer blade in place
8. removing and stowing the chain.

Figure 36. An operator crawling beneath the dozer blade in order to attach the chain to a shackle.

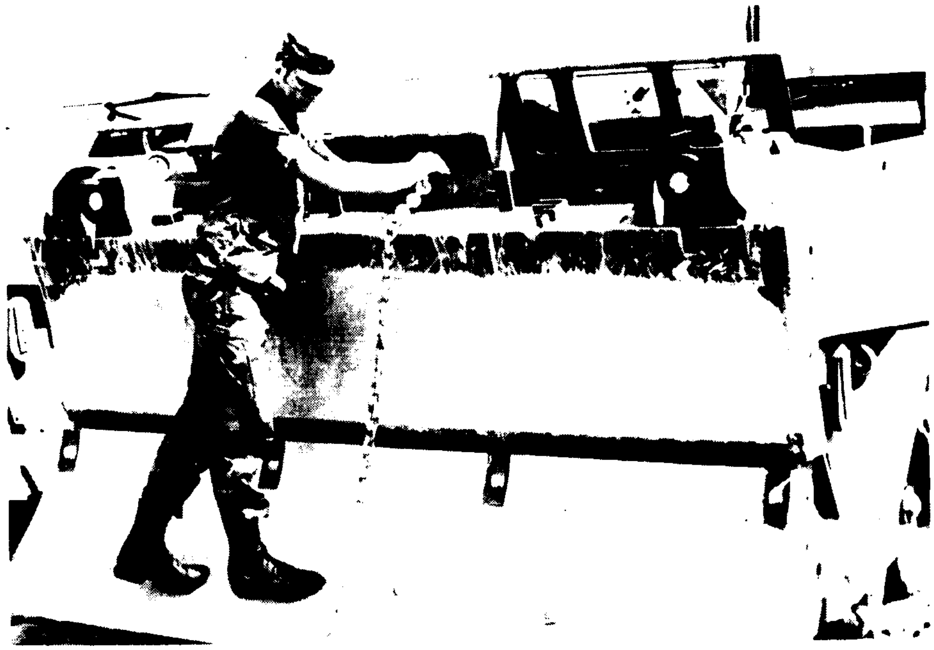


Figure 37. An operator attaching the chain to the ejector blade and positioning it down the center of the dozer blade. (NOTE: The chain passes through the stowage area above the dozer blade.)

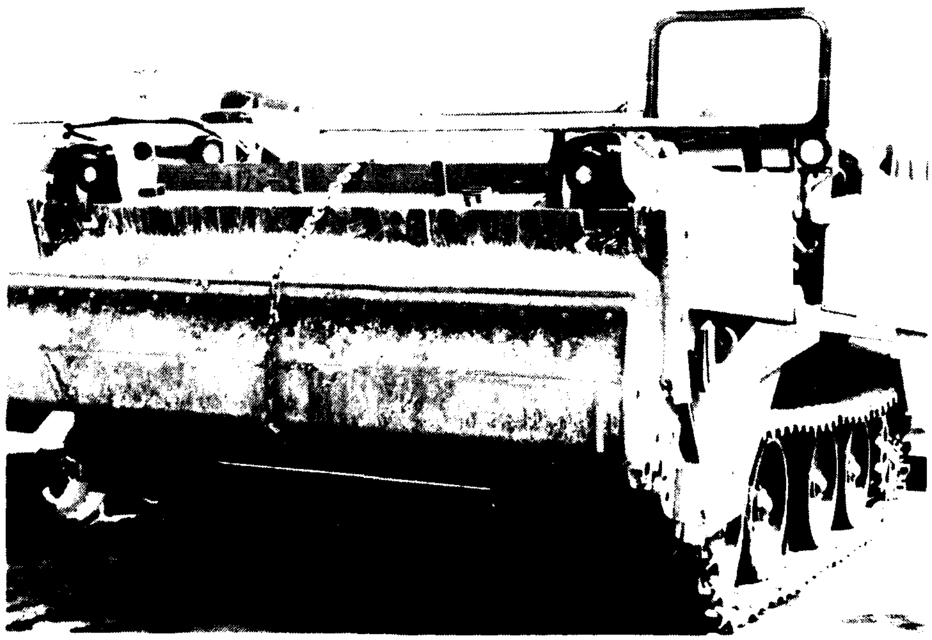


Figure 38. The folded dozer blade and chain position.

An alternative to the procedures involves raising the apron and dozer blade allowing the operator to stand beneath the dozer blade to attach the chain. However, the additional steps add approximately 15 minutes to the 20 to 30 minutes procedure. The additional time results from removing and replacing the apron pins (see Deficiency: Apron and Dozer Blade Lock Pins, pg 64). Moreover, unless the apron is fully raised and locked with its safety pins (making the shackle difficult to reach) the dozer blade and apron could fall on the operator, again as a result of pressure changes in the hydraulic system.

Implications for the Operator and the Equipment: Severe injury or the death of an operator may occur if the dozer blade were to descend on an operator. The dozer blade may need to be folded frequently in the field. However, the blade was folded infrequently during the test due to the time required to do so. Blocks to support the suspension seldom are available in the field and the procedure is likely to be omitted. Raising the apron and dozer blade, as an alternative procedure to reaching under the lowered blade, is time consuming and is likely to be omitted.

Other Affected Tasks and Equipment Functions: Folding the dozer blade is discussed in the operator's manual as an optional procedure. However, the procedure should be required due to the safety hazard that results when the blade strikes the ground during cross country travel (see Deficiency: Dozer Blade Clearance, pg 90). Unless the M9 is modified to speed the folding of the dozer blade, a great deal of time will be required to prepare the vehicle for travel. The time required to perform the procedure may not be available when the M9 operates with rapidly moving armored units.

The chain used to fold the dozer blade damaged the upper edge of the blade. When the ejector blade was retracted, raising the lower dozer blade up, the chain abraded the upper edge of the dozer blade. The chain also interfered with the dozer blade stowage area. The stowage area on top of the the dozer blade must be cleared of stowed items before the chain can be placed in position.

Potential Solutions: The dozer blade should be hydraulically folded. This might be accomplished by fully raising the dozer blade and apron. Some other mechanism (to be developed) might be positioned beneath the raised dozer blade. As the dozer blade descends the other mechanism would push on the blade, causing it to fold. The other mechanism might be manually positioned. Thus, adding additional hydraulic cylinders would not be necessary.

Safety Hazard: Flammable Hydraulic Fluid.

Description of the Safety Hazard: The M9 uses a standard 10w hydraulic fluid in its hydraulic systems. The hydraulic fluid is flammable and is likely to ignite if struck by schrapnel or weapons fire.

Implications for the Operator and the Equipment: The dip stick port for the hydraulic fluid reservoirs is located in the driver's station. Moreover, there are numerous hydraulic components and lines in the vehicle. Thus, a hydraulic fluid fire is likely to engulf the operator and the vehicle.

Other Affected Tasks and Equipment Functions: Several hydraulic lines are mounted on the rear wall of the bowl. If fluid leaks and collects in the bowl, it might be ignited by fragments of burning phosphorous from the firing of the smoke grenade launcher.

Potential Solutions: Modify the hydraulic system, allowing it to operating using nonflammable hydraulic fluid.

Safety Hazard: Slippery Walking Surfaces.

Description of the Safety Hazard: All seven of the M9 operators reported that the slippery walking surfaces of the M9 ACE were hazards. Five of the operators reported having slippped and fallen. Two operators fell from the upper engine grilles into the bowl (a distance of 5.5 ft. (1.8 m) when the bowl is empty). No severe injuries resulted.

The slippery walking surfaces include:

1. the sloped top of the radiator housing,

2. the sloped forward edge of the engine housing,

3. the upper vented engine grilles,

4. the upper surface of the track wells, inside of the bowl,

5. the surface of the foot space below the apron cylinder armature on the side of the vehicle,

6. the upper surfaces of the edges of the bowl formed by the apron mechanism,

7. the floor surface of the operator's cab.

Implications for the Operator and the Equipment: Slip and fall accidents are likely, especially when the surfaces are wet or muddy. Moreover, mud on the operators' boots can make the surfaces slippery. The operator might fall from the top of the vehicle to the ground, a distance of more than 6 ft. (2 m) when the suspension is raised (sprung).

Other Affected Tasks and Equipment Functions: Three of the seven operators reported having difficult maintaining their footing while loading the smoke grenade launcher as the mechanism is located on the forward sloping edge of the engine housing. The operators also reported that it was difficult to maintain their footing on the engine grilles while removing the grilles and while servicing the engine. Footing was also difficult to maintain when operators climbed into and out of the bowl to obtain tools or to check for hydraulic leaks behind the ejector blade. Maintaining safe footing was difficult before and after amphibious operations. Amphibious operations often occur in muddy terrain and water crossings make vehicle surfaces wet.

Potential Solutions: Granulated material might be added to the vehicle's paint to provide a rough texture to the surfaces. Walking surfaces that are used frequently (ie., the engine grilles, radiator housing, and forward engine housing) should have raised or notched surfaces to provide maximum traction for walking.

Safety Hazard: Steps and Handrails.

Description of the Safety Hazard: Figure 39 shows the crushed rear steps and handrails on the rear of the M9. The rear lower cable step snagged on objects and the cables and steps were broken. The rear upper platform step was crushed on all the vehicles. The handrails were bent on many of the vehicles. Scraped metal on the handrails had burrs that would stab the operator's hand.

Several locations need additional steps and handrails, and include:

1. The radiator housing. Figure 40 shows an operator trying to step down from the radiator housing.

2. The smoke grenade launcher area including the sloped deck above the tool box.

3. The right and left apron cylinder areas used by personnel to enter or exit the bowl. Figure 41 shows an operator climbing up by the apron cylinder in order to see into the bowl.

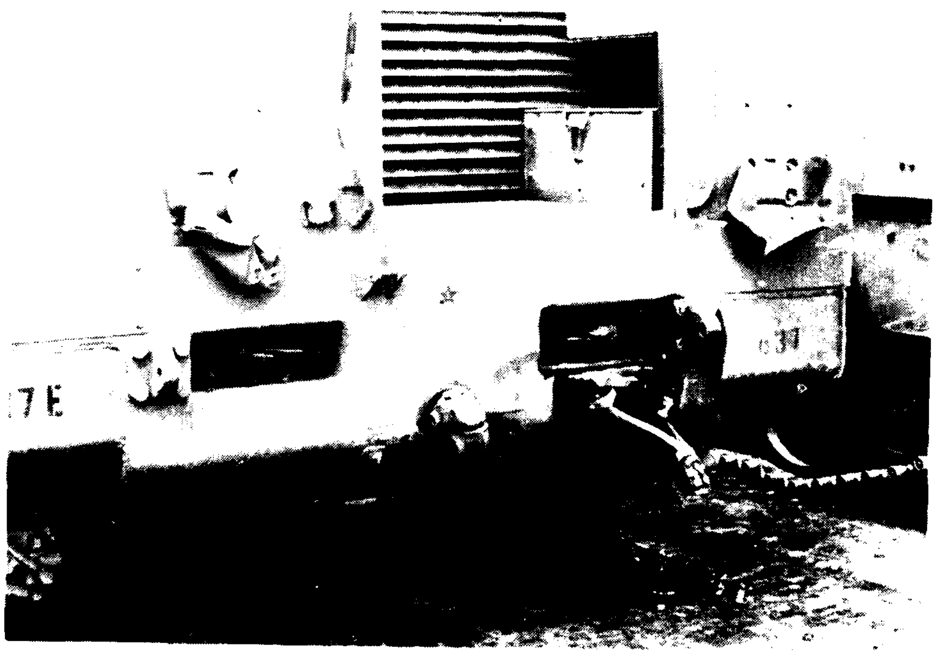


Figure 39. The crushed rear step and handrail.

Figure 40. An operator stepping down from the radiator housing.

Figure 41. The route operators use to climb in and out of the bowl.

Implications for the Operator and the Equipment: Slip and fall accidents are likely, especially when existing steps and handholds are damaged.

Potential Solutions: Add steps and handholds designed according to MIL-STD-1472C. Specific suggestions include:

1. Add a protective rear bumper to the vehicle. The bumper should extend across the lower rear and up the sides of the rear of the vehicle. The bumper should protrude far enough to protect the rear handrails and any other structures on the rear of the vehicle. The rear steps should be incorporated into the rear bumper. The bumper would also protect stowed equipment on the rear of the vehicle (see Deficiency: Insufficient Stowage Space and Secure Locations for Stowage, pg 49).

2. Steps should be added to the radiator housing so that the operators can safely climb up to and down from the engine grilles.

3. Handholds should be positioned close to the smoke grenade launcher to help the operators maintin their balance when loading the launcher or accessing the tool box.

4. A nonslip, notched surface should be added to the flat areas below the right and left apron cylinders. This is where personnel step in order to enter or exit the bowl. Handholds should be positioned on top of the aprons to help the operators maintain their balance when climbing into or out of the bowl.

Safety Hazard: Engine Access Grilles.

Description of the Safety Hazard: Figure 42 shows the eight engine access grilles in place above the engine. Three mechanics and four operators reported that the weight of the exhaust grilles (approximately 50 lbs (22.6 kg)) discouraged the operators from performing PMCS checks. Moreover, there is no safe way to stand above the grilles to remove them as the surfaces in front and to the rear of the grilles are sloped and slippery (safety hazard).

Implications for the Mechanic, the Operator, and the Equipment: PMCS maintenance checks of the engine may be postponed or omitted. Time is consumed removing and installing the grilles. The grilles are thrown or dropped into the bowl or onto the rear deck, possibly causing equipment damage. Lifting the grilles is likely to cause back injury to the operators who must stand awkwardly when lifting them.

Other Affected Tasks or Equipment Functions: The grilles are removed and dropped more frequently onto the rear deck than into the bowl. The grilles on the rear deck block the rear door opening and create a serious tripping hazard in the primary ingress and egress route.

Potential Solutions:

1. Reduce the weight of the grilles. Use a lighter material for the grilles other than steel (ie., aluminum).

2. Make the grille sections into one piece that is hinged and can be raised and supported like the hood of a truck.

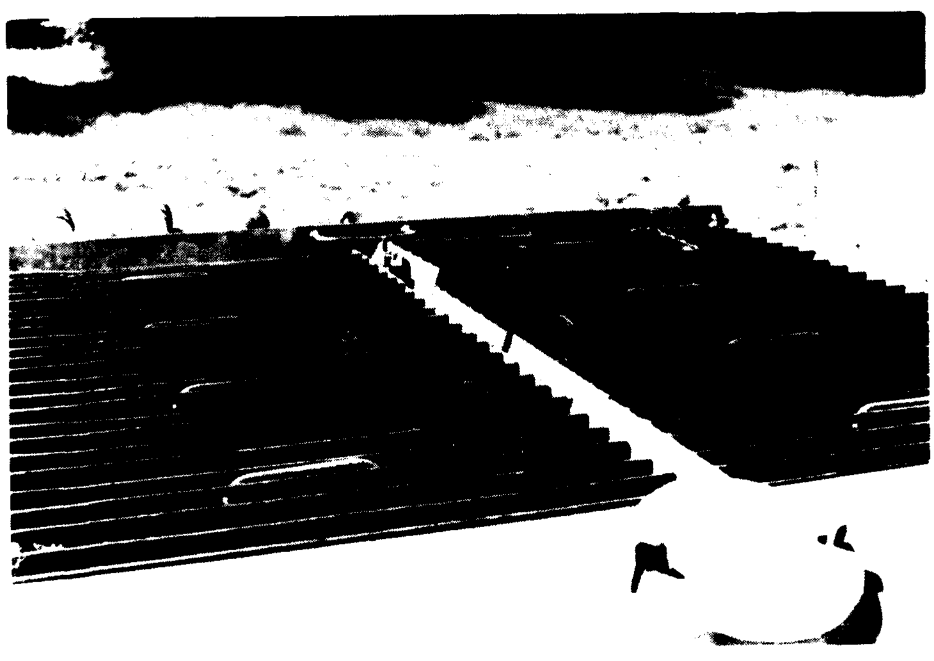


Figure 42. The eight engine grille panels.

Safety Hazard: Amphibious Operations.

Description of the Safety Hazard: Operators experienced several problems during amphibious operations that could cause injury to the operator or loss of the vehicle. The problems include:

1. The bilge pump is powered hydraulically by the power pack and will cease pumping if the engine stalls.

2. The two lower boxes of the double box frame that support the actuators trap water and are not drained by the bilge pump. The operators reported that the free board (the amount of the vehicle's hull remaining above water) is reduced from six inches to three inches.

3. When the bilge pump is operating, other hydraulic functions do not operate. This may be critical when the suspension or dozer blade need to be adjusted for egress while the vehicle is still in the water.

4. The steering of the vehicle is extremely sensitive because the CB (clutch brake) steering is used. This makes it extremely difficult for the operator to operate other controls.

Implications for the Operator and the Equipment: It requires approximately two hours to prepare the vehicle for amphibious operations and two hours to prepare the vehicle after amphibious operations. Most of the time is consumed removing and installing armor plates. Should the operator suspect that the vehicle will come under hostile fire during amphibious operations, it is not likely that he will remove the armor and place it in the bowl. The stability, steering and freeboard problems will become more severe.

The bilge pump was shut off when the vehicle adjusted its suspension in order to dig an egress ramp from the water. At this point, the M9 had already leaked water onboard and with the bilge pump off, the M9 continued to fill with water. The M9 frequently became stuck during its egress from the water due to the added weight of the water. Unless the bilge pump can remain on during the vehicle's egress from the water, the vehicle may become mired.

Potential Solutions: Suggestions to improve amphibious operations include:

1. Add an electrically driven bilge pump that will not stop pumping should the engine stall. An electrically driven bilge pump would not interfere with the use of other hydraulic functions.

2. The double box frame should be modified to drain into the bilge pump sump.

3. The bilge pump should have the necessary capacity to pump the additional water seepage that occurs when the armor is left in place.

4. Add a track skirt similar to the ones used on the M113 APC. This may help the operator control the direction of travel when the M9 is swimming.

Suggestions to improve the time required to prepare the M9 for amphibious operations include:

1. Make the dozer blade latch pins and apron pins easier to remove and install; such as tapering the pins and adding quick release mechanisms.

2. Make the M9 swimmable and controllable without removing its armor.

3. Hydraulically fold the blade or find some other way to do it more rapidly than it is done.

4. Place handholds on the top edge of the rear door, making it easier to handle and install.

Safety Hazard: Winch Operations.

Description of the Safety Hazard: Figure 43 shows a frayed and broken winch cable improperly wrapped on the winch spool. Operators experienced several problems using the winch and many problems resulted in wire rope failure. The problems included:

1. There was no winch brake on the winch.

2. The winch had to be moving in order to shift gears.

3. The winch capacity is only 30,000 lbs, while the vehicle weighs approximately 55,000 lbs, when the bowl is full and the vehicle is likely to become stuck. Most of the wire rope failures occurred during self-recovery operations.

4. The wire rope wrapped itself unevenly on the drum which causes damage to the wire rope. The operators could not see whether the wire rope was wrapped appropriately as the winch was spooling it in.

Implications for the Operator and the Equipment: The winch is under capacity for most self-recovery operations. Often another M9 would use its winch in combination with the winch on the stuck M9 (double winching), yet cables broke when the double winching method was used. The depth of mud in which the M9 is mired doubles or triples the weight capacity required of the winch in order to pull the mired vehicles (FM 17-20). Thus, a winch capacity of 30,000 lbs is insufficient for a combat loaded M9 weighing 34,800 lbs with its bowl empty and mired up to its hull (a depth of mire that doubles the weight factor of the vehicle by friction and suction to approximately 68,000 lbs). Shackles and snatch blocks can be used to increase the mechanical advantage of the winch by folding the wire rope. However, shackles and snatch blocks limit the length the wire rope can be extended (refer to FM 17-20).

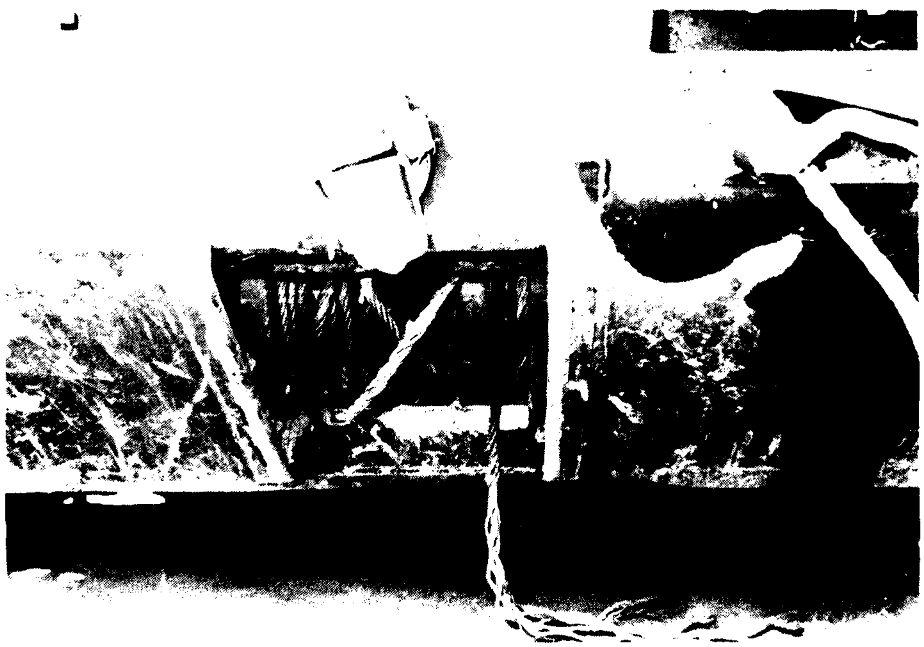


Figure 43. A damaged winch cable and the cable unevenly wrapped on the winch drum.

Safety Hazard: Fire Extinguishers.

Description of the Safety Hazard: Table 22 lists the operators' responses concerning the adequacy of the M9 fire extinguishing system. The operators rated the locations of the fire extinguisher handle and the portable unit as adequate (Means 3.5 and 3.9) because they can be reached in an emergency. However, Figure 44 shows a broken red handle on the right side of the vehicle's hull for the engine compartment fire extinguisher. The red handles were broken on seven of the M9s during the FOE. The red handles were struck by tree limbs and other objects while the M9 constructed combat roads. At least three incidents resulted in activation of the fire extinguishers.

Figure 45 shows the control valve at the top of the fire extinguisher canister in the engine compartment. Three mechanics reported striking the control valve accidentally while they performed maintenance tasks in the engine compartment. Striking the control valve activated and drained the canister. The control valve is exposed and easily struck.

Implications for the Operator and the Equipment: Extinguishing muffler fires, or accidentally draining the canister in the engine compartment reduces the capacity of the fire extinguisher system. Replacing or refilling the fire extinguishers during extended operations may not be possible.

Potential Solutions: The red handles should be positioned in a deeper inset. The inset should have a red colored protective cover that can be opened quickly or removed in order to activate the fire extinguisher. The control valve above the canister in the engine compartment should be covered so that it cannot be accidentally activated.

Table 22

Adequacy of the Fire Extinguishing System

	Number of responses						
System component	Very adeq 5	Adeq 4	Mar-ginal 3	Inadeq 2	Very inadeq 1	Mean	SD
Location of the external red handles	1	6	0	1	1	3.5	1.23
Location of the portable extinguisher	2	6	0	0	1	3.9	1.34
Overall adequacy of the fire suppression system	1	5	1	0	0	4.0	0.57

Figure 44. The external, red handle for the engine fire extinguisher.

Figure 45. The fire extinguisher valve above the canister.

Safety Hazard: Muffler Fires.

Description of the Safety Hazard: Table 23 lists the number of muffler fires having occurred on M9s during the test. Figure 46 shows an operator using a fire extinguisher to extinguish a fire. Operators reported that 16 fires occurred on their vehicles. The fires were caused by debris (sticks, leaves, and grass) collecting in the well surrounding the muffler and exhaust pipe. Several of the fires were extinguished using the fire extinguisher from the driver's station.

Table 23

The Number of Muffler Fires Aboard the M9 ACE Reported by Operators

	Vehicles having fires	Number of fires on each vehicle
	M901	1
	M902	2
	M903	2
	M905	4
	M906	3
	M907	4
Totals	6 vehicles	16 fires

Implications for the Operator and the Equipment: The operators were able to extinguish the fires before serious equipment damage occurred. Radio cables close to the muffler were occasionally burned. The operators' hand-held fire extinguishers were often empty as a result of extinguishing muffler fires. The operators' fire extinguishers were not available for additional fire emergencies. Four operators reported that the capacity of the handheld fire extinguisher was insufficient.

Potential Solutions: Add a metal plate above the muffler well that prevents debris from collecting in the well.

Figure 46. An operator extinguishing a fire in the muffler well.

Safety Hazard: Dozer Blade Clearance.

Description of the Safety Hazard: Six operators reported that the dozer blade strikes the ground when the vehicle travels cross country or on rough secondary roads. The blade often catches on raised portions of earth or in dips, forcibly jarring the vehicle. The operator is pitched forward in the driver's station. Occasionally, the vehicle is stopped abruptly. The vehicle rocks back and forth (low frequency vibration) when it is traveling on rough terrain. The rocking reduces the ground clearance of the dozer blade.

Implications for the Operator and the Equipment: The probability of injury to the operator is greatest when the M9 travels at night because rough terrain is difficult to see and avoid. Injury to the operator is likely when the hatch is closed because of the design of the hatch. The night vision periscope and vision blocks are very close to the operator's head. The operator's head and face may strike the hatch features.

Potential Solutions: The operator's manual displays a caution concerning traveling with the dozer blade unfolded. Folding the dozer blade is described as an optional procedure. However, the operator should be required to fold the dozer blade when the M9 travels between work sites. Folding the dozer blade provides approximately 10 in (25.4 cm) of additional clearance between the ground and the lower edge of the scraper blade when the vehicle's suspension is raised. Moreover, the stability provided by the suspension should be increased in order to decrease the rocking motion of the vehicle.

Safety Hazard: Driver's Seat Belt.

Description of the Safety Hazard: The seat belt does not remain tight around the operator's waist as the seat is adjusted down. The right end of the belt is attached to the seat frame while the left end of the belt is attached below the seat to the wall of the driver's station. Thus, lowering the seat loosens the seat belt.

Implications for the Operator and the Equipment: Retightening the seat belt was often overlooked by the operators. Two operators reported that the loosened seat belt caught on the seat adjustment lever, causing the lever to unlatch and drop the seat. The seat belt is most likely to be loose when the operator lowers the seat to operate with the hatch closed. However, having the seat belt worn tightly when the hatch is closed is important due to the closeness of the hatch features to the operator's face (see Deficiency: Driver's Station Hatch, pg 70), and the possibility that the operator may strike the features.

Potential Solutions: Attach both ends of the seat belt to the seat frame. Another alternative solution might be to add a device that removes the slack in the seat belt by automatically tightening it.

Safety Hazard: No Warnings.

Description of the Safety Hazard: There were no warning plates on the vehicle for several potential hazards, including:

1. Blocking the hull suspension for maintenance beneath the hull and for folding the dozer blade.

2. Using the apron lock pins appropriately.

3. Avoiding burning oneself on the hot engine grilles and radiator housing.

4. Protecting hearing from excessive noise.

5. Keeping the bilge pump on at all times when the vehicle is in the water.

6. Using the winch with less than four turns of wire rope on the drum. Using the winch to pull a load with the winch lever in high speed.

7. The vehicle must be driven in reverse up steep slopes.

Potential Solutions: Add the warning plates according to MIL-STD-1472C. Warnings should be located where they are most likely to be seen. The safety problem and its warning plate should be eliminated if possible.

M9 Maintenance

Table 24 lists the M9 mechanics' responses concerning vehicle maintainability. Table 25 lists the difficulties mechanics encountered on the M9 when they performed general maintenance tasks. Human factors deficiencies and safety hazards requiring expanded descriptions follow the tables.

Table 24

M9 ACE Mechanics' Responses Concerning Vehicle Maintainability

Topic and Question	Number of Responses				Mechanics' Comments
Tools and test equipment					
Were there times when field repairs were difficult to make because the proper tools were not available in the mechanic's tool kit?	5	Yes	3	No	Need a complete contact truck. Additional tools requested: a. More than two hydraulic reservoir stoppers b. Road arm puller c. Torque wrenches d. More than one dog bone e. Larger wrenches, 1-1/16 and greater f. Tow cable
Were there times when field repairs were difficult to make because the proper test equipment was not available to the mechanics?	4	Yes	4	No	Additional test equipment requested: a. Simplified test equipment (STE-ICE) b. Hydraulic test kit adapters c. Multimeter d. Gauges for accumulator e. Troubleshooting test for hydraulics f. Vacuum gauge and timing light
Access panels and lube points					
Are there any access panels that are difficult to remove?	3	Yes	6	No	Difficult to get to the panels beneath the vehicle in the field. Apron cylinders are behind the armor.

Table 24 (cont'd)

Topic and Question	Number of Responses				Mechanics' Comments
Are there any lubrication points that are difficult to locate?	3	Yes	3	No	Lube points difficult to locate or access: a. Drive line b. Universal joints c. Steer unit d. Brake crossover shaft e. Apron cylinder
Are there any lubrication points that are difficult to lube properly with a grease gun?	3	Yes	2	No	Lube points that cannot be properly lubed with a grease gun: a. Drive shaft b. Universal joints c. Steer unit d. Left brake lever
<u>PMCS maintenance</u>					
Overall, how complete are the listed PMCS checklist procedures?	3 3 1	Complete Marginal Incomplete			Need to rework procedures. Should make batteries a daily check instead of weekly.
Were the PMCS checklist procedures properly followed by operators and mechanics?	By operators: 3 By mechanics: 5	 Yes Yes	 2 1	 No No	Shortcutting procedures and laziness became a problem. The procedures were rushed many times due to missions.
Are all PMCS checkpoints easy to find and service?	Easy to find: 5 Easy to service: 5	 Yes Yes	 0 0	 No No	Same comments as those for the lubrication points.
<u>Maintenance manuals</u>					
Overall, were the maintenance manuals easy to read and complete with all instructions?	Easy to read: 8 Complete with all instructions: 1	 Yes Yes	 1 8	 No No	Incomplete or incorrect procedures: a. Changing roadwheels b. Removing fire extinguishers The manuals didn't explain fully how to repair components. The instructions jumped from one section to another. Time consuming to search and read.

Table 24 (cont'd)

Topic and Question	Number of Responses				Mechanics' Comments
Can mechanics find the necessary parts and stock numbers in the -20 and -34 series maintenance manuals?	-20 manuals				No comments.
	Find parts:				
	7	Yes	0	No	
	Find stock numbers:				
	7	Yes	1	No	
	-34 manuals				
	Find parts:				
	8	Yes	1	No	
	Find stock numbers:				
	8	Yes	1	No	
Repair parts supply					
Does the PLL contain the right type and quantity of repair parts to support maintenance activities?	5	Yes	2	No	All parts were provided from outside sources.
Does the ASC contain the right type and quantity of repair parts to support maintenance activities?	5	Yes	1	No	No comments.
Manpower and staffing					
Are a sufficient number of mechanics assigned at the following levels to adequately maintain vehicles?					
Organizational level	6	Yes	1	No	Only one mechanic per vehicle is needed during heavy usage.
Direct support level	4	Yes	4	No	Only two were trained. Other mechanics could not perform much work.
General support level	4	Yes	2	No	No need according to the MAC chart. More work could be done at the general support level.

Table 25

Difficulties Encountered on the M9 ACE When Mechanics Performed General Maintenance Tasks

Maintenance task	No. of mechanics reporting difficulties	Decription of difficulty based on mechanics' comments
Gaining access to the vehicle's batteries and checking fluid levels.	4	Blocked by the radio mount. Cannot inspect furthest fluid ports or cable terminals. Cannot quickly remove and replace batteries due to the radio mount.
Gaining access to the engine.	3	Removing and replacing the heavy grilles discourages the operators from checking engine fluid levels.
Gaining access to the transmission.	8	Must remove the engine in order to repair the transmission or access the sending unit. Need a quicker way to access all of the components through the hull.
Gaining access to the final drives.	2	Blocked by the hull.
Checking final drive fluid levels.	4	Need a way to check the fluid levels without draining and measuring the fluid. There should be a dipstick.
Gaining access to the drive shaft.	3	The drive shaft grease fittings are very difficult to reach.
Removing the drive shaft.	1	The ejector cylinder must be removed in order to remove the drive shaft.
Gaining access to the suspension system.	3	The hull blocks access to the actuator line. No way to rapidly troubleshoot hydraulic problems.

Table 25 (cont'd)

Maintenance task	No. of mechanics reporting difficulties	Decription of difficulty based on mechanics' comments
Servicing the apron cylinders.	2	Blocked by an armor panel. Time consuming to remove armor panel. Manual states an incorrect tension.
Checking and adjusting track tension.	2	It can only be done on a paved surface.
Replacing cooling system hoses.	1	Cannot reach the lower end of the radiator hose. If no one can reach it the radiator must be removed. The radiator hose was being torn by being rubbed by the brake linkage.
Servicing the fan tower.	1	The fan tower belts are always breaking.
Servicing the brakes.	5	The left side brake cylinder is blocked by the ejector guide rollers.
Removing the steer unit.	3	Must remove the engine in order to remove the steer unit. The number 3 line to the steer unit is difficult to reach and remove.

Deficiency: Ejector Cylinder Location.

Description of the Deficiency: Figure 47 shows the ejector cylinder and blade fully extended. The ejector blade roller guides are the armatures on the left and right sides of the blade. The center positioned ejector cylinder must be removed in order to remove the engine and other major drive components. The left and right roller guides require frequent alignment and replacement of the roller bearings.

Implications for the Mechanic and the Equipment: Additional time is required to remove the ejector cylinder before other major components can be removed. Ejecting heavy loads from the bowl torques the cylinder and the roller guides affecting the reliability of these parts. Four operators also reported that they traveled with the ejector blade extended in order to stabilize the ride. Traveling on rough terrain with the ejector blade extended stressed the ejector cylinder, damaging the cylinder seals and changing the alignment. The roller guides bounce and are knocked out of alignment.

Potential Solutions: Add two ejector cylinders to the left and right side of the blade. Eliminate the single center cylinder and then modify and reduce the size of the left and right roller guides. The benefits include:

1. Rapid removal and replacement of other components.

2. More room would be available in the driver's station by eliminating the roller guide housing.

3. Increased reliability by providing balanced force as the ejector blade is extended and reducing problems of roller guide alignment.

Figure 47. The center ejector blade cylinder and left and right roller guide armatures.

Deficiency: Hydraulic Lines and Other Lines.

Description of the Deficiency: Figure 48 shows fluid lines connected to the engine manifold. Figure 49 shows hydraulic lines disconnected and tagged with numbered cards. When components are removed from the engine compartment, numerous hydraulic lines are disconnected. Numbered tags are attached to the lines to facilitate reconnecting the lines to their fittings. Two mechanics estimated that nearly 50 percent of the time required to perform maintenance was due to the time required to disconnect and tag lines.

Implications for the Mechanic and the Equipment: The M9 has many components that are operated hydraulically. Figure 50 shows the numerous hydraulic and other fluid lines at the rear wall of the bowl. During major repairs such as removal of the transmission, as many as 30 lines may have to be disconnected and removed. Each line and its corresponding fitting must be tagged with number cards so that mechanics can identify the line to reconnect it. Shortcutting the procedure resulted in incorrect hookups and frequent referrals to the maintenance manuals.

Potential Solutions: Many other military vehicles, such as the AVLB, have color coded hydraulic fittings and quick disconnect hydraulic couplers. Add quick disconnect couplers and a coding system to the hydraulic lines and fittings. The coding could be colors or numbers that match on the lines and the fittings they are connected to. Color codes are easy to identify. Numbers, however, can also be used as parts numbers when new lines and fittings are ordered. Moreover, the numbers can also be used in maintenance manual diagrams as reference numbers.

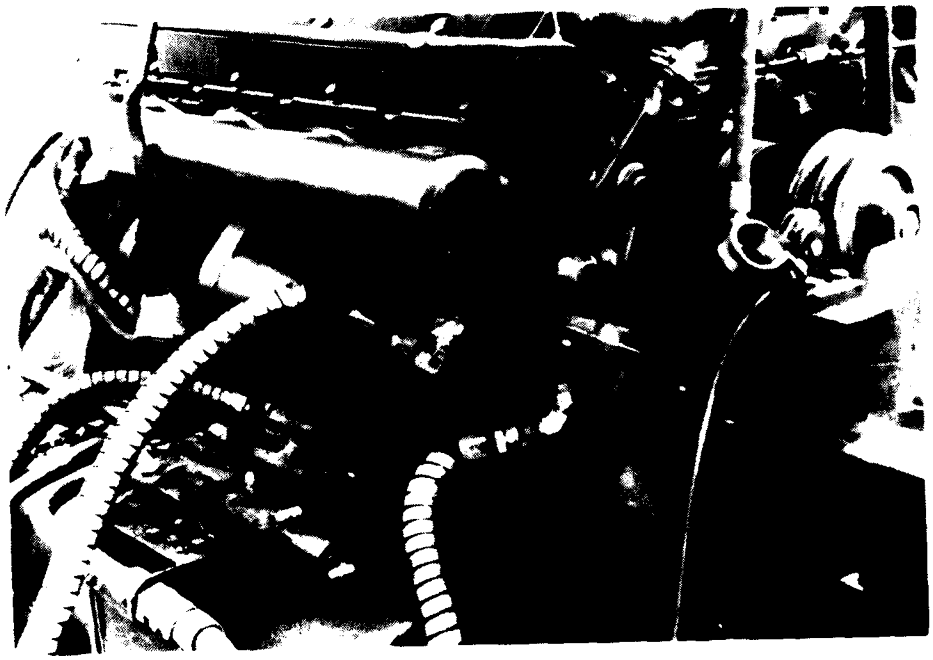


Figure 48. Fluid lines attached to the engine.

Figure 49. Tagged hydraulic fluid lines.

Figure 50. The fluid lines on the rear wall of the bowl.

Deficiency: Location of Lubrication Points.

Description of the Deficiency: Table 26 lists the lubrication points mechanics and operators found to be hard to reach. The table also lists potential solutions to correct the deficiency.

Implications for the Mechanic, the Operator, and the Equipment: Lubrication points that are difficult to reach are likely to be unnoticed or neglected during PMCS lube service. Equipment damage is likely to result.

Table 26

Difficult Lubrication Points to Service

Lubrication point	Potential solution
The fitting on the left brake control shaft is difficult to reach due to its position in the hull and its distance from the access opening.	Improve the size and location of the access openings.
The drive shaft lubrication points are very difficult to reach due to the small spaces between it and the other components.	No solution without major modifications.
The final drive fluid level can only be checked by draining and measuring the fluid.	Add a dipstick to the final drives.
Fig. 51 shows the armor plate covering the apron cylinder.	
The apron cylinders are behind armor plates which must be removed in order to lubricate the cylinders.	Add an opening in the lower right corner of the armor panel allowing the grease fittings to be accessed.
The fitting on the left track adjustment cylinder is difficult to reach due to its position under a brace.	No solution without major modifications.

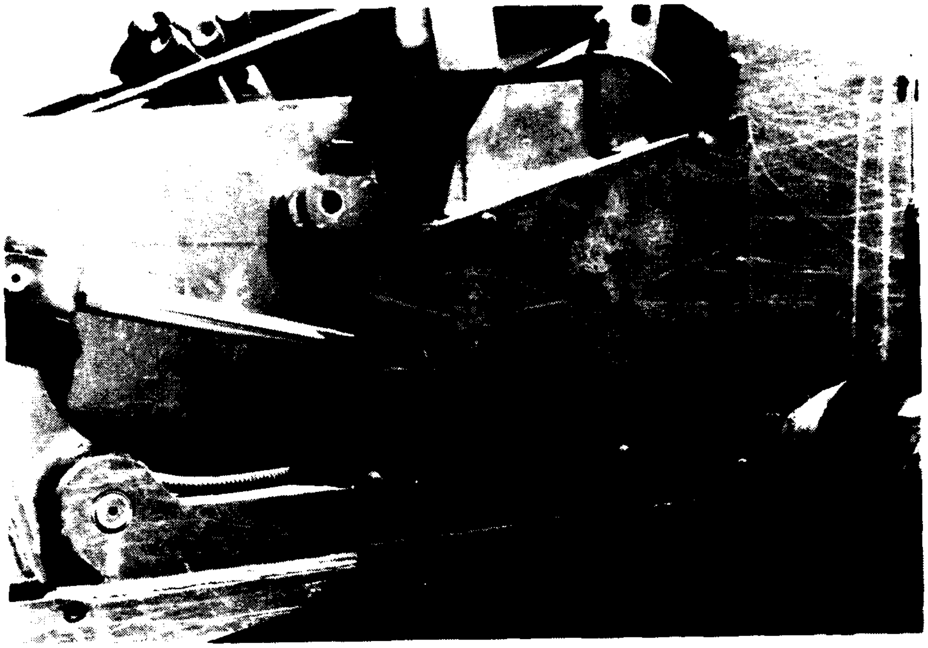


Figure 51. The armor plate covering the apron cylinder.

Deficiency: Location of the Batteries.

Description of the Deficiency: Figure 52 shows the battery box located beneath the radio box at the rear of the M9. Three operators and four mechanics reported that they could not see into the furthest battery ports or inspect the terminals because their view and reach were blocked by the radio box. The radio box is approximately 12 in (29 cm) above the batteries. The limited space also makes removing and replacing the batteries difficult.

Implications for the Mechanic, the Operator, and the Equipment: The battery fluid was frequently low due to the high temperatures created by the muffler and the radiator. The low fluid levels were often not detected during daily PMCS maintenance checks. Damage to the batteries may result.

Potential Solutions: The radio and batteries may need to be relocated. High temperatures generated by the muffler and radiator damaged the equipment during the test. If the hatch and driver's station are reconfigured, the radio might be placed in the driver's station and the battery box might be located above the fuel tank.

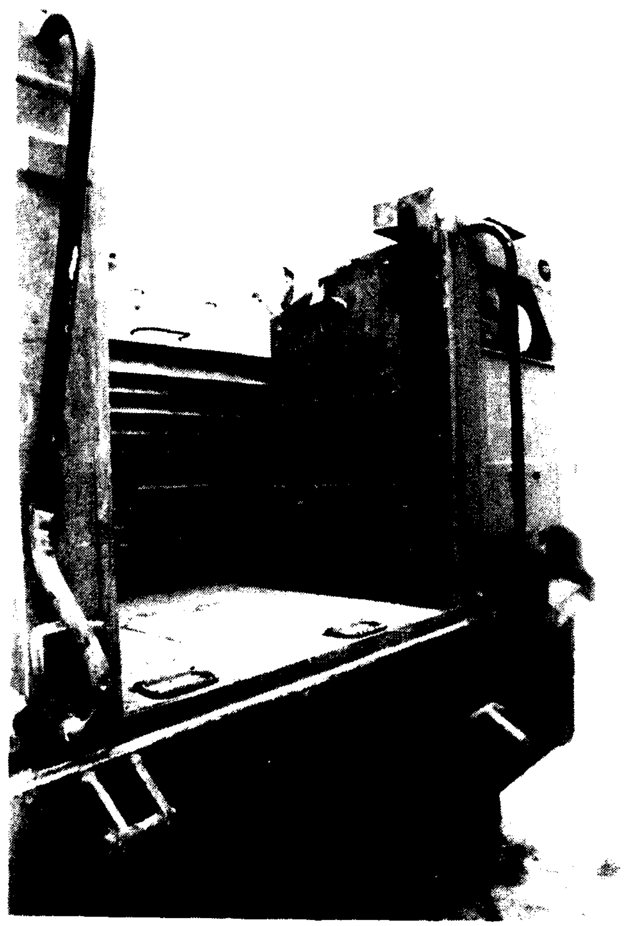


Figure 52. The location of the battery box below the radio box and behind the radiator grille.

Deficiency: Location of Transmission Sending Unit.

Description of the Deficiency: Eight mechanics reported that the engine must be removed in order to access or remove the transmission sending unit.

Implications for the Mechanic and the Equipment: Removing and replacing the transmission sending unit was a time-consuming task, possibly requiring several days to complete repairs.

Potential Solutions: Modify the transmission and the transmission sending unit so that the transmission sending unit is located below rather than above the transmission. Mechanics can then access and remove the sending unit from the access openings beneath the hull.

Safety Hazard: Roadwheel Changes.

Description of the Safety Hazard: Figure 53 shows a mechanic reaching into the roadwheels in order to hold a dog bone jack in place between the upper and lower portions of the track. Figure 54 shows the dog bone jack.

During the FOE, 187 roadwheels were removed and replaced on the M9 vehicles. One procedure used to replace roadwheels is to separate the track and drive the M9 off the track until the roadwheels were free of the upper track. However, the procedure was time consuming and was not considered by the mechanics to be an expedient procedure. Mechanics preferred to raise the upper track and roadwheel until the roadwheel was free of the upper and lower track guides. The track must be separated from the roadwheels in order to remove and replace the roadwheels. Raising and separating the track and roadwheels involves two problems:

1. Hydraulic jacks used to separate the track must be placed on hard stable ground. The jacks are not usable in most field situations due to soil and terrain conditions. Once during the test, a hydraulic jack collapsed during roadwheel changes. Moreover, the hydraulic jacks were seldom available on the contact trucks during the test.

2. Dog bone jacks are often used in the field. The dog bone jack is a large metal bar with notches in both ends. The dog bone jack is wedged between the lower track, on the inside edge of the track and the roadwheel armature. In order to wedge the dog bone jack into position, a mechanic must hold the jack in position by extending his arm across the lower track and between the roadwheels. While the mechanic is in this position, the operator must slowly drive the vehicle forward, wedging the jack between the upper and lower tracks. The track, roadwheel or jack could crush the mechanic's arm.

Implications for the Operator and the Equipment: Injury to the mechanic is likely when the dog bone jack is used. However, using the dog bone jack is the field expedient method for changing roadwheels. The dog bone jack is available on contact trucks and it can be used on less stable ground than is required for hydraulic jacks. Thus, mechanics will probably continue to use the dog bone jack regardless of the dangers involved in positioning it.

Potential Solutions:

1. Use the hydraulic jack only on hard paved surfaces.

2. Modify the dog bone jack to make it self-standing during positioning of the vehicle. This might be done by adding a hinged bipod to one side of the jack. The bipod would angle outward from the jack and wedge into the ground, creating a tripod of the jack.

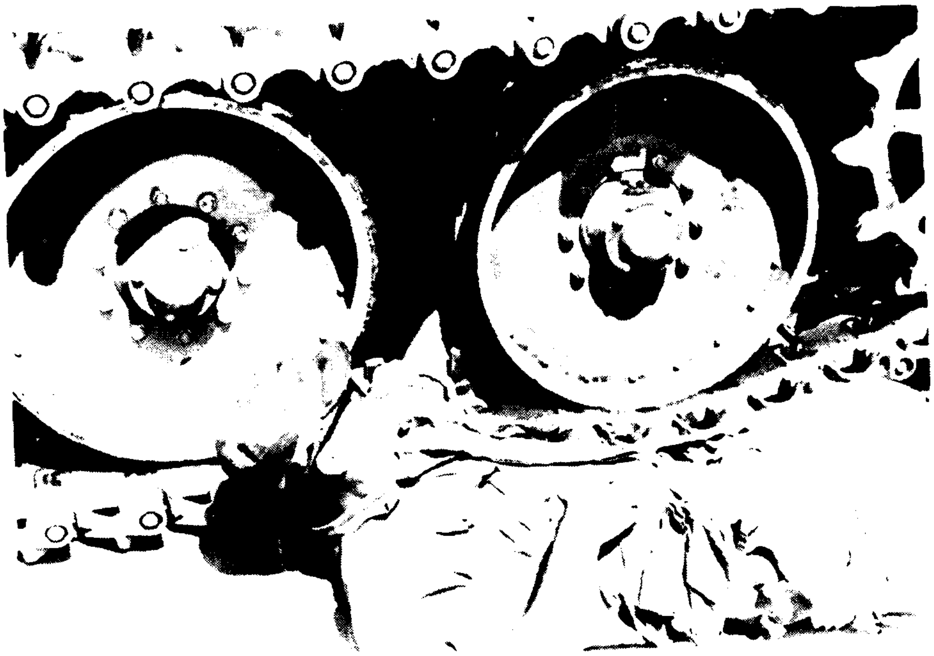


Figure 53. A mechanic reaching between the roadwheels to position the dog bone jack.

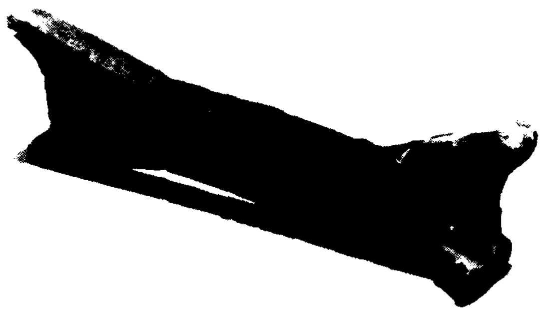


Figure 54. The dog bone jack.

Safety Hazard: Inspecting the Ejector Blade Guide Rollers.

Description of the Safety Hazard: Figure 55 shows a mechanic kneeling between the ejector blade and rear wall of the bowl. Mechanics must position themselves between the ejector blade, while it is moving, and the rear wall of the bowl in order to inspect the travel of the ejector blade rollers. The ejector blade rollers are positioned on two armatures that guide the left and right sides of the ejector blade. The armatures and rollers extend into the hull as the ejector blade is retracted. The mechanic must watch the travel of the roller guides to inspect the alignment of the rollers periodically and after replacement. While the mechanic is in this position, the operator must retract the ejector blade. The ejector blade could pinch or crush the mechanic.

Potential Solutions:

1. Modify the ejector blade or hull so that the mechanic can view the travel of the roller guides without having to position himself behind the ejector blade.

2. Replace the center ejector blade cylinder and the left and right roller guides with left and right ejector blade cylinders. This will also improve maintainability and the removal of components in the engine compartment.

Figure 55. A mechanic between the rear wall of the bowl (left) and ejector blade (right) inspecting the roller guides.

Safety Hazard: No Ejector Blade Lockout Device.

Description of the Safety Hazard: There is no lockout device on the ejector blade or its control to insure that the blade is not retracted accidentally when personnel are working between it and the rear wall of the bowl. The power pack and hydraulics must be operating in order for mechanics to perform several tasks involving equipment on the rear wall of the bowl. It is when the vehicle is idling that the ejector blade could be retracted accidentally.

Potential Solutions: Add a lockout device to the ejector blade control lever or to the ejector blade that prohibits it from being accidentally retracted or extended.

Operator and Mechanic Training

Operator training. Table 27 lists the operators' ratings of the pretest new equipment training (NET) for major M9 engineering tasks. Table 28 lists the operators' ratings of the pretest NET techniques. Most questionnaire items were given ratings of adequate. However, operators suggested a number of improvements they felt could be included in the training program; their comments follow the tables.

Table 27

The Operators' Ratings of the NET for Major M9 Engineering Tasks

Major tasks	Very adeq 5	Adeq 4	Marginal 3	Inadequate 2	Very inadeq 1	Mean	SD
Breach a road crater	1	4	1	1	0	3.7	0.95
Breach a tank ditch	1	5	0	1	0	3.9	0.89
Construct a combat trail	1	2	1	1	0	3.6	1.14
Construct a combat road	1	3	1	1	0	3.6	1.03
Self-recovery	0	5	1	1	0	3.6	0.78
Swim the ACE	1	6	0	0	0	5.8	0.37
Ford a waterway	1	5	0	0	0	4.2	0.44
Construct access and egress points	0	3	1	1	1	3.0	1.26
Construct antitank ditch	1	4	0	2	0	3.6	1.13
Construct defensive and defilade positions	1	5	1	1	0	3.8	0.86
Clear fields of fire	0	3	2	0	0	3.6	0.54
PMCS checks	3	6	0	0	0	4.3	0.50

Table 28

The Operators' Ratings of the NET Techniques

Training techniques	Very adeq 5	Adeq 4	Marginal 3	Inadequate 2	Very inadeq 1	Mean	SD
Length of training	2	1	2	3	0	3.3	1.28
Training literature	3	5	1	0	0	4.2	0.66
Demonstration of the vehicle capabilities	1	6	0	2	0	3.6	1.00
Demonstration of the equipment (ie., winch, bilge pump, ejector blade, etc.)	2	6	0	1	0	4.0	0.86
Hands-on exercises	2	4	1	1	0	3.8	0.99
Overall effectiveness of the training	1	5	2	0	0	3.8	0.64

Operators' comments concerning the NET included improving the training in the following areas:

1. Hands-on practice and demonstrations of the major tasks.
2. Driving the M9 up slopes in reverse.
3. Digging egress ramps after amphibious operations.
4. Demonstration of M9 self-recovery techniques and use of the winch.
5. Digging to the appropriate fighting position dimensions for the different combat vehicles.
6. Replacing roadwheels.

The overriding comment made by most of the operators was that the proper operation of the equipment and its use in engineering tasks should be demonstrated in the training. The M9 operating procedures were explained in the classroom and the operation of the equipment functions were demonstrated in the motor pool. Following the initial training, operators performed M9 tasks in the field. However, the operators felt that the demonstrations of the M9 performing tasks in the field should occur initially; thus, giving the operator a basis of experience to aid in their understanding of the technical instruction to follow.

One hundred and eighty five (185) roadwheels were replaced during the FOE. Operators should be trained to remove and replace roadwheels. During extended operations with armored units, the operator may be required to make roadwheel replacements rather than waiting for the maintenance contact truck to arrive.

Mechanic training. Table 29 lists the mechanics' ratings of the pretest NET for major M9 maintenance tasks. Table 30 lists the mechanics' ratings of the pretest NET techniques. Most questionnaire items were given ratings of adequate. However, mechanics suggested a number of improvements they felt could be included in the training program; their comments follow the tables.

Table 29

The Mechanics' Ratings of the NET for Major M9 Maintenance Tasks

Maintenance tasks	Very adeq 5	Adeq 4	Mar-ginal 3	Inade-quate 2	Very inadeq 1	Mean	SD
Power package assembly	2	6	0	1	0	4.0	0.86
Fuel system	3	4	1	0	0	4.3	0.70
Exhaust system	2	3	2	1	1	3.4	1.33
Electrical system	2	5	1	1	0	3.8	0.92
Transmission, torque converter	1	5	1	2	0	3.5	1.01
Transfer case assembly and final drives	1	7	1	0	0	4.0	0.50
Propeller shaft and universal joint	2	5	1	1	0	3.8	0.92
Steer unit assembly	2	2	3	2	0	3.4	1.13
Brakes	1	2	2	2	0	2.5	1.40
Trailer brake connections and controls	2	3	2	1	0	3.7	1.03
Wheels and tracks	2	3	1	0	1	4.1	0.75
Steering control & linkage	2	5	0	1	0	4.0	0.93
Towing attachments	3	4	1	0	0	4.3	0.70
Springs & shock absorbers	3	3	0	0	0	4.5	0.54
Body, chassis and hull accessory items	3	4	1	0	0	4.3	0.70
Hydraulic & fluid system	3	3	1	1	0	4.0	1.06

Table 29 (cont'd)

Maintenance tasks	Very adeq 5	Adeq 4	Mar-ginal 3	Inade-quate 2	Very inadeq 1	Mean	SD
Special purpose kits	0	4	2	0	0	3.6	0.51
Armament	0	2	2	1	0	3.2	1.80
Precision instruments	1	1	3	0	0	3.6	0.89
Scanning & signaling devices	0	1	3	0	0	3.3	0.50
Earthmoving equipment components	1	5	1	0	0	4.0	0.57
Body, cab, hood and hull	4	3	1	0	0	4.3	0.74
Winch assembly	1	5	2	0	0	3.8	0.64
Guards	3	4	1	1	0	4.0	1.06

Table 30

The Mechanics' Ratings of the NET Techniques

Training techniques	Very adeq 5	Adeq 4	Mar-ginal 3	Inade-quate 2	Very inadeq 1	Mean	SD
Length of training	2	2	3	1	1	3.2	1.48
Training literature	5	2	2	0	0	4.3	0.86
Demonstration of vehicle peculiar maintenance techniques	1	5	3	0	0	3.7	0.66
Demonstration of trouble-shooting procedures	1	5	2	1	0	3.5	1.13
Hands-on exercises	4	2	2	1	0	4.0	1.11
Overall effectiveness of the training	3	4	1	1	0	4.0	1.00

Mechanics' comments concerning the NET included improving the training in the following areas:

1. Increase the length of the training.
2. Add training on adjustment of the throttle control linkage.
3. Improve diagrams of the hydraulic system; show the routes and flow directions for specific components.
4. Demonstrate test equipment and procedures for hydraulic and electrical systems.

Developers of the NET for mechanics must decide to what extent the training should teach vehicle maintenance for the different components. However, the decision is difficult to make because the actual reliability of the test vehicle and the components which the maintenance needs to be emphasized usually is not known until the vehicle is purchased and in the Army's inventory for some time. Moreover, mechanics often do not realize the shortcomings of their training or repair manuals until they have experienced difficulties in making repairs to certain components which may not occur during a test. Thus, the Army should develop a feedback loop that provides impact for training after the vehicle has been placed in the Army's inventory for several years. Maintenance problems should be recorded, solutions identified, and the information should be used to improve training and maintenance documents.

DISCUSSION

The numerous M9 human engineering deficiencies and safety hazards found on the M9 may have been artifacts of the vehicle's development. Prototypes were designed and tested over 20 years ago, when there was little emphasis or importance placed on identifying human engineering problems. Early M9 prototype testing and development was concerned with the vehicle's reliability due to its unique suspension and complex hydraulic systems. Only recently, after the vehicle's reliability had been improved, did the human engineering and safety problems begin to be identified. Unfortunately, there may be a reluctance to improve the deficiencies or eliminate the hazards at this late stage in the vehicle's development and procurement.

Table 31 lists a summary of the 30 human factors deficiencies, safety hazards and potential solutions concerning M9 operations. Table 32 lists a summary of the 10 deficiencies, safety hazards and potential solutions found concerning M9 maintenance. Each deficiency was rated using four criteria categories that describe the impact the deficiency may have on the M9 and the operator. Each hazard was rated using four criteria categories for its severity and six criteria categories for its probability of occurring. The hazard criteria categories used are from MIL-STD-288A. Each deficiency and hazard was given a priority for correction. The criteria and priority for correction are:

Table 31

Summary of Human Factors Deficiences, Safety Hazards and Potential Solutions Associated with Vehicle Operations

Human Factors Engineering Deficiencies

Deficiency	Potential solutions	Rating criteria	Correction priority
Vehicle Noise	Insulate noisy components. Improve muffler.	A	1
Temperature and Ventilation	Add NBC microclimate system. Add a positive pressure system.	B	1
Vehicle Vibration	Measure vibration levels of less than 1 Hz. Stiffen vehicle suspension.	C	2
Drive Shaft Failures	Add a torque converter.	A	1
Communications	Locate radio in the driver's station. Provide a CVC helmet with a two-position commander's switch.	A	1
Night Vision Devices (Models AN/VVS-2 and AN/PVS-5)	Use the goggles rather than the periscope.	A	1
Ground Surface Visibility	Improve vision block arrangement. Add rear view mirrors.	A	1
Indicator Lights and Night Operations	Add a BITE warning light panel with an audible warning signal. Add a dimmer switch for the warning lights.	B	1
MOPP Mask (M25) and Hose	Add a longer hose to the gas particulate filter. Improve the snap arrangement on the CVC helmet.	A	1
Insufficient Stowage Space	Improve load plan. Add stowage locations to the rear of the vehicle. Protect the stowage locations from collisions by adding a rear bumper.	A	1

Table 31 (cont'd)

Human Factors Engineering Deficiencies

Deficiency	Potential solutions	Rating criteria	Correction priority
Insufficient BII and Support Supplies	Improve load plan. Add items necessary for extended operations.	B	1
Inappropriate Controls and Displays	Modify controls. Add colored operating range markings to displays. Add emergency engine shutdown device. Add a lockout device to the ejector blade control lever.	B	1
Legroom	Relocate the heater unit. Move driver's seat rearward if the station is lenthened.	B	2
Driver's Seat Vinyl	Improve the vinyl. Add a foldup seat bottom and stepping platform.	D	3
Apron and Dozer Blade Lock Pins	Taper the lock pins. Add quick release mechanisms.	B	1
Flood and Operating Lights	Improve protection device for floodlights. Comply with Army Secure Lighting program.	B	1

Table 31 (cont'd)

Safety Hazards

Hazard	Potential solutions	Hazard severity and probability	Correction priority
Driver's Station Hatch	Reconfigure the latch.	Catastrophic, Reasonably probable	1
Weight of the Hatch	Reduce the weight of the hatch.		
Time Required to Open It	Modify the hatch so that it can be opened with a single motion of the hand.		
No Seal	Add a seal to the hatch.		
Driver's Station Location	Add protective structures to the left side of the vehicle to protect the driver.	Critical, Reasonably probable	1
Folding the Dozer Blade	Modify the dozer blade so that it can be folded safely without an operator having to crawl under it.	Catastrophic, Reasonably probable	1
Flammable Hydraulic Fluid	Modify the hydraulic system to operate using nonflammable fluid.	Critical, Reasonably probable	2
Slippery Walking Surfaces	Add a nonslip surface to walking surfaces. Notch the upper edges of the engine grilles.	Critical, Reasonably probable	1
Steps and Handrails	Protect steps and handrails from collisions. Add steps to the radiator housing above the rear deck. Add steps and handholds by the apron cylinder.	Critical Reasonably probable	1

Table 31 (cont'd)

Safety Hazards			
Hazard	Potential solutions	Hazard severity and probability	Correction priority
Engine Access Grilles	Reduce the weight of the grilles. Modify the grilles to open similar to a truck hood.	Marginal, Frequent	1
Amphibious Operations	*Add an electric bilge pump.*	Catastrophic, Occasional	2
Bilge Pump Failure	Improve the bilge pump sump in order to drain the double box frame.		
Steering Difficulties	Add a track skirt to improve steering control.		
Time to prepare	Modify vehicle allowing it to swim with the armor in place.		
Winch operations	Increase the capacity of the winch.	Critical, Reasonably probable	1
Wire rope failure	Add a wire rope guide.		
No winch brake	Protect drum from collisions.		
Fire Extinguisher	Protect the external red handle and and internal canister valve from collisions.	Marginal, Reasonably probable	2
Muffler Fires	Modify the muffler well in order to prevent debris from collecting in it.	Critical, Frequent	1

Table 31 (cont'd)

Safety Hazards			
Hazard	Potential solutions	Hazard severity and probability	Correction priority
Dozer Blade Clearance	Require the dozer blade to be folded when the vehicle travels. Improve the blade folding procedures.	Critical Frequent	1
Driver's Seat Belt	Attach both ends of the seat belt to the seat frame.	Critical, Reasonably probable	1
No Warnings	Add warning plates to the vehicle to warn the operators and mechanics of potential hazards.	Marginal, Reasonably probable	2

Table 32

Summary of Human Factors Deficiences, Safety Hazards and Potential Solutions Associated with Maintenance

Human Factors Engineering Deficiencies

Deficiency	Potential solutions	Rating criteria	Correction priority
Ejector Cylinder Location	Remove the ejector cylinder located in the center and the two roller guide armatures on the left and right sides of the blade. Add two ejector blade cylinders to the left and right sides of the blades.	C	2
Hydraulic Lines and Other Lines	Add quick disconnect fittings to the hydraulic and other fluid lines. Add number or color codes to the lines and couplings.	C	2
Lubrication Points	Improve the access to lubrication points. Add a dip stick or other measuring device to the final drives.	C	2
Location of the Batteries	Increase the size of the opening above the battery box. Move the batteries farther from the radiator and muffler.	C	2
Transmission Sending Unit	Locate the transmission sending unit below the transmission so that it can be accessed from beneath the hull.	C	2
Tools and Test Equipment	Add STE-ICE, gauges for the accumulator, and all the adapters necessary for the hydraulic test kit.	C	2
PMCS Maintenance	Check batteries daily rather than weekly. Reduce the time required to lube the vehicle.	C	2

Table 32 (cont'd)

Safety Hazards

Hazard	Potential solutions	Hazard severity and probability	Correction priority
Roadwheel Changes	Modify the dog bone jack to be self-standing. Equip the M9 with a dog bone jack.	Critical, Frequent	1
Inspecting the Roller Guides	Modify the ejector blade so that the mechanic can view the rollers without having to be behind the blade.	Critical, Occasional	1
No Ejector Blade Lockout Device	Add a lockout device to the ejector blade control or to the blade that prevents the blade from being accidentally moved.	Critical, Occasional	1

I. Criteria Categories For Human Factors Deficiencies:

A. The design deficiency has a significant impact on human performance, leading to a high probability of mission failure, damge to the vehicle or injury to personnel.

B. The design deficiency has a significant impact on human performance, leading to a high probability of degraded mission capacity.

C. The design deficiency can be corrected by a hardware change or can be compensated for thorough training.

D. The design deficiency has minimal impact on the mission, but would enhance human performance.

II. Hazard Severity Criteria:

A. Category I - Catastrophic. May cause death or system loss.

B. Category II - Critical. May cause severe injury, severe occupational illness, or major system damage.

C. Category III - Marginal. May cause minor injury, minor occupational illness, or minor system damage.

D. Category IV - Negligible. Will not result in injury, occupational illness, or system damage.

III. Hazard probability criteria:

Descriptive Word	Level	Specific Individual Item	Fleet or Inventory
Frequent	A	Likely to occur frequently	Continuously experienced
Reasonably probable	B	Will occur several times in life of an item	Will occur frequently
Occasional	C	Likely to occur sometime in life of an item	Will occur several times
Remote	D	So unlikely, it can be assumed that this hazard will not be experienced	Unlikely to occur but possible
Extremely improbable	E	Probability of occurrence cannot be distinguished from zero	So unlikely, it can be assumed that this hazard will not be experienced
Impossible	F	Physically impossible to occur	Physically impossible to occur

IV. Correction priorities:

Priority 1 Corrective action is considered essential for the production model.

Priority 2 Corrective action would substantially improve operability and/or maintainability and should be taken.

Priority 3 Corrective action would have minor impact on operation and should be taken if no significant cost is involved.

Many of the deficiencies and hazards pose serious problems for the M9 and its operator. The impact of each deficiency and hazard was described in the Results section. Thus, only the general implications for the M9 and the operator need to be discussed further. The numerous deficiencies and hazads found on the M9 are serious for four important reasons:

1. The M9 is operated by one individual. Thus, any deficiency or hazard affecting the operator will have an immediate effect on the system's productivity and mission.

2. Several of the deficiencies, such as noise (as high as 115 dB), cab temperatures (at least 20°F higher than ambient temperature) and vibration (with exposure limits as low as 1 hour), are at levels that are at the extremes of human tolerance and violate MIL-STD-1472C.

3. Not only does each deficiency and hazard have an impact, they can combine to bring ill effects on the operator rapidly.

4. Several of the deficiencies and hazards affect other aspects of M9 operation. For example, low frequency vehicle vibration not only affects the operator's health, it also results in the dozer blade striking the ground, or in the operator experiencing nausea when he uses the night vision devices. High noise levels interfere with hearing the radio and transmitting. High temperatures make NBC MOPP operations unbearable.

During the FOE, the ill effects of the deficiencies were felt and reported by the operators. Note that the final report of the M9 FOE does not indicate that the deficiencies affected the vehicle's productivity. However, in order to avoid potential serious injury to the operators, steps were taken to minimize the negative impact of the deficiencies. Frequent rest breaks were allowed, where the operator could leave the vheicle to stretch, eat and drink. During MOPP operations, rest breaks occurred as often as every 15 minutes. Yet, the times required for rest breaks and delays were subtracted from the times required to complete the M9 engineering tasks. Thus, the task completion times provide no indication of the impact of the deficiencies. Moreover, specialists from the Chemical School, Engineer School, and MEDDAC medical units implemented available solutions to the health and safety problems. Additional training was provided to the operators concerning the vehicle and their personal protective equipment, foam earplugs were issued, water coolers were supplied, and operators were allowed to take their rest breaks when necessary as interim solutions. Yet, the deficiencies and hazards still persisted and were reported by the operators.

The effects of the human factors deficiencies and safety hazards are likely to influence the success of the M9 on the battlefield. Combined with the stress of combat, deficiencies such as high cab temperatures, noise, vibration, and the other problems will degrade the operator's performance during the long hours of operation. The maintenance deficiencies such as the lack of quick disconnect couplings and identification codes on the fluid lines will result in needlessly lengthy repair times. Moreover, in its present configuration, the M9 does not have the stowage capacity nor sufficient BII, or a load plan for all the parts and supplies required during extended operations with armored units.

The human factors deficiencies and safety hazards are correctable and should be within the technological capabilities of the manufacturer. The roadblock to solving the human factors deficiencies traditionally has been in accepting the deficiencies as problems that affect the system. Often, once the deficiencies are acknowledged and accepted, low cost solutions can be implemented. Fortunately, most of the solutions identified for the correction of the M9 deficiencies already exist as hardware. For example, solutions such as winch line levelers, NBC microclimate units, and BITE indicator light units are already available.

The human factors deficiencies and safety hazards of the M9 should be corrected. Based on the data from the FOE and previous FA-IPT, not correcting these problems is likely to result in injury to the operator and mission failure.

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APPENDIX

HUMAN FACTORS ASSESSMENT: M9 ARMORED COMBAT EARTHMOVER, ASSESSMENT MATERIALS

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M9 ACE FOE HUMAN FACTORS QUESTIONNAIRE

GENERAL QUESTIONNAIRE FOR ALL OPERATORS

Date __ __ __ __ __ __ Vehicle ID _____ Player ID ____________
d d m m y y

INSTRUCTIONS: The purpose of this questionnaire is to obtain information from you based on your experience during the M9 ACE Operational Test. This information will help the Army to evaluate the operational effectiveness of the vehicle and determine what features need to be improved. Your honest opinions are therefore essential.

This questionnaire contains five-point rating scales. The questionnaire also contains space for comments. Please fill out the questionnaire as completely as you can. Please describe anything that needs to be changed in order to make the vehicle easier to use or more effective. Everything we find out will help improve the equipment in future versions and will help others learn to operate the M9 ACE more effectively.

Rate your opinions like this:

Use the following scale shown at the top of every page of questions to be rated.

Adequacy Rating Scale:

+2	+1	0	-1	-2	N
Very Adequate	**Adequate**	**Borderline**	**Inadequate**	**Very Inadequate**	**Not Applicable or Not Observed**

Circle one number for every item listed:

EXAMPLE

1. How adequate is the comfort of the driver's seat for prolonged travel?

+2 +1 0 (-1) -2 N

Comments: Please describe any inadequacies (-)

(**Example**)

When the driver's seat is raised for periscope viewing my head hits the hatch latch.

Circle "N" if you have no experience on which to base an opinion.

That's it! If you have any questions, please ask the human factors specialist seated in this room to answer them.

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

1. How adequate was the communications net for the following situations?

	VA	A	B	I	VI	N	Mean	SD
Communicating using the AN/VRC-64 short range radio	0	1	2	0	2	4	2.4	1.34
Communicating with your platoon commander	0	1	2	0	2	4	2.4	1.34
Communicating with your company commander	0	1	0	1	1	5	2.3	1.53
When working alone	0	1	2	1	1	4	2.6	1.14
When working with combined arms operations	0	2	2	1	1	3	2.8	1.17
When working at squad or platoon tasks	0	3	2	1	0	3	3.3	0.81
Communicating changes in mission requirements	0	1	4	1	0	3	3.0	0.63

Comments: Please describe any inadequacies (-)

Most radios did not work so the only communication had to be face to face. (2)

The CVC helmet had a problem with keying unintentionally. A separate "switch" or frequency, something along those lines, is needed to communicate separately with your partner that is digging with you. Also, need a way of changing frequency while in the hatch.

M905 never had communication throughout the entire test.

2. How adequately could radio transmissions be heard over the CVC helmet headset?

	VA	A	B	I	VI	N	Mean	SD
With the engine running	0	2	4	0	0	2	3.3	0.52
With the engine off	0	6	1	0	0	2	3.9	0.37

Comments: Please describe any inadequacies (-)

(No comments)

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

3. How adequately are the radio controls located for the driver's use?

	VA	A	B	I	VI	N	Mean	SD
In the driver's station	1	6	1	0	1	0	3.6	1.11
Above the rear deck	0	0	1	3	5	0	1.5	0.72

Comments: Please describe any inadequacies (-)

Cannot get to radio without getting out of compartment. (6)

4. How adequately can dismounted personnel be communicated with when they are near-by the vehicle?

VA	A	B	I	VI	N	Mean	SD
1	1	5	1	0	1	3.3	0.88

Comments: Please describe any inadequacies (-)

Very high noise level so cannot be heard well. (4)

5. How adequate are the hand signals used by the ground guide in directing you and your vehicle?

VA	A	B	I	VI	N	Mean	SD
0	7	1	1	0	0	3.6	0.70

Comments: Please describe any inadequacies (-)

Hand signals need to be used in populated areas for safety only. Ground guides cannot be used for digging operations.

They had a bunch of non-operators for guides.

6. Were new hand signals developed and used to direct you and your vehicle during this test?

Yes	0
No	9
Unknown	9

If Yes, please describe:

(No comments)

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

7. How adequate is the view through the vision blocks during the following conditions?

	VA	A	B	I	VI	N	Mean	SD
Daylight	1	1	4	2	0	1	3.1	0.99
Darkness	0	0	2	2	4	1	1.8	0.88
Rain/splashing water	0	0	1	2	1	5	2.0	0.82
Fog	0	0	1	1	1	6	2.0	1.00
Smoke	0	0	1	1	2	5	1.8	0.96
Mud	0	0	1	2	2	4	1.8	0.84

Comments: Please describe any inadequacies (-)

When vision blocks get dirty, it's almost impossible to see. At nighttime, it's almost impossible to see through the blocks.

Hard to judge what you're doing.

Vision to front has approximately 30 ft. blind spot. Vision to rear almost nonexistent. (3)

8. How adequately are the vision blocks positioned to avoid blind spots?

VA	A	B	I	VI	N	Mean	SD
0	1	2	1	3	2	2.1	1.25

Comments: Please describe any inadequacies (-)

Vision blocks are too low on the vehicle. They need to be a little higher to see around you all the way. (4)

9. How adequate is the night vision periscope for viewing from the driver's station?

VA	A	B	I	VI	N	Mean	SD
0	0	4	1	3	1	2.1	0.99

Comments: Please describe any inadequacies (-)

Very large blind spot, hard to work the machine.
It made me nauseous, and was not enough room. (2)
Can't see behind you. (2)

Adequacy Rating Scale:

+2	+1	0	-1	-2	N
Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate	Not Applicable or Not Observed

10. How adequate are the night vision goggles for viewing from the driver's station?

VA	A	B	I	VI	N	Mean	SD
1	4	4	0	0	0	3.6	0.71

Comments: Please describe any inadequacies (-)

Goggles weigh too much, causing headaches.

11. Please rate your comfort while you were seated in the vehicle during the following situations:

	VA	A	B	I	VI	N	Mean	SD
Traveling cross-country at high speeds	0	7	1	0	0	1	3.9	0.35
Traveling on gravel roads at high speeds	4	4	0	0	0	1	4.5	0.53
Traveling on highways at high speeds	5	4	0	0	0	0	4.5	0.53
Traveling lengthwise across slopes	0	5	2	1	0	1	3.4	1.06
Traveling up or down 30% slopes	1	5	1	1	0	1	3.7	0.88
Traveling while towing another vehicle	0	4	0	0	0	5	4.0	0.00
Traveling for two or more hours	0	5	2	1	0	1	3.4	1.06
Turning corners while traveling faster than 15 mph	2	6	0	1	0	0	4.0	0.86
Traveling during repeated braking and stopping	1	5	3	0	0	0	3.7	0.66

Comments. Please describe any inadequacies (-)

During long periods of time, legs get tired. (2)
Seat needs some type of side support so then when you are on a side hill, you don't slip off the seat.
Vehicle tends to tilt too much while going up slopes.

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

12. How comfortable is the driver's seat for sleeping?

VA	A	B	I	VI	N	Mean	SD
0	1	2	2	3	1	2.1	1.13

Comments. Please describe any inadequacies (-)

Too crowded in driver's compartment for sleeping. (3)
Needs to recline.

13. How adequately does the removable canvas canopy over the driver's station protect you from:

	VA	A	B	I	VI	N	Mean	SD
Rain	5	3	0	0	0	1	4.6	0.53
Snow	4	0	0	0	0	5	5.0	0.00
Sun/Heat	4	3	1	0	0	1	4.4	0.74
Cold Temperatures	5	2	0	0	0	2	4.7	0.48

Comments. Please describe any inadequacies (-)

Leave it on.

14. How adequately does the driver's seat protect you from vibration?

VA	A	B	I	VI	N	Mean	SD
0	2	6	1	0	0	3.1	0.60

Comments: Please describe any inadequacies (-)

Need more and firmer padding. (3)
Vehicles vibrate too bad.

15. How adequately does the driver's seat adjust up or down?

VA	A	B	I	VI	N	Mean	SD
3	4	1	1	0	0	4.0	1.00

Comments: Please describe any inadequacies (-)

Seat needs to adjust higher up for increased viewing area around entire vehicle.

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

16. How adequately can the driver's seat be adjusted for open and closed hatch operations?

VA	A	B	I	VI	N	Mean	SD
2	3	3	0	0	1	3.9	0.84

Comments: Please describe any inadequacies (-)

Needs to move back farther.

17. How adequately can your footing be maintained when you are standing in the open hatch position and the vehicle is moving?

VA	A	B	I	VI	N	Mean	SD
0	5	1	0	0	3	3.8	0.41

Comments: Please describe any inadequacies (-)

(No comments)

18. How comfortable was the ventilation (air flow) during the following conditions?

	VA	A	B	I	VI	N	Mean	SD
Hatch open, vehicle moving cool weather	2	6	0	0	0	1	4.25	0.46
Hatch open, vehicle standing cool weather	1	7	0	0	0	1	4.12	0.35
Hatch closed, vehicle moving cool weather	1	4	2	1	0	1	3.5	1.20
Hatch closed, vehicle standing, cool weather	1	3	3	1	0	1	3.5	0.92
Hatch open, vehicle moving, hot weather	1	3	2	1	1	1	3.1	1.45
Hatch open, vehicle standing, hot weather	1	0	4	2	1	1	2.8	1.16

(cont'd)

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

(question 18 cont'd)

	VA	A	B	I	VI	N	Mean	SD
Hatch closed, vehicle moving, hot weather	0	1	2	3	2	1	2.3	1.03
Hatch closed, vehicle standing, hot weather	0	0	2	2	3	1	1.9	0.89

Comments: Please describe any inadequacies (-)

It gets very hot with hatch closed whether moving or not. Also, it has poor ventilation inside the compartment. (6)

19. How adequate was the ventilation system in removing fumes and vapors during the following conditions?

	VA	A	B	I	VI	N	Mean	SD
Hatch open, vehicle moving	1	5	1	0	0	1	4.0	0.57
Hatch open, vehicle standing	0	4	3	0	0	1	3.6	0.53
Hatch closed, vehicle moving	0	4	1	1	1	2	3.1	1.21
Hatch closed, vehicle standing	0	4	1	1	1	2	3.1	1.21

Comments: Please describe any inadequacies (-)

Frequently smelled exhaust fumes during closed hatch operations.
The two holes are inadequate.

20. How adequate was the heating for your comfort when used during the following conditions?

	VA	A	B	I	VI	N	Mean	SD
Hatch open, vehicle moving	3	5	0	0	0	1	4.4	0.51
Hatch open, vehicle standing	4	4	0	0	0	1	4.5	0.53
Hatch closed, vehicle moving	6	1	0	0	0	2	4.9	0.37
Hatch closed, vehicle standing	6	1	0	0	0	2	4.9	0.37

Comments: Please describe any inadequacies (-)

It is great if the canopy is there.

Adequacy Rating Scale:

+2	+1	0	-1	-2	N
Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate	Not Applicable or Not Observed

21. How adequate was the temperature and ventilation for your comfort while you were wearing NBC MOPP IV gear during the following conditions?

	VA	A	B	I	VI	N	Mean	SD
Hatch closed, vehicle moving	0	0	4	2	2	1	2.3	0.89
Hatch closed, vehicle standing	0	0	3	2	2	1	2.1	0.89

Comments: Please describe any inadequacies (-)

Wearing MOPP gear is always hot, except moderately cold periods of time. (3)
No ventilation, too hot.

22. How adequately are you protected from noise when you are in the vehicle with your CVC helmet on during the following situations?

	VA	A	B	I	VI	N	Mean	SD
Hatch open during warmup	1	7	0	0	1	0	3.8	1.09
Hatch open while traveling cross country	1	5	1	1	1	0	3.4	1.24
Hatch open while traveling at 25 mph or greater	0	6	1	1	1	0	3.3	1.12
Hatch closed during warmup	1	4	0	0	1	3	3.6	1.36
Hatch closed while traveling cross country	1	2	0	0	1	5	3.5	1.73
Hatch closed while traveling at 25 mph or greater	1	1	0	0	1	6	3.3	2.08

Comments: Please describe any inadequacies (-)

Machine is very noisy. You must wear double hearing protection, but sometimes that isn't enough. (2)

Ease of Use Rating Scale:

+2	+1	0	-1	-2	N
Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult	Not Applicable or Not Observed

23. How easy or difficult is it to:

		VE	E	B	D	VD	N	Mean	SD
(a)	Enter or exit the driver's station without the canvas canopy in place and with the hatch open	4	4	1	0	0	0	4.3	0.70
(b)	Enter or exit the driver's station with the canvas canopy in place	1	4	3	1	0	0	3.5	0.88
(c)	Open or close the driver's hatch	0	1	2	2	4	0	2.0	1.11
(d)	Climb into or out of the bowl	0	1	4	4	0	0	2.6	0.71
(e)	Climp up to or down from the rear deck	0	3	5	1	0	0	3.2	0.66
(f)	Step up to or down from the driver's station to the rear deck	0	1	6	2	0	0	2.8	0.60
(g)	Open or close the hatch during a combat emergency	0	0	0	2	6	1	1.3	0.46

Comments: Please describe any inadequacies (-)

Moving from place to place has very poor traction. One could slip and fall and easily be injured.

The hatch is heavy. There's no place to put feet slipping down. Slippery when wet. (6)

Fix the hatch. Hatch needs grease fittings. It also needs a handle for the second stop on both the outside and inside.

24. How easily can a wounded driver be evacuated from the driver's station?

VE	E	B	D	VD	N	Mean	SD
0	0	3	2	0	3	2.6	0.54

Comments: Please describe any inadequacies (-)

Long reach down into the compartment.
No place to stand and no footholds.

Ease of Use Rating Scale:

+2 Very Easy	+1 Easy	0 Neither Easy nor Difficult	-1 Difficult	-2 Very Difficult	N Not Applicable or Not Observed

25. How easy or difficult is it to perform the following tasks while you are wearing fatigues (without MOPP gear)?

	VE	E	B	D	VD	N	Mean	SD
Mounting or dismounting the vehicle	2	5	2	0	0	0	4.0	0.70
Speaking into the radio	1	5	1	0	0	2	4.0	0.58
Listening to the radio	1	5	1	0	0	2	4.0	0.58
Performing maintenance service to the vehicle	1	7	1	0	0	0	4.0	0.50
Using towing equipment	1	5	1	0	0	2	4.0	0.58
Refueling the vehicle	2	6	1	0	0	0	4.1	0.60
Viewing through vision blocks	1	2	3	2	0	1	3.3	1.04
Viewing through the night vision periscope	0	2	3	1	1	1	2.9	1.07
Viewing with hatches open	3	5	1	0	0	0	4.2	0.66
Using handtools	3	5	1	0	0	0	4.2	0.66
Seeing gauges and displays under white light	1	6	2	0	0	0	3.9	0.60
Seeing gauges and displays under blue light	1	5	2	0	0	1	3.9	0.64
Manipulating vehicle and equipment controls	1	8	0	0	0	0	4.1	0.33

Comments. Please describe any inadequacies (-)

Night vision periscope has very bad quality.
There is a blank spot in front of you.

Ease of Use Rating Scale:

+2	+1	0	-1	-2	N
Very Easy	Easy	Neither Easy nor Difficult	Difficult	Very Difficult	Not Applicable or Not Observed

26. How easy or difficult is it to perform the following tasks while you are wearing the MOPP IV uniform?

	VE	E	B	D	VD	N	Mean	SD
Mounting or dismounting the vehicle	0	4	5	0	0	0	3.4	0.53
Speaking into the radio	1	2	1	1	1	3	3.2	1.47
Listening to the radio	1	1	2	1	1	3	3.0	1.41
Performing maintenance service to the vehicle	0	0	3	2	1	3	2.3	0.82
Using towing equipment	0	0	2	0	0	7	3.0	0.00
Refueling the vehicle	0	0	2	0	0	7	3.0	0.00
Viewing through vision blocks	0	0	3	3	1	2	2.3	0.82
Viewing through the night vision periscope	0	2	0	0	3	3	2.2	1.64
Viewing with hatches open	1	1	3	2	1	1	2.9	1.25
Using handtools	0	1	2	1	1	4	2.6	1.14
Seeing gauges and displays under white light	1	1	2	4	0	1	2.8	1.13
Seeing gauges and displays under blue light	1	1	2	3	1	1	2.8	1.28
Manipulating vehicle and equipment controls	1	2	6	0	0	0	3.4	0.73

Comments. Please describe any inadequacies (-)

Hard to hold and use tools while wearing MOPP IV. It is hard to see through mask.
Can't see behind you with the gas mask on.
Too hot. One should be able to drink water through mask.

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

27. Please rate the adequacy of the following driver's station features:

	VA	A	B	I	VI	N	Mean	SD
Space for work when wearing fatigues	1	3	2	2	0	0	3.4	1.06
Space for work when wearing MOPP or heavy clothing	1	0	5	2	0	0	3.0	0.92
Armroom when seated while wearing fatigues	1	5	2	0	0	0	3.9	0.64
Armroom when seated while wearing MOPP or heavy clothing	1	4	3	0	0	0	3.8	0.70
Legroom when seated while wearing fatigues	1	3	2	1	1	0	3.2	1.28
Legroom when seated while wearing MOPP or heavy clothing	1	2	2	2	1	0	3.0	1.30
Headroom when seated while wearing fatigues	3	4	1	0	0	0	4.3	0.70
Headroom when seated while wearing MOPP or heavy clothing	3	4	1	0	0	0	4.4	0.53
Overall, the space provided in the driver's station for your work	1	3	2	1	1	0	3.3	1.28

Comments: Please describe any inadequacies (-)

Not enough room when you close the hatch. (3)

28. How adequately can the NBC filters be serviced and maintained?

VA	A	B	I	VI	N	Mean	SD
0	1	0	0	0	8	4.0	0.00

Comments: Please describe any inadequacies (-)
(No comments)

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

29. How adequately does the driver's hatch seal when fully closed and locked?

VA	A	B	I	VI	N	Mean	SD
0	2	3	3	1	0	2.6	1.00

Comments: Please describe any inadequacies (-)

A draft blows in front of the rear.
Seals need to be better because it leaks. (3)

30. How adequately does your hatch lock in the following positions?

	VA	A	B	I	VI	N	Mean	SD
Fully opened	5	4	0	0	0	0	4.5	0.53
Half opened	1	1	0	2	2	3	2.5	1.64
Fully closed	5	4	0	0	0	0	4.5	0.53

Comments: Please describe any inadequacies (-)

Nothing actually holds the hatch half open. (2)
Half open is a safety hazard.

31. How adequately was the space provided for the stowage of?

	VA	A	B	I	VI	N	Mean	SD
Smoke grenades	0	3	2	1	1	2	3.0	1.15
Chains	0	4	4	0	1	0	4.1	1.27
Common tools	0	0	6	2	1	0	2.5	0.72
NBC gear	0	0	2	4	2	1	2.0	0.75
Personal gear	0	1	1	5	2	0	2.1	0.93
Water	0	1	3	2	2	1	2.4	1.06
Oils/lubricants	0	0	2	4	2	1	2.0	0.75
Hydraulic fluid	0	0	1	2	2	4	1.8	0.84
Repair parts	0	0	1	2	2	4	1.8	0.84
Manuals	1	7	0	0	1	0	3.8	1.09

Comments: Please describe any inadequacies (-)

Not enough storage space for anything. (4)

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

32. How adequate are the locations for the stowage of?

	VA	A	B	I	VI	N	Mean	SD
Smoke grenades	0	1	0	5	3	0	1.4	0.73
Chains	1	4	4	0	0	0	3.6	0.71
Common tools	1	3	4	1	0	0	3.4	0.88
NBC gear	0	0	2	3	2	2	2.0	0.86
Personal gear	0	0	2	3	3	1	1.9	0.83
Water	0	1	2	4	1	1	2.4	0.92
Hydraulic fluid	0	0	0	2	1	6	1.6	0.58
Oils/lubricants	0	0	2	2	1	4	2.2	0.83
Repair parts	0	1	0	2	1	5	2.3	1.25
Manuals	2	6	1	0	0	0	4.1	0.60

Comments: Please describe any inadequacies (-)

Most places are too hot to stow article there. (2)
Can't get to smoke grenades. You usually put personal gear in hatch. It falls out and makes it difficult to close hatch quickly.
Hard to get to. Water spalings for the water get smashed up a lot.

33. How adequate are the stowage loops/rails for securing equipment to the exterior of the vehicle?

VA	A	B	I	VI	N	Mean	SD
0	2	4	0	0	3	3.3	0.52

Comments: Please describe any inadequacies (-)

(No comments)

34. How adequate are the tool sets for the work that is required?

VA	A	B	I	VI	N	Mean	SD
0	5	4	0	0	0	3.5	0.52

Comments: Please describe any inadequacies (-)

Need needlenose vicegrips to remove circlips on final drives. The aluminum plates put between final drives get scarred up and put metal particles in oil. They should be made of hardened steel. Need regular vicegrips and wire cutters.

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

35. How adequately are warning and advisory lights located to alert you when lighted?

VA	A	B	I	VI	N	Mean	SD
0	5	1	1	0	2	3.2	0.95

Comments: Please describe any inadequacies (-)

Except for pumplight.
Need air and transmission pressure gauges.

36. How adequate are the locations of the external red-handled fire extinguisher activators?

VA	A	B	I	VI	N	Mean	SD
1	6	0	1	1	0	3.5	1.23

Comments: Please describe any inadequacies (-)

Get set off a lot. Need a guard.
They always get pulled by trees.

37. How adequate is the location of the hand-operated fire extinguisher in the operator's cab?

VA	A	B	I	VI	N	Mean	SD
2	6	0	0	1	0	3.9	1.34

Comments: Please describe any inadequacies (-)

When in MOPP IV with the gas particulate hooked up, the air supply hose hangs up on fire extinguisher.

38. Overall, how adequate is the fire suppression system for extinguishing vehicles fires?

VA	A	B	I	VI	N	Mean	SD
1	5	1	0	0	2	4.0	0.57

Comments: Please describe any inadequacies (-)

Fire extinguishers are too small. Hand operated extinguisher is not big enough to put out exhaust fires.

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

39. How adequate are the interior lights for providing light at the driver's station?

VA	A	B	I	VI	N	Mean	SD
2	6	0	1	0	0	4.0	0.86

Comments: Please describe any inadequacies (-)

Need dimmer lights for all interior lights to include idiot lights.

40. How adequate are the vehicle's exterior flood lights for working at night?

VA	A	B	I	VI	N	Mean	SD
4	2	0	0	0	3	4.0	1.55

Comments: Please describe any inadequacies (-)

(No comments)

41. Is the operator's manual (check one):

Easy to read?		Complete with all the correct instructions?	
Yes	9	Yes	1
No	0	No	7
Unknown	0	Unknown	1

Please describe any difficult to read or missing instructions:

They still need to put the changes in it. (2)
Swim preparation is not organized.

42. How adequate was the pretest NET training in instructing you to perform the following tasks?

	VA	A	B	I	VI	N	Mean	SD
Breach a road crater	1	4	1	1	0	2	3.7	0.95
Breach a tank ditch	1	5	0	1	0	2	3.9	0.89
Construct a combat trail	1	2	1	1	0	4	3.6	1.14
Construct a combat road	1	3	1	1	0	3	3.6	1.03
Self-recovery	0	5	1	1	0	2	3.6	0.78

(cont'd)

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

(question 42 cont'd)

	VA	A	B	I	VI	N	Mean	SD
Swim the ACE	1	6	0	0	0	2	5.8	0.37
Ford a waterway	1	5	0	0	0	3	4.2	0.44
Construct access and egress points	0	3	1	1	1	3	3.0	1.26
Construct antitank ditch	1	4	0	2	0	1	3.6	1.13
Construct defensive and defilade positions	1	5	1	1	0	1	3.8	0.86
Clear fields of fire	0	3	2	0	0	4	3.6	0.54
PMCS checks	3	6	0	0	0	0	4.3	0.50

Comments: Please describe any inadequacies (-)

They only showed pictures of the items.
They need to have people that know what they are doing to run the sites.

43. How adequate were the following NET training features and techniques?

	VA	A	B	I	VI	N	Mean	SD
Length of training	2	1	2	3	0	1	3.3	1.28
Training literature	3	5	1	0	0	0	4.2	0.66
Demonstration of the vehicle capabilities	1	6	0	2	0	0	3.6	1.00
Demonstration of the equipment (ie., winch, bilge pump, ejector blade, etc.)	2	6	0	1	0	0	4.0	0.86
Hands-on exercises	2	4	1	1	0	1	3.8	0.99
Overall effectiveness of the training	1	5	2	0	0	1	3.8	0.64

Comments: Please make suggestions for improving training for this equipment.

The winch is not made to pull the M9 out. It always broke and winch itself is not strong.

It needs to be one week longer.

The training needs to be longer and they need to show the operators how to do the tasks right.

Let people that have actually done the job run the training. Rank and MOSs are no guarantee that they know what they're doing. They should be tested for competency. This was a drawback.

M9 ACE HUMAN FACTORS QUESTIONNAIRE

FOR MECHANICS

Date __ __ __ __ __ __ Vehicle ID _____ Player ID ____________
d d m m y y

Name ______________________________ MOS __________ Rank ______________

INSTRUCTIONS: The purpose of this questionnaire is to obtain information from you based on your experience during the M9 ACE FOE. This will help the Army evaluate the effectiveness of the vehicle and determine what features need to be improved. If you have been assigned as a mechanic to work on the D7, your answers on this questionnaire should concern only the M9 ACE.

Please check (✓) Yes or No to answer the following questions. If you have no experience with the subject matter of the question, check Unknown. If you check Yes, please give a brief description of any difficulty you may have had when working with the M9 ACE.

1. Were there times when field repairs were difficult to make because the proper tools were not available in the mechanic's tool kit? (check one)

Yes	5
No	3
Unknown	1

Please describe any tools you did not have that you needed:

Need a complete contact truck. Should have more than two hydraulic reservoir stoppers. Need pulley for road arms and torque wrenches. Need dog bone automotive wrenches and multimeter. Need 3/4 inch drive set and bigger wrenches. Road arm puller and large wrenches, 1-1/16 and up.

2. Were there times when field repairs were difficult to make because the proper test equipment was not available to mechanics? (check one)

Yes	4
No	4
Unknown	1

Please describe any test equipment you did not have that you needed:

Incomplete contact truck. At times we were missing lots of tools to equipment from the general mechanics box that were dropped because of tight areas in the vehicle. The hydraulic test kit didnot have everything we need to perform the hydraulic test. We're missing some adapters.

3. Are there any access panels that are difficult to remove? (check one)

Yes	3
No	6
Unknown	0

Please describe any difficulties:

(No comments)

4. Are there any lubrication points that are difficult to locate? (check one)

Yes	3
No	3
Unknown	3

Please describe any difficulties:

Drive line and universal joints. Steer unit brake crossover shaft under radiator/apron lifting cylinder, must remove armor to grease fitting on each side.

5. Are there any lubrication points that are difficult to lube properly with a grease gun? (check one)

Yes	3	(NOTE: No response from one mechanic)
No	2	
Unknown	3	

Please describe any difficulties:

Drive shaft.
Drive line and universal joints.
The steer unit left brake lever.

6. Are any of the following components difficult to remove and replace because they are difficult to reach or are blocked by other components? If there are, please describe what made it difficult. Use the Comment column.

Component	Yes	No	Unknown	Comment*
Engine	3	5	0	*Follows question 6
Air filters	0	3	0	
Transmission	3	5	0	
Transfer case	2	6	0	
Final drives	1	7	0	
Clutch	0	5	3	
Brakes	5	1	2	
Apron cylinders	0	7	1	

Component	Yes	No	Unknown	Comment*
Steer unit	3	3	2	*Follows question 6
Ejector cylinder	1	7	0	
Track tension cylinders	0	6	2	
Hydraulic valve bank	0	7	1	
Track planetaries	1	4	3	
Hub bearings	0	6	2	
Bilge pump	2	3	2	
Others (fill in)				
Drive shaft	1	0	0	
____________	_	_	_	
____________	_	_	_	

Comments:

Need to move the temp sending unit to a different oil passage to avoid having to pull and separate the complete pack to replace sending unit.

All parts are difficult to reach.

Brakes: Left side difficult to adjust.
Difficult to get to, especially the left.

Steer unit: #3 line to steer unit is difficult to remove.
The steer unit mount.

Engine: Drive shaft.

Ejector cylinder: Blocks you from adjusting the left brake cylinder.

Drive shaft: Ejector cylinder must be removed.

7. Were the maintenance manuals: (check one)

a. Easy to read?

Yes	8
No	1
Unknown	1

b. Complete with all the correct instructions?

Yes	1
No	8
Unknown	1

Please describe any difficult to read or missing instructions:

Some procedures are just listed flat-out wrong.
Changing roadwheels.
Removing fire extinguishers.
The manuals didn't explain fully on how to repair the parts on the vehicle.
Things were not written correctly; also, the manuals jump too much from one page to the other. The entire book needs to be rewritten and put in order so we don't have to jump all over the book trying to figure things out

8. Were the parts listings complete with all the needed parts? (check one)

Yes	7
No	0
Unknown	2

Please describe any missing items from the parts listing:

(No comments)

HAZARD IDENTIFICATION

Please check (✓) Yes or No to indicate whether or not you have noticed an unsafe condition involving the following components. If you have not observed anyone using a component, check Not Observed. If you check Yes, please give a brief description of the hazard. Use the back of the page if you need more space to write a description (include the item number from the following list).

M9 ACE Component		Hazards Yes	No	Not Observed	Description*
9.	Driver's seat	0	7	2	*Follows question 42
10.	Winch	0	6	3	
11.	Winch controls	0	6	3	
12.	Ejector	1	6	2	
13.	Apron lock pins	1	6	2	
14.	Apron and dozer extensions	0	8	1	
15.	Dozer blade	0	7	2	
16.	Dozer blade latches	0	7	2	
17.	Trailer brake couplings	0	6	3	
18.	Rear swim door	1	5	3	
19.	Smoke grenade launchers	1	4	3	
20.	Exhaust grills	2	7	0	
21.	Hydraulic oil fill port	0	8	1	
22.	Maintenance access panels	0	9	0	
23.	Driver's hatch	3	3	3	
24.	Tool box location	0	6	3	
25.	Windshield	3	4	2	
26.	Rear steps	1	7	1	
27.	Trailer electrical receptacle	0	7	2	
28.	Heater	0	6	3	
29.	Tool and equipment locker	0	8	1	
30.	Hydraulic reservoir	1	6	2	
31.	Top walking surfaces	1	7	1	
32.	Steps and handholds	0	8	1	
33.	Storage compartments	0	7	2	
34.	Power pack	1	8	0	
35.	Transfer case	0	9	0	
36.	Transmission	0	9	0	
37.	Exhaust system	4	5	0	
38.	Tracks	1	6	2	
39.	Hydraulic hoses	1	7	1	
40.	Electrical wiring	3	6	0	
	OTHERS (fill in)				
41.	Roadwheels	0	1	0	
42.	________________	–	–	–	

Description:

Item #:

12. Ejector: Replacing the ejector requires adjusting the rollers. This requires being in the bowl area while the ejector is moving in order to properly check clearances.

13. Apron lock pins: The lock pins on the apron had to be driven in.

18. Rear swim door: Narrow clearance when removing or replacing in storage area.

19. Smoke grenade launchers: Loading and unloading them.

20. Exhaust grills: Exhaust system tends to burn up electrical components.
May cause battery to overheat.

23. Driver's hatch: Too Heavy.

25. Windshield: Prone to breakage; drivers can wear goggles.
Dangerous to operate when breaking.
Doesn't need one.

26. Rear steps: Half the time they're smashed.

30. Hydraulic reservoir: A single well placed round would create a fire behind the operator.

31. Top walking surfaces: Become slick when wet or muddy.

34. Power pack: Danger of fire from leaves and twigs falling through the grills.

37. Exhaust system: Runs on top of the starter wire.
Danger of fire from leaves and twigs and oil next to muffler pipe.
High frequency noise, damage to hearing.
Leaks can cause a serious fire and damage to the batteries.

38. Tracks: Replacing roadwheels requires placing self in a position of loss of life and limb.

39. Hydraulic hoses: Easy to mix up.

40. Electrical wiring: Runs too close to exhaust.
Exposed wires next to batteries catch on fire.
Starter wiring.

Have you or has anyone else working on the M9 ACE received any of the following injuries:

		Yes	No	You	Someone else
43.	Cuts or scrapes	6	3	___	___
44.	Burns	1	8	___	___
45.	Broken bones	0	9	___	___
46.	Sprained or twisted limbs	1	8	___	___
47.	Electrical shocks	0	9	___	___
48.	Sickness from noxious fumes	1	8	___	___
49.	Headaches from noise	2	7	___	___
50.	Back or kidney pain	0	8	___	___

51. Other: ____________________

52. Any medical treatment? ____________________

Short Answer

		Hazards Yes	No	Not Observed	Description
53.	Are there enough safety lock pins on the M9 ACE?	6	0	3	No comments.
54.	Are the apron safety pins adequate?	7	0	2	No comments.
55.	Are all safety lock pins easy to install and remove?	7	1	1	Difficult or impossible to install lock pins for apron up or down without help.

GENERAL MAINTENANCE TASKS

Please answer Yes or No to indicate whether or not you have had any difficulties performing the tasks. Please describe briefly any of the difficulties you encountered in the Comments column. If you have no experience with the equipment, then state Not Applicable (N/A). (Use the back of the page if more space for comments is required, and please include the item number.)

	Tasks	Difficulties Yes	No	N/A	Comments*
56.	Gaining access to the vehicle's batteries	4	4	1	*Follows item 95
57.	Checking battery and fluid levels	3	5	1	
58.	Checking tightness of battery cables	2	7	0	
59.	Gaining access to the engine	3	6	0	
60.	Checking engine fluid levels	1	8	0	
61.	Checking the engine coolant level	0	9	0	
62.	Checking the engine air filter	0	9	0	
63.	Draining engine fuel filters	0	8	1	
64.	Gaining access to the transmission	8	1	0	
65.	Checking the transmission fluid level	0	8	1	
66.	Gaining access to the differential	2	7	1	
67.	Checking the differential fluid level	0	8	1	
68.	Gaining access to the final drives	1	6	1	
69.	Checking final drive fluid levels	4	4	1	
70.	Checking hydraulic fluid levels	0	9	0	
71.	Gaining access to grease fittings	3	4	2	
72.	Gaining access to the suspension system	3	5	1	
73.	Servicing ejector cylinder	1	6	2	
74.	Servicing apron cylinders	2	5	2	
75.	Checking and adjusting track tension	2	4	3	
76.	Checking track retainers	1	6	2	
77.	Checking and servicing the NBC system(s)	0	3	6	
78.	Gaining access to built-in self test equipment	1	1	7	
79.	Operating built-in self test equipment	0	2	7	
80.	Adding water to the batteries	3	4	2	
81.	Adding water to the coolant system	0	7	1	
82.	Adding oil to the engine	2	6	1	
83.	Adding fluid to the transmission	0	7	2	
84.	Adding fluid to the differential	0	8	1	
85.	Adding fluid to the final drives	1	7	1	
86.	Adding fluid to the hydraulic systems	1	7	1	
87.	Adding grease to grease fittings	3	4	2	
88.	Adding fuel to the vehicle	1	7	1	
89.	Servicing interior lighting system	0	4	5	
90.	Servicing exterior lighting system	1	5	3	

	Tasks	Difficulties Yes	No	N/A	Comments
91.	Servicing interior communications system components	0	0	9	*Follows item 95
92.	Servicing exterior communications system components	1	2	6	
	OTHER (fill in)				
93.	Adjust fan pulley	2	1	0	
94.	Coolant hose	1	0	0	
95.	________________________	-	-	-	

Item No.	Comments

56. Move radio mount.
Removing top battery panel is difficult. Does not allow viewing of all battery cells or easy removal of the batteries.
Hard to remove batteries with radio box overhead.

57. Move radio mount.

59. Removing and replacing the grills discourages the operators from checking the engine fluid levels.

64. The hull is in the way, access is difficult.
Engine must be removed.
Transmission sending unit needs to be somewhere where you can get to it.
It's hard to get to the drive shaft.

66. The hull is in the way, access is difficult.

68. The hull is in the way, access is difficult.

69. The oil must be drained and refilled to check the level.
Final drives should have a dipstick.
Should be a dipstick.

71. Drive shaft.
Drive line is difficult to access.

72. Hull is in the way of the actuator line.
Troubleshooting - same problems as actuator or hydraulic system.

74. The book states the wrong tension.

Item No.	Comments
75.	Must be done on hard top.
78.	Hull is in the way.
80.	Move radio mount Cannot see all the fluid levels. Battery overheats (due to its location next to the muffler). Hard to do with radio box overhead.
81.	The radiator hose was being torn because the brake pedal (linkage) was rubbing - serious problem to remove.
82.	Removing and replacing grills is a lot of work
87.	Drive shaft. Lubing drive line.
92.	In order for the operator to change frequency he must be exposed. It also overheats (due to location next to muffler).

Other:

Pulling pack - too many hydraulic lines.
Fan tower belts always breaking.
Fan pulley in too small a space.
Coolant hose too far to reach.

Adequacy Rating Scale:

+2	+1	0	-1	-2	N
Very Adequate	Adequate	Borderline	Inadequate	Very Inadequate	Not Applicable or Not Observed

96. How adequate was the pretest NET training in instructing you to perform the following component maintenance?

	VA	A	B	I	VI	N	Mean	SD
Power package assembly	2	6	0	1	0	0	4.0	0.86
Fuel system	3	4	1	0	0	1	4.3	0.70
Exhaust system	2	3	2	1	1	0	3.4	1.33
Electrical system	2	5	1	1	0	0	3.8	0.93
Transmission, torque converter	1	5	1	2	0	0	3.5	1.01
Transfer case assembly and final drives	1	7	1	0	0	0	4.0	0.50
Propeller shaft and universal joint	2	5	1	1	0	0	3.8	0.93
Steer unit assembly	2	2	3	2	0	0	3.8	0.92
Brakes	1	2	2	2	0	1	3.3	1.11
Trailer brake connections and controls	2	3	2	1	0	1	3.8	1.03
Wheels and tracks	2	3	1	0	1	1	3.7	1.02
Steering control and linkage	2	5	0	1	0	1	4.0	2.00
Towing attachments	3	4	1	0	0	1	4.2	0.70
Springs and shock absorbers	3	3	0	0	0	3	3.6	1.86
Body, cab, hood and hull	4	3	1	0	0	1	4.3	0.74
Winch assembly	1	5	2	0	0	1	3.8	0.64
Guards	3	4	1	1	0	1	4.0	1.00
Body, chassis and hull accessory items	3	4	1	0	0	1	4.3	0.70
Hydraulic and fluid system	3	3	1	1	0	0	4.0	1.06
Special purpose kits	0	4	2	0	0	3	3.5	0.57
Armament	0	2	2	1	0	4	3.2	0.86
Precision instruments	1	1	3	0	0	3	3.6	1.89
Scanning and signaling devices	0	1	3	0	0	5	3.3	0.50
Earthmoving equipment components	1	5	1	0	0	2	4.0	0.58

Comments: Please describe any inadequacies (-)

School was too short. Needed to take into account that most mechanics in the field lack practical experience in basic principles.

Adequacy Rating Scale:

+2 Very Adequate	+1 Adequate	0 Borderline	-1 Inadequate	-2 Very Inadequate	N Not Applicable or Not Observed

97. How adequate were the following NET training features and techniques?

	VA	A	B	I	VI	N	Mean	SD
Length of training	2	2	3	1	1	0	3.3	1.30
Training literature	5	2	2	0	0	0	4.3	0.86
Demonstration of vehicle peculiar maintenance techniques	1	5	3	0	0	0	3.7	0.66
Demonstration of trouble-shooting procedures	1	5	2	1	0	0	3.5	1.13
Hands-on exercises	4	2	2	1	0	0	3.8	1.36
Overall effectiveness of the training	3	4	1	1	0	0	4.0	1.00

Comments: Please make suggestions for improving training for this equipment.

Have several M9s available during training and increase length of course.

1. Overall, how complete are the listed PMCS checklist procedures? (Check one)

<u>0</u>	5	Very complete
<u>3</u>	4	Complete
<u>3</u>	3	Marginal
<u>1</u>	2	Incomplete
<u>0</u>	1	Very incomplete
<u>2</u>	N	Unknown or not observed

<u>Comment</u>. Briefly describe any problems with the PMCS procedures:

Need to rework procedures using test data. Should make batteries a daily check instead of weekly.

2. Were the PMCS checklist procedures properly followed by operators and mechanics? (Check one for both operators and mechanics)

Operators		Mechanics	
Yes	3	Yes	5
No	2	No	1
Unknown	4	Unknown	2

<u>Comment</u>. If answered No, please describe:

Shortcuts and laziness started becoming a problem. They were rushed many times because of missions. There was a big problem lubing the vehicles and checking the batteries.

3. Are all the PMCS checkpoints easy to find and service? (Check one for both finding and servicing)

Easy to find		Easy to service	
Yes	5	Yes	5
No	0	No	0
Unknown	4	Unknown	4

<u>Comment</u>. Please describe the checkpoints were difficult to find or service:

(No comments)

4. Overall, how complete are the following manuals or lists?

a. -10 Manuals, Operators

0	5	Very complete
3	4	Complete
4	3	Marginal
1	2	Incomplete
0	1	Very incomplete
1	N	Unknown or not observed

b. -20 Manuals, Organizational Maintenance

0	5	Very complete
4	4	Complete
2	3	Marginal
2	2	Incomplete
0	1	Very incomplete
1	N	Unknown or not observed

c. -20p Manuals, Organizational Maintenance

1	5	Very complete
5	4	Complete
1	3	Marginal
1	2	Incomplete
0	1	Very incomplete
1	N	Unknown or not observed

d. -30 Manuals, DS Maintenance

1	5	Very complete
4	4	Complete
1	3	Marginal
2	2	Incomplete
0	1	Very incomplete
1	N	Unknown or not observed

5. How easily can the -10 operators manuals be read and understood? (Check one)

1	5	Very easy
5	4	Easy
1	3	Marginal
0	2	Difficult
0	1	Very difficult
2	N	Unknown or not observed

6. How easily can the -20 and -20p maintenance manuals be read and understood? (Check one)

0	5	Very easy
6	4	Easy
1	3	Marginal
1	2	Difficult
0	1	Very difficult
1	N	Unknown or not observed

7. How easily can the -30 and -30p maintenance manuals be read and understood? (Check one)

0	5	Very easy
5	4	Easy
4	3	Marginal
0	2	Difficult
0	1	Very difficult
0	N	Unknown or not observed

8. Can mechanics find the necessary parts and stock numbers in the -20 and -30 series maintenance manuals? (Check one)

a. -20 Manuals

Find parts		Find stock numbers	
Yes	7	Yes	8
No	0	No	1
Unknown	1	Unknown	0

b. -30 Manuals

Find parts		Find stock numbers	
Yes	8	Yes	8
No	1	No	1
Unknown	0	Unknown	0

9. Do the mechanics need diagnostic maintenance test equipment for the vehicle in order to find maintenance faults?

Yes	7
No	2
Unkown	0

Comment. If Yes, please describe any suggestions you may have concerning what test equipment is needed:

Need Ste-Ice, gauges to check accumulator, to troubleshoot hydraulic, multimeter, vacuum gauge, timing light for hydraulics.

10. Are repair responsibilities allocated to the proper maintenance level?

Yes	2
No	6
Unknown	1

Comment. If No, please describe the proper maintenance level the responsibilities should be allocated to:

Pulling the pack - Org. Repair of components - GS. Accumulators - Org. There is very little in the MAC that goes to GS. Some depot level functions could be downgraded. Some things currently DS could be handled at Organizational Maintenance. Depot should be GS. The #1 starter to Organization. The #2 actuator to Organizational. There should be a lot more organizational things that should be DS and more for the operator that shouldn't be Organizational. Starter - Org., Exhaust - Org. Pack removal - Org., Track, roadwheels, belly plates - driver.

11. Does the PLL contain the right type and quantity of repair parts to support maintenance activities?

Yes	5
No	2
Unknown	2

Comment. If No, please describe the type and quantity of the repair parts that should be added to the PLL:

All parts were provided from outside.

12. Does the ASC contain the right type and quantity of repair parts to support maintenance activities?

Yes	5
No	1
Unknown	3

Comment. If No, please describe the right type and quantity of repair parts that should be added to the ASC:

All parts were provided from outside the system.

13. Are sufficient mechanics assigned at Organizational Level to adequately maintain assigned vehicles?

Yes	6
No	1
Unknown	2

Comment. If No, please describe how many mechanics should be assigned at the Organizational Level:

Only one mechanic per vehicle in heavy usage.

14. Are there a sufficient number of mechanics assigned at the Direct Support Level to adequately maintain assigned vehicles?

Yes	4
No	4
Unknown	1

Comment. If No, please describe how many mechanics should be assigned at the Direct Support Level:

Mechanics could not perform much other work. Only two were trained.

15. Are there a sufficient number of mechanics assigned at the General Support Level to adequately maintain assigned vehicles?

Yes	4
No	2
Unknown	3

Comment. If No, please describe how many mechanics should be assigned at the General Support Level:

You don't need any according to the MAC chart. Currently, very little GS Maintenance. Only two were trained.

16. Is Materiel Support Hardware (e.g., tools, TMDE) adequate to accomplish the maintenance mission?

Yes	4
No	2
Unknown	3

Comment. If No, please describe what additional Materiel Support Hardware is needed:

People bent over backwards to support this test, we don't know anything for sure until the M9 is fielded.

#1 common and a section's worth of mechanics were used to support this equipment for this test which left none for the other equipment.

M9
SUMMARY SHEET

Date __ __ __ __ __ __ Vehicle ID _____ Player ID ___________
d d m m y y

Name ______________________________ MOS __________ Rank ________________

M9 HAZARD IDENTIFICATION: STRUCTURED INTERVIEW

I will name equipment on the M9 ACE. Please answer Yes or No to indicate whether or not you have noticed an unsafe condition involving the following components. I would also appreciate your comments concerning any unsafe conditions. If you have no experience with the equipment, then state Not Applicable (N/A). (Use the back of the page if more space for comments in required, and please include the item number.)

	M9 ACE		Hazards	
	Component	Yes	No	N/A
1.	Driver's seat	2	5	0
2.	Winch	0	7	0
3.	Winch controls	0	7	0
4.	Ejector	0	7	0
5.	Apron lock pins	1	6	0
6.	Apron and dozer extensions	0	7	0
7.	Dozer blade	0	7	0
8.	Dozer blade latches	2	5	0
9.	Trailer brake couplings	0	6	1
10.	Rear swim door	0	7	0
11.	Smoke grenade launchers	1	5	1
12.	Exhaust grills	4	3	0
13.	Hydraulic oil fill port	0	7	0
14.	Maintenance access panels	0	7	0
15.	Driver's hatch	4	3	0
16.	Tool box location	2	5	0
17.	Windshield	0	7	0
18.	Rear steps	0	7	0
19.	Trailer electrical receptacle	0	6	1
20.	Heater	0	7	0
21.	Tool and equipment locker	1	6	0
22.	Hydraulic reservoir	0	7	0
23.	Top walking surfaces	6	1	0
24.	Steps and handholds	1	6	0
25.	Storage compartments	1	6	0
26.	Power pack	1	6	0
27.	Transfer case	0	7	0
28.	Transmission	0	7	0
29.	Exhaust system	2	7	0
30.	Tracks	0	7	0

	M9 ACE Component	Yes	Hazards No	N/A
31.	Hydraulic hoses	0	7	0
32.	Electrical wiring	0	7	0
	OTHERS (fill in)			
33.	Dozer blade	1	0	0
34.	________________	-	-	-

Comments:

Driver's seat: Cushions too soft - feel metal.
Apron lock pins: Difficult to install.
Dozer blade latches: Must climb under blade to hook up chain to fold.
Smoke grenade launchers: Loading them.
Exhaust grills: No place to stand when removing. Too heavy.
Driver's hatch: Too heavy. Bump head on periscope.
Tool box location: Needs open lid support. Too small.
Tool and equipment locker: Too small.
Top walking surfaces: Slippery.
Steps and handholds: Not enough. No footholds.
Storage compartments: No place for personal gear.
Power pack: Too loud.
Exhaust system: Fires start in well.
Dozer blade: Hits ground.

Have you or has anyone else working on the M9 ACE received any of the following injuries:

		Yes	No	You	Someone else
35.	Cuts or scrapes	5	2	5	1
36.	Burns	0	7	0	0
37.	Broken bones	0	7	0	0
38.	Sprained or twisted limbs	2	5	1	0
39.	Electrical shocks	0	7	0	0
40.	Sickness from noxious fumes	1	6	1	0
41.	Headaches from noise	4	3	3	0
42.	Back or kidney pain	1	6	1	0
43.	Other: (No response)				
44.	Any medical treatment? (No response)				

Short Answer

		Hazards	
	Yes	No	Not Observed
45. Are there enough safety lock pins on the M9 ACE?	6	1	0
46. Are the apron safety pins adequate?	6	1	0
47. Are all safety lock pins easy to install and remove?	2	5	0

Comments: Apron lock pins, lower blade pins, and Allen head bolts are difficult to remove.

M9
SUMMARY SHEET

Date __ __ __ __ __ __ Vehicle ID _____ Player ID ____________
d d m m y y

Name ________________________________ MOS __________ Rank __________________

M9 PMCS MAINTENANCE: STRUCTURED INTERVIEW

I will name maintenance tasks that you performed on the M9 ACE. Please answer Yes or No to indicate whether or not you have had any difficulties performing the tasks. I would also appreciate your comments concerning the difficulties you encountered. If you have no experience with the equipment, then state Not Applicable (N/A). (Use the back of the page if more space for comments is required, and please include the item number.)

			Difficulties	
	Tasks	Yes	No	N/A
1.	Inspecting track and roadwheels	0	7	0
2.	Checking track tension	2	5	0
3.	Inspecting blade cutting	0	7	0
4.	Inspecting hull	1	6	0
5.	Inspecting cylinders and lines	0	7	0
6.	Inspecting fuel filter	0	7	0
7.	Inspecting fuel tank lines	0	7	0
8.	Inspecting engine components	0	7	0
9.	Checking engine oil level	1	6	0
10.	Checking fire extinguisher pressure gauge	0	7	0
11.	Inspecting power transfer assembly	0	7	0
12.	Inspecting steer unit	0	7	0
13.	Inspecting air reservoir	0	6	1
14.	Draining condensation from air reservoir	0	7	0
15.	Operating the hatch lock	1	6	0
16.	Checking vision block seals	0	7	0
17.	Checking portable fire extinguisher for missing seals	0	7	0
18.	Inspecting exhaust system	0	7	0
19.	Checking for hot wheel hubs	0	7	0
20.	Checking infrared lights	0	7	0
21.	Checking operating lights	0	7	0
22.	Checking hydraulic reservoir oil level	0	7	0
23.	Inspecting hydraulic valve bank	0	7	0
24.	Checking hydraulic controls for smooth operation	0	7	0
25.	Observing gauges and warning lights for normal operation	0	7	0

Tasks	Difficulties Yes	No	N/A
26. Checking for loose bolts on drive shaft	1	2	4
27. Inspecting winch hydraulic lines	0	6	1
28. Inspecting winch wire rope	0	7	0
29. Cleaning bilge pump screen	3	4	0
30. Checking battery fill level	3	4	0
31. Checking radiator fill level	0	7	0

Item No.	Comments:
2.	Must be on smooth surface. Can't check in the field.
4.	Hull blocks, doesn't fit.
9.	Dipstick difficult to install.
26.	Difficult to get to.
29.	Can't be reached.
30.	Can't reach back cells.

Other or additional comments:

(No responses)

M9
SUMMARY SHEET

Date __ __ __ __ __ __ Vehicle ID ____ Player ID __________
d d m m y y

Name ________________________________ MOS __________ Rank ________________

M9 CONTROLS AND DISPLAYS: STRUCTURED INTERVIEW

I will name controls and displays for the M9 ACE. Please answer Yes or No to indicate whether or not you have had any difficulties when using the following items. I will ask you about difficulties encountered when you wore fatigue uniforms and MOPP IV uniforms or other heavy clothing such as gloves. I would also appreciate your comments concerning the difficulties you encountered. If you have no experience with the equipment, then state Not Applicable (N/A). (Use the back of the page if more space for comments is required, and please include the item number.)

		Difficulties Fatigues			Difficulties MOPP IV		
	Controls	Yes	No	N/A	Yes	No	N/A
1.	Steering wheel	0	7	0	0	7	0
2.	Suspension control lever	2	5	0	2	5	0
3.	Sprung/unsprung lever	0	7	0	0	7	0
4.	Trailer brake control	0	4	3	0	2	5
5.	Wiper control	0	7	0	0	5	2
6.	Start aid control	0	3	4	0	2	5
7.	Winch control lever	0	6	1	0	3	4
8.	Ejector control lever	0	7	0	0	7	0
9.	Apron control lever	0	7	0	0	7	0
10.	Dome light dimmer switch	0	7	0	0	4	3
11.	Bilge pump light	1	5	1	0	3	4
12.	Bilge pump control	0	6	1	0	3	4
13.	Transmission shift lever	1	6	0	1	6	0
14.	Warning buzzer	0	7	0	0	1	0
15.	Personnel heater	0	7	0	0	1	0
16.	Driver's compartment vent	0	7	0	0	6	1
17.	Winch shift lever	1	6	0	1	4	2
18.	Steer selector lever	0	7	0	0	6	1
19.	Hand throttle	0	7	0	0	5	2
20.	Hand brake lever	0	7	0	0	7	0
21.	Hatch cover release	2	5	0	1	4	2
22.	Hydraulic oil reservoir filler and dipstick	0	7	0	0	5	2
23.	Seat vertical adjusting lever	C	7	0	0	7	0
24.	Accelerator pedal	0	7	0	0	7	0
25.	Brake pedal	2	5	0	2	5	0

	Controls	Yes	Difficulties Fatigues No	N/A	Yes	Difficulties MOPP IV No	N/A
26.	Headlight beam selector switch	0	7	0	0	7	0
27.	Seat horizontal control lever	0	7	0	0	7	0
28.	Floodlight switch (Front)	0	7	0	0	6	1
29.	Floodlight switch (Rear)	0	7	0	0	6	1
30.	Bo drive-infrared selector switch	0	7	0	0	5	2
	Displays and Gauges						
31.	Panel light	3	4	0	2	4	1
32.	Light switch assembly	0	7	0	0	6	1
33.	Low trans press indicator light	4	3	0	1	4	2
34.	Low air indicator light	0	7	0	0	7	0
35.	Battery generator indicator	0	7	0	0	7	0
36.	High beam indicator light	0	7	0	0	7	0
37.	Low-oil PRESS indicator light	0	7	0	0	7	0
38.	Unsprung indicator light	2	5	0	1	5	1
39.	Fuel level indicator	0	7	0	0	7	0
40.	Start switch	0	7	0	0	7	0
41.	Panel (lights)	2	5	0	1	5	1
42.	Eng oil press indicator	0	7	0	0	7	0
43.	Water temp indicator	0	7	0	0	7	0
44.	Hyd oil temp indicator	0	7	0	0	7	0
45.	Trans oil temp indicator	1	6	0	1	6	0
46.	Speedometer	0	7	0	0	7	0
47.	Tachometer/hourmeter	0	7	0	0	7	0
48.	Parking brake indicator light	1	6	0	0	7	0
49.	Heater switch	0	7	0	0	6	1
50.	Utility outlet	0	7	0	0	5	2
51.	Ignition ON/OFF switch	0	7	0	0	6	1
52.	Master switch	0	7	0	0	6	1

Comments:

Suspension control lever: Drops to the right. Left side reacts too slowly.
Bilge pump light: Light is hidden below hatch rim.
Transmission shift lever: Difficult to find 6th.
Winch shift lever: Winch drum must be turning in order to shift.
Hatch cover release: Hatch too heavy. Difficult to close.
Brake pedal: Not enough legroom. Brake pressure inconsistent.
Panel light: Left light too big and bright. (3)
Low trans press indicator light: Blinks on and off during night operations. (3)
Unsprung indicator light: Blinds you at night. (2)
Panel (lights): Too bright for night operations.
Trans oil temp indicator: Book says 200^{o} - it runs at 220^{o}
Parking brake indicator light: Too bright for night operations.

Short Answer

53. Did your MOPP IV face mask or hoses interfere with viewing the displays or using the controls?

Yes	2
No	4
N/A	1

Comments: Please describe any interference:

The face mask eyepieces get blurry.

54. Are any controls likely to be accidentally turned on or off?

Yes	0
No	7
N/A	0

Comments: Please list controls if you answered Yes

(No comments)

55. Do you have any difficulties using the controls and displays during night operations?

Yes	4
No	3
N/A	0

Comments: Please explain which controls/displays are difficult to use if you answered Yes:

Left panel light too bright for night operations.
Shifting causes the low transmission light to come on.
Can't see gauges when wearing the night vision goggles.

56. Do you have any difficulties using the controls and displays while wearing your MOPP IV NBC uniform?

Yes	1
No	5
N/A	0

Comment (please explain which controls/displays are difficult to use if you answered Yes):

(No comments)

M9
SUMMARY SHEET

AMPHIBIOUS OPERATIONS: STRUCTURED INTERVIEWS

Name of Respondent ______________________________ Date ____________

I will name tasks that you and the earthmovers performed. Please answer Yes or No to indicate whether or not the earthmover had any difficulties performing the tasks. I would also appreciate your comments concerning the difficulties you encountered. If you have no experience with the task, then state Not Applicable (N/A). (Use the back of the page if more space for comments is required, and please include the item number.)

M9 ACE	Yes	No	N/A
1. Digging access ramps	0	3	1
2. Installing flotation kit			
a. Drain plugs	0	6	1
b. Rear door	0	7	0
c. Blade rivets	0	7	0
3. Removing armor panels	2	5	0
4. Performing pre-ops swim check	0	7	0
5. Entering water	0	7	0
6. Steering while swimming	4	3	0
7. Exiting water	0	7	0
8. Removing flotation kit	0	7	0
9. Installing armor panels	1	6	0
10. Performing post-ops swim check	0	7	0
11. Digging egress ramps	2	3	2

Item
No. Comment:

1. Gets stuck.
3. Tiresome, panels heavy.
6. Hard to guide.
9. Tiresome.
11. Gets stuck (2)

12. Other: Comments

It's hard to put engine grille in bowl by yourself. (3)
You slip a lot.
The grilles are heavy. (2)
Needs a track side skirt for swimming like the 113. (3)

PRELIMINARY HEALTH AND SAFETY QUESTIONNAIRE

Data Summary

The data were collected as part of the human factors assessment of the M9 ACE and D7 earthmover systems FOE. The data were collected on 3 April 1985, the day after vehicle operators had made comments to the test human factors engineer concerning safety issues, including noise and vibration. Responses were obtained from the operators of both systems and are summarized by each question that appeared on the questionnaire.

1. The number of operators responding:

   One D7 operator was on medical leave for an injury that was unrelated to the test.

   7 M9 ACE   6 D7

2. Does the noise from your vehicle ever become loud enough to cause your ears to ring or your head to ache?

Number of Responses

M9 Operators		D7 Operators	
Yes	No	Yes	No
6	1	6	0

3. When is the noise that loud?

Number of Responses

		M9 Operators		D7 Operators	
		Yes	No	Yes	No
a.	When traveling cross country	1	6	3	3
b.	When traveling on secondary roads	2	5	2	4
c.	When traveling on paved roads	0	7	3	3
d.	While wearing the MOPP mask and hood	6	1	4	2
e.	While wearing double ear protection	0	7	0	6
f.	While scraping or dozing	3	4	3	3
g.	At any other time (you fill in)	3	_	_	_

M9: All are Yes without hearing protection. Hatch closed. Cannot see through mask because of sweat. D7: No comments.

4. Do you (complete the following):

		Number of Responses			
		M9 Operators		D7 Operators	
		Yes	No	Yes	No
a.	Wear earplugs when operating?	3	4	2	4
b.	D7 operators: Wear ear protection headsets when operating?	N/A	N/A	6	0
c.	M9 operators: Wear your CVC helmet when operating?	7	0	N/A	N/A
d.	M9 operators: Turn your CVC headphones on full volume when operating?	2	5	N/A	N/A

5. Have you ever felt any of the following sensations or pains during or after operating the earthmover?

		Number of Responses			
		M9 Operators		D7 Operators	
		Yes	No	Yes	No
a.	Back pain	0	7	4	2
b.	Back stiffness	1	6	4	2
c.	Kidney pain	0	7	2	4
d.	Muscle pain	2	5	1	5
e.	Dizziness	4	3	2	4
f.	Sick to your stomach (nausea)	1	6	2	4
g.	Blurred vision	0	7	3	3
h.	Headaches	5	2	5	1

If you checked Yes to any of the above, what do you feel caused the pain or sensation?

M9 Operators:

Night vision devices. CVC helmet fit. CVC helmet volume. The noise and ride itself. Sitting posture. Pressing the accelerator. Noise. Lack of legroom.

D7 Operators:

Vibration. I have a crooked spine. Dust in my eyes. MOPP gear causes nausea and sickness. Staying in same position for long times. Long hours in rough terrain. Blurred vision from looking backwards. Kidney pain after 2 to 4 hours.

6. Does your earthmover rock or bounce forcibly while traveling:

		Number of Responses			
		M9 Operators		D7 Operators	
		Yes	No	Yes	No
a.	Cross country	6	1	5	1
b.	On secondary roads	3	4	2	4
c.	On paved roads	0	7	2	4

7. How often does the blade hit the ground when traveling cross country or on secondary roads? (check one)

		Number of Responses	
		M9 Operators	D7 Operators
a.	Never	0	4
b.	Not often	0	1
c.	Sometimes	4	1
d.	Often	1	0
e.	Very often	1	0

If the blade hits the ground, does this throw you forward? (check one)

Number of Responses				
M9 Operators		D7 Operators		
Yes	No	Yes	No	N/A
4	3	2	1	5

8. Has any part of your body been painfully bruised or bumped when operating?

Number of Responses			
M9 Operators		D7 Operators	
Yes	No	Yes	No
0	7	4	2

Comments: Please briefly describe the incident.

(cont'd)

(question 8 cont'd)

Comments summarized:

M9 Operators		D7 Operators	
Number Commenting 0		Number Commenting 3	
Body part struck	Object struck	Body part struck	Object struck
		Elbow & knee	
		Hemmorrhoids	
		Back	LBE

9. Have you ever felt sick to your stomach (nausea) during or after using the:

	Number of Responses			
	M9 Operators		D7 Operators	
	Yes	No	Yes	No
a. Night vision goggles	6	1	1	5
b. M9 operators: Night vision periscope	6	1	N/A	N/A

10. M9 Operators: Have you traveled with the ejector blade forward in order to smooth out the earthmover's ride? (check one)

Number of Responses

Yes	No
5	2

11. M9 Operators: Have you traveled with dirt in the bowl in order to smooth out the earthmover's ride?

Number of Responses

Yes	No
5	2