

AD 3-3-87
AD
(2)

DTIC FILE COPY

AD-A191 153

MEMORANDUM REPORT BRL-MR-3630

MAINTENANCE OPERATIONS IN
MISSION ORIENTED PROTECTIVE
POSTURE LEVEL IV (MOPPIV) PART II

CHARLES H. WICK
JOHN A. MORRISSEY

OCTOBER 1987

APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED

US ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

DTIC
ELECTE
MAR 21 1988
S CA H D

88 3 18 021

DESTRUCTION NOTICE

Destroy this report when it is no longer needed. DO NOT return it to the originator.

Additional copies of this report may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The use of trade names or manufacturers' names in this report does not constitute indorsement of any commercial product.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER BRL-MR-3630	2. GOVT ACCESSION NO.	3. RECIPIENT'S CAT. LOG NUMBER A191133
4. TITLE (and Subtitle) MAINTENANCE OPERATIONS IN MISSION ORIENTED PROTECTIVE POSTURE LEVEL IV (MOPPIV), PART II		5. TYPE OF REPORT & PERIOD COVERED FINAL
7. AUTHOR(s) CHARLES H. WICK JOHN A. MORRISSEY		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Ballistic Research Laboratory ATTN: SLCBR-VL-T Aberdeen Proving Ground, MD 21005-5066		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 1L162618AH80
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Ballistic Research Laboratory ATTN: SLCBR-DD-T Aberdeen Proving Ground, MD 21005-5066		12. REPORT DATE
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution is unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Maintenance Operations MOPPIV M60A3 Degraded Effectiveness		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The performance degradation resulting from the wearing of individual protective equipment (IPE) is a concern to military commanders. Responding to this concern a series of field trials were implemented in an attempt to quantify the IPE effect. Maintenance tasks are considered to be particularly difficult to perform while wearing protective equipment. This difficulty is believed to be exasperated by elevated temperatures. To evaluate this situation and provide a quantitative estimate of the degra-		

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

dation, six maintenance tasks were performed in a field environment during summer temperatures (75-85°F) and humidity (58-88% RH). The tasks included: remove and replace: M60A3 powerpack, M60A3 transmission, M109 Breech Block; and repair: M60 Machine gun and M901 ITV traverse mechanism. These operations were performed by several teams who alternated starts while wearing the standard battle dress uniform (BDU) and the MOPPIV ensemble. Individuals were highly motivated, in high physical readiness and psychologically prepared for the operation.

Data were analyzed using standard statistical procedures. A correction factor was defined as that value by which the time to complete a procedure in BDU should be multiplied to provide the time required to complete the task while wearing IPE. These factors for the maintenance tasks are:

Correction Factors for Wearing MOPPIV

Task	Factor	Probable Range
M60A3 Power Pack		
Remove	1.0#	0.8-1.2
Replace	1.1	1.0-1.2
M60A3 Transmission		
Remove	1.7	1.3-2.1
Replace	1.2	1.0-1.3
M109 Breech Block		
Remove	1.4	0.7-2.1
Replace	2.2	a
M60 Machine Gun		
Barrel Group	1.0#	1.0-1.1
Trigger Group	1.0#	0.7-1.4
M901 Traverse Mechanism		
Remove	1.7	0.7-2.7
Replace	1.9	1.6-2.4
Recover M60A3	1.1*	0.9-1.3
#Probably not degraded		
*Without boots		
a = insufficient data for calculation		

It was confirmed that the first time effect, experience gained through repetition, is comparable in magnitude to the IPE effect. This indicates that training improves personnel performance while wearing this equipment. The protective overboot remains a hazard in operations where mud is encountered and should be redesigned to improve its performance. Correction factors should be used as a guide for performing tasks in the field. It should be noted, however, that these values do not reflect performance under continuous operations where other factors, such as fatigue, may influence performance.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

CONTENTS

I.	INTRODUCTION.....	1
1.	Background.....	1
2.	Objective.....	2
II.	APPROACH.....	2
1.	Overview.....	2
2.	Trial Description.....	3
a.	Remove/Replace M60A3 Power Pack.....	3
b.	Remove/Replace M60A3 Transmission.....	3
c.	Remove/Replace M109 Breech Block.....	4
d.	Recover M60A3 Tank.....	4
e.	Repair M60 Machine Gun.....	5
f.	Repair M901 ITV Traverse Mechanism.....	5
3.	Trial Matrix and Questionnaire.....	5
a.	Trial Matrix.....	5
b.	Survey.....	6
4.	Aggregated Events.....	6
III.	RESULTS/DISCUSSION.....	7
IV.	DATA ANALYSIS/DISCUSSION.....	10
1.	Analysis.....	10
2.	Regression Results for all Tasks.....	10
a.	M60A3 Power Pack.....	10
b.	M60A3 Transmission.....	10
c.	M109 Breech Block.....	12
d.	Recover M60A3 Tank.....	12
e.	M60 Machine Gun.....	12



By	
Distribution/	
Availability	
Dist	Avail an
Specia	

A-1

f. M901 Traverse Mechanism.....	13
3. Aggregating Results.....	13
4. General Discussion.....	13
a. Survey Questions.....	14
V. SUMMARY/CONCLUSIONS.....	21
APPENDIX A: Climatic Conditions.....	23
APPENDIX B: Field Data.....	27
APPENDIX C: Regression Results by Task and Event.....	37
APPENDIX D: Multiple Linear Regression.....	45
DISTRIBUTION LIST.....	51

LIST OF TABLES

TABLE 1.	Maintenance Operations.....	2
TABLE 2.	M60A3 Power Pack.....	3
TABLE 3.	M60A3 Transmission.....	4
TABLE 4.	M109 Breech Block.....	4
TABLE 5.	M60A3 Tank Recovery.....	5
TABLE 6.	M60 Machine Gun.....	5
TABLE 7.	M901 ITV Traverse Mechanism.....	5
TABLE 8.	Participant Questionnaire.....	6
TABLE 9.	Task Grouping for Analysis.....	6
TABLE 10.	Remove/Replace M60A3 Power Pack.....	7
TABLE 11.	Remove/Replace M60A3 Transmission.....	7
TABLE 12.	Remove/Replace M109 Breech Block.....	8
TABLE 13.	Recovery of a M60A3 Tank.....	8
TABLE 14.	Repair M60 Machine Gun.....	9
TABLE 15.	M901 ITV Traverse Mechanism.....	9
TABLE 16.	Regression Results by Task.....	11
TABLE 17.	Grouped MOPPIV Effect.....	14
TABLE 18.	Survey Results for M60A3 Power Pack.....	15
TABLE 19.	Survey Results for M60A3 Transmission.....	16
TABLE 20.	Survey Results for M109 Breech Block.....	17
TABLE 21.	Survey Results for Recovery of M60A3 Tank.....	18
TABLE 22.	Survey Results for M60 Machine Gun.....	19
TABLE 23.	Survey Results for M901 ITV Traverse Mechanism.....	20

TABLE 24.	Correction Factors for MOPP IV.....	21
TABLE A-1.	Temperature - Relative Humidity Summary.....	25
TABLE B-1.	Field Data Tables.....	29
TABLE B-2.	Remove M60A3 Power Pack.....	29
TABLE B-3.	Replace M60A3 Power Pack.....	30
TABLE B-4.	Remove M60A3 Transmission.....	30
TABLE B-5.	Replace M60A3 Transmission.....	31
TABLE B-6.	Remove M109 Breech Block.....	31
TABLE B-7.	Replace M109 Breech Block.....	32
TABLE B-8.	Recovery of a M60A3 Tank.....	33
TABLE B-9.	Repair M60 Machine Gun.....	34
TABLE B-10.	Repair M901 ITV Traverse Mechanism.....	35
TABLE C-1.	Tables for Regression Results.....	39
TABLE C-2.	Remove/Replace M60A3 Power Pack.....	39
TABLE C-3.	Remove/Replace M60 Power Pack, Regression Coef- ficients.....	40
TABLE C-4.	Remove/Replace M60A3 Transmission.....	40
TABLE C-5.	Remove/replace M60A3 Transmission, Regression Coefficients.....	41
TABLE C-6.	Remove/Replace M109 Breech Block.....	41
TABLE C-7.	Remove/Replace M109 Breech Block.....	42
TABLE C-8.	M60A3 Tank Recovery.....	42
TABLE C-9.	Recover a M60A3 Tank, Regression Coeffi- cients.....	42
TABLE C-10.	Repair M60 Machine Gun.....	43
TABLE C-11.	Repair M60 Machine Gun, Regression Coeffi- cients.....	43
TABLE C-12.	Remove/Replace M901 ITV Traverse Mechanism.....	43
TABLE C-13.	Remove/Replace M901 ITV Traverse Mechanism.....	44

TABLE D-1.	Data Used in Example Regression.....	48
TABLE D-2.	Regression Coefficients for Example.....	48
TABLE D-3.	Calculations for Example.....	49
TABLE D-4.	Example Results.....	49

I. INTRODUCTION

1. Background

Troop performance degradation due to chemical protective equipment has been of increasing concern to military commanders. This protective equipment is worn in one of four configurations referred to as mission oriented protective posture (MOPP) levels. The highest protective level, MOPPIV, in which all equipment is worn and sealed, is also the most bulky, cumbersome and restrictive mode. Personnel are protected at the expense of this encumbrance - a circumstance which results from impeded physiological functions such as: vision, hearing, speaking, manual dexterity and others. This encumbrance produces degradation in the form of (usually) increased time to complete tasks and in some cases reduced accuracy. For the purposes of this evaluation time to complete a task was the only factor used in determining personnel degradation due to wearing MOPPIV. To quantify this degradation for the commander's use, in simulations, war gaming and other studies of unit effectiveness and combat readiness, field studies are necessary.

This evaluation was performed in response to a requirement submitted to the Dugway Proving Ground (DPG) administered Chemical Biological Joint Contract Point and Test Program, referred to as DO-49, to conduct an evaluation to determine the effect of MOPPIV on personnel performing military tasks. Presently, the program includes several specific operational areas with additional emphases on operations during cold, moderate and hot temperatures. The Ballistic Research Laboratory (BRL) was contracted to make an evaluation of the performance decrement.

A concern in interpreting field data is the need to quantify the degradation. It is not unusual to find subjective judgements made on the effect protective equipment has on individual performance. One purpose of this evaluation is to provide a numerical estimate of the performance decrement resulting from wearing individual protective equipment.

This report presents the results of selected maintenance operations conducted at Aberdeen Proving Ground (APG), Maryland in July and August 1985 under summer temperatures (75-85° F). A summary of the temperature and relative humidity is included in Appendix A. Trials were performed by soldiers of the Student Brigade of the U.S. Ordnance Center and School, APC. Two sub-contractors, Lockheed Engineering and Management Service Company and the Human Engineering Laboratory (HEL) assisted in collecting the data and providing videotape coverage of all trials. Trials were performed during the daylight hours. Teams remained in MOPPIV without relief for each trial. Several tasks were performed (Table 1).

TABLE 1. Maintenance Operations

Task
Remove/Replace M60A3 Power Pack
Remove/Replace M60A3 Transmission
Remove/Replace M109 Breech Block
Recover M60A3 Tank
M60 Machine Gun Repair
M901 ITV Traverse Mechanism Repair

2. Objective

The primary objective of this evaluation was to monitor the operational capabilities and to quantify the performance degradation of personnel dressed in MOPPIV performing selected maintenance tasks.

II. APPROACH

1. Overview

The measure of personnel performance degradation for each task was the time difference between performing the task in battle dress uniform (BDU) and MOPPIV. For these trials there were five teams for each task. A trained military observer (Senior NCO) timed each task performance and rated the overall operation. The tasks were measured in real time and recorded on a data sheet carried by the observer.

Individuals had been trained in the appropriate military operational speciality (MOS) and were highly motivated. Teams did not have prior experience working together. Further, the teams did not have prior practice before completing the first trial of this series of tasks. Teams were familiar with chemical protective equipment, but received no special prior instruction in the wearing or completing the above tasks in MOPPIV.

Since these tests were repetitive, individuals gained experience as they progressed through the trials. In an effort to control and later estimate the experience effect, the order of start was recorded; i.e., whether a team was in BDU or MOPPIV the first time it performed a trial. For the purposes of this analysis, all references to "first time effect" pertain to the first trial for each team.

For each trial, the task completion time, the protective profile (BDU/MOPP), and the trial order were recorded.

Individual core body temperature, skin temperature and heart beat were monitored continually and recorded every two minutes during each task.

A multiple linear regression technique, explained in Appendix B, was used to estimate the effect of the chemical protective equipment and practice on the time to complete the various tasks.

2. Trial Description

The trials were designed to collect performance data on maintenance teams conducting a maintenance mission consisting of repairing various systems. These systems included the power pack and transmission from a M60A3 Tank, a M901 traverse mechanism, a M60MG, and the breech block on the M109.

a. **Remove/Replace M60A3 Power Pack.** A four-man crew performed this task. These crewmen were systems mechanics MOS 63N/63H. Each team performed once in BDU and once in MOPPIV. There was a one hour break between trials. A fifteen minute break, in which the team stayed in uniform, was taken between removing and replacing the power pack (Table 2).

TABLE 2. M60A3 Power Pack

Event	Operation
1	Cover
2	Turret Connections
3	Accessory Connections
4	Power Pack

b. **Remove/Replace M60A3 Transmission.** This was a two-man task, the crew consisted of one experienced and one student member trained in MOS 63H. The transmission was separated from the power pack and then replaced (Table 3). Each team completed

-
1. C.H. Wick, J.T. Klopacic, " Maintenance Operations in Mission Oriented Protective Posture Level IV (MOPPIV)." Draft DPG Report 1985.

the task once in BDU and once in MOPPIV except team 4 which performed the task once in BDU and twice in MOPPIV. A fifteen minute break was given between separating and rejoining the transmission; the crewmen did not remove the MOPPIV equipment during this break. An hour break was taken between BDU and MOPPIV operations.

TABLE 3. M60A3 Transmission

Event	Operation
1	Shroud
2	Accessories
3	Mounting Bolts
4	Transmission

c. **Remove/Replace M109 Breech Block.** The crew consisted of two personnel, one experienced and one student, both trained as artillery repairmen, MOS 45L/45K. Each team performed the task (Table 4) four to eight times, depending upon the weather and the time to accomplish the task by individual teams. The task was conducted in two phases, remove the breech block and replace it with no break between phases.

TABLE 4. M109 Breech Block

Event	Operation
1	Damper
2	Firing Mechanism
3	Breech Block

d. **Recover M60A3 Tank.** A disabled M60A3 tank was recovered by a four-man team utilizing an M88 recovery vehicle (Table 5). The team consisted of students trained as automotive repairmen MOS 63H/63N. The protective overboot, a potential hazard to the wearer due to the deep mud at the test site, was deleted as part of the MOPPIV gear after trial M-3.

TABLE 5. M60A3 Tank Recovery

Event	Operation
1	Attach Tow Bar
2	Open Grill Doors and Remove Heat Shields
3	Disconnect Final Drives
4	Secure Grill Doors and Replace Heat Shield

e. **Repair M60 Machine Gun.** This was a one-man task simulating the field repair of the M60 Machine gun (Table 7). Personnel were trained in small weapon repair, MOS 45K, and performed this task in a tent located in a field.

TABLE 6. M60 Machine Gun

Event	Operation
1	Barrel Group
2	Trigger Assembly

f. **Repair M901 ITV Traverse Mechanism.** A one man task with personnel trained in MOS 45K disassembled and assembled a traverse mechanism (Table 8). The task was performed on a workbench in a tent located in a field.

TABLE 7. M901 ITV Traverse Mechanism

Event	Operation
1	Outer Gear and Snap Ring
2	Gear Assembly

3. Trial Matrix and Questionnaire

a. **Trial Matrix.** The order of start was recorded to assist in determining the effect of training on performing the various tasks. The trial matrix indicating the day, the team, and the uniform worn was maintained. The uniform worn for the first time is indicated by an "*." Where possible the uniform worn was alternated between BDU and MOPPIV.

b. **Survey.** At the conclusion of a MOPPIV trial, individuals were asked to complete a questionnaire. Each was asked to rate the perceived difficulties encountered while wearing the mask, boot, and overgarment. The items to be rated are given in Table 7. Ratings were determined by checking one of four boxes: none, minor, average, and major. Each box later received a numerical weight of 0, 5, 10 and 15, respectively, for further analysis.

TABLE 8. Participant Questionnaire

Number	Situation
1	Mask-Vision Hampered
2	Mask-Perspiration Buildup
3	Mask-Breathing Difficulties
4	Mask-Voice Communication
5	Boots-Movement Difficulties
6	Boots-Slipping
7	Gloves-Operating Equipment
8	Gloves-Performing Tasks
9	Overgarment-Bulkiness
10	Overgarment-Heat Buildup

4. Aggregated Events

Some tasks can be considered together or grouped as the result of similar physical functions. Tasks which are generally gross motor skills can be considered as variations of a single task, likewise tasks composed generally of fine motor skills. Grouping the data in this manner provided a basis for estimating the difference between these types of tasks. A MOPPIV correction factor can then be estimated for each group. Task groupings are given in Table 9.

TABLE 9. Task Grouping for Analysis

Gross Motor Skills		Fine Motor Skills	
I Remove Power Pack Transmission M109	II Replace Power Pack Transmission M109	III Remove Traverse M60 MG	IV Replace Traverse M60 MG

III. RESULTS/DISCUSSION

The following tables (Tables 10 to 15) are the actual times for performing the major subdivisions of each task. Typically, this includes the removal and replacement times except in the recovery and M60 machine gun operations where this division was not appropriate. Where a team was able to accomplish a task more than once, multiple numbers are given. Both BDU and MOPPIV times are indicated. Details by event are provided in Appendix B.

TABLE 10. Remove/Replace M60A3 Power Pack

Team	Total Time Minutes			
	BDU		MOPPIV	
	Remove	Replace	Remove	Replace
1	60.3*	75.4	28.0	64.0
2	57.3*	89.4	42.6	a
3	27.8	66.7	49.8*	86.1
4	17.5	49.1	40.0*	85.4
5	50.7*	73.9	35.0	54.4
* = First time				
a = No data				

TABLE 11. Remove/Replace M60A3 Transmission

Team	Total Time Minutes			
	BDU		MOPPIV	
	Remove	Replace	Remove	Replace
1	a	a	316.0*	68.0
2	48.6*	48.6	64.2	40.6
3	26.3 18.4	33.0 28.4	54.5*	47.6
4	36.6*	44.9	36.8	48.3
5	19.7	29.1	29.3*	37.3
* = First time				

TABLE 12. Remove/Replace M109 Breech Block

Team	Total Time Minutes			
	BDU		MOPPIV	
	Remove	Replace	Remove	Replace
1	22.0*	a	11.2	9.8
2	4.0	4.0	20.9*	14.2
3	a	a	a	4.9
4	3.3	3.3	10.1*	28.0
	3.0	9.0		
5	11.5*	8.7	6.6	8.4
			4.5	7.5
* = First time				
a = No data				

TABLE 13. Recovery of a M60A3 Tank

Total Time, Minutes		
Team	BDU	MOPPIV
1	25.7* 18.2	12.7
2	8.8 5.6	18.4* 17.1
3	16.7*	16.2
4	9.5 8.2	15.6*
5	18.9* 12.5	7.9
* = First time		

TABLE 14. Repair M60 Machine Gun

Team	Total Time, Minutes			
	BDU		MOPPIV	
	Barrel	Trigger	Barrel	Trigger
1	18.8*	4.1*	4.6	4.4
	6.6	3.8	9.1	4.2
	4.4	2.2	4.5	3.4
2	4.7	2.8	9.0*	5.0*
	2.9	2.2	3.0	5.3
	2.5	2.0	3.8	2.1
			2.6	2.7
3	4.9*	4.0*	4.1	2.9
	2.8	2.4		
	3.1	1.5		
4	2.4	2.4	4.9*	5.6*
	2.4	1.8	3.7	4.0
5	6.4*	19.1*	4.8	5.6
	5.6	10.0		
* = First time				

TABLE 15. M901 ITV Traverse Mechanism

Team	Total Time, Minutes			
	BDU		MOPPIV	
	Disassembly	Reassembly	Disassembly	Reassembly
1	42.0*	33.0*	30.0	55.0
2	9.0	12.0	58.0*	41.0*
3	25.0*	26.0*	a	35.0
			a	24.0
4	6.0	12.0	11.0*	35.0*
5	34.0*	30.0*	a	22.0
* = First time				
a = No data				

IV. DATA ANALYSIS/DISCUSSION

A regression analysis was used to analyze the data. This technique is explained and an example provided in Appendix D. This section presents regression analyses for each task performed during the several maintenance tasks. In addition, the questionnaire responses are presented and discussed.

1. Analysis

The regression technique provided two values for calculating a correction factor (CF) and a probable range; i.e., T_0 which is the practiced unencumbered term and a , the uniform correction. An additional value b is given which represents the first time correction. The b value was determined simply to remove this effect from the correction factor calculation. The results of these analyses are given in Table 16. The MOPPIV degradation for any particular task is defined as $T_0/(T_0 + a)$. The MOPPIV correction factor is the inverse of this term and is used to multiply the time to complete a task while wearing BDUs to give an estimate of the time to complete the task while wearing MOPPIV. A negative a or b indicates that a task was completed in less time by a team wearing MOPPIV or by a less experienced team, respectively. Generally, such results are attributed to non-correctable inconsistencies in some team's performance for that task.

2. Regression Results for all Tasks

a. **M60A3 Power Pack.** Replacing the power pack required 10% more time when wearing MOPPIV than wearing BDU. Other events during this operation ranged from no correction to 1.9; the removal and replacement corrections being relatively equal.

b. **M60A3 Transmission.** MOPPIV corrections of 1.1 and 1.5 exist for the events of removing and replacing the shroud, respectively. The difference between these events appears to be attributable to replacing the bolts on the shroud where extra time was required aligning and replacing these bolts. It is interesting to note that the larger mounting bolts were exactly the opposite. To remove the mounting bolts required a CF of 2.1 and a CF of less than 1.0 to replace them. Evidently, replacing small bolts requires an extra effort of first finding where the bolt fits, then starting the operation of threading. After the bolt is started (that is the tightening phase is started) the operation appears not to be affected. The larger mounting bolts are, evidently, easier to grasp and start than the bolts of the shroud. Other events in this task were not affected by the wearing of MOPPIV, in fact, some events were performed in less time; this observation is believed to represent a natural variation between teams performing an operation not affected by wearing MOPPIV.

TABLE 16. Regression Results by Task

Task	Unencumbered Term	Clothing Correction	First-Time Correction	MOPPIV Factor/ PR*
	T_o	a	b	
M60A3 Power Pack				
Remove	29.8	0.7 ± 5.9	21.5 ± 5.9	1.0 0.8-1.2
Replace	56.6	3.9 ± 5.2	23.9 ± 5.2	1.1 1.0-1.2
M60A3 Transmission				
Remove	24.8	16.7 ± 10.2	5.4 ± 10.2	1.7 1.3-2.1
Replace	31.1	4.8 ± 4.7	9.8 ± 4.7	1.2 1.0-1.3
M109 Breech Block				
Disassembly	4.2	1.8 ± 2.9	10.4 ± 2.9	1.4 0.7-2.1
Reassembly	4.5	5.6 ± 3.5	8.7 ± 3.7	2.2 a
M60 MG				
Barrel Gp	4.1	0.1 ± 1.2	4.4 ± 1.4	1.0 1.0-1.1
Trigger Gp	3.6	0.1 ± 1.3	3.7 ± 1.5	1.0 0.7-1.4
M901 Traverse Mechanism				
Disassembly	12.1	8.6 ± 12.5	18.4 ± 12.5	1.7 0.7-2.7
Reassembly	16.3	15.5 ± 6.5	10.5 ± 6.5	1.9 1.6-2.4
Recover M60A3	11.3	0.9 ± 2.3	7.4 ± 2.4	1.1 0.9-1.3
* PR = Probable range a = Insufficient data for calculation Regression results by each event are in Appendix B.				

c. **M109 Breech Block.** The MOPPIV correction factors, for the six events in this task, ranged from less than 1.0 to 3.4. Removing the breech was the most difficult taking 3.4 times longer in MOPPIV than in BDU. Replacing the breech had a CF of 1.6. Replacement requires both gross motor activity and some judgements made as the result of near vision and fine motor skills. The breech must be installed according to timing marks which determine if the breech will lock and operate correctly. Setting the breech in place and alignment with these marks are considered the source for the increased correction factor. Generally, no difference was observed between removal and replacement events except the replacement of the breech itself; remaining events required a CF of 0.6 to 1.6 while wearing MOPPIV.

d. **Recover M60A3 Tank.** With CFs ranging from 0.8 to 0.9, disconnecting the final drives, opening the grill doors, and removing the heat shield were the least affected recovery events while personnel were in MOPPIV. A correction factor of 1.1 applied to all other events. As discussed earlier, the protective overboot was not worn during the fourth and fifth trials because of the potential mud hazard. During trials 1 and 2 the ground was relatively dry with little mud. The tank was recovered in this condition. Following rain the second day and the increase in the churning-up of the ground by the vehicles, it was evident that the boots were becoming a safety hazard. As a result, the boots were not worn because of this concern. It is thought that the recovery operation could be completed if some attention was given to improving the fastening of the boots to the soldier. Specifically, if the mud and water entry into the boot was restricted by a better seal on the top, and better fit of the boot it was thought that the boot could be worn. It was the general consensus that this was the result of the vacuum created by the sucking action of the mud that pulled the boot off, as the soldiers moved about. It should be noted that the gloves were pulled off the soldiers as they worked about the tow bar. Each case, however, the soldier was able to replace the glove in an appropriate manner to minimize possible contamination.

The alignment of the hitch with the tow bar was difficult. No flexibility is permitted during this operation, the driver of the M88 recovery vehicle must line-up the hitch exactly with the tow bar. Disconnecting the final drives can be completed quickly in either uniform depending upon how tight the drive was and the position from which the disconnection is initiated. As a result the task can vary from trial to trial. This variation may account for, in part, why a team wearing MOPPIV can complete this event in less time than a team wearing BDU.

e. **M60 Machine Gun.** The barrel group required 1.2 and 1.5 times longer to remove and replace while wearing MOPPIV than wearing BDU. It was observed that this operation was completed with little observed difficulty other than the increase in time required to complete the procedure. Removing/disassembling and

reassembling/replacing the trigger assembly had CFs of 1.3 and 1.0, respectively. It should be noted, however, that the time required to complete these events was usually less than 5.0 minutes.

f. **M901 Traverse Mechanism.** Disassembling the traverse mechanism in MOPPIV took three times as long to complete while wearing MOPPIV. It took 1.3 times longer to reassemble the gears and more than 2.6 times as long to replace the outer gear, the snap rings and bevel washer. The gear assembly required that the mechanism be aligned to timing marks necessary for proper function. This alignment was completed correctly by all teams. The correction factors observed represent the difference between complex disassembly and reassembly operations.

3. Aggregating Results

Combining events requiring similar physiological functions for task performance allows several general comments about types of tasks. Such aggregations are important in relating individual-quantified tasks to indirectly measured operational concepts such as "movement to the line." Aggregations, as the data becomes available, may be divided into such general areas as arming, maintaining, and fueling a system, such as a tank or aircraft.

In these analyses, tasks were grouped into "gross" and "fine motor functions." Gross motor is defined as those tasks requiring the use of predominantly large muscles, arms, legs, and general whole body movements such as walking, running, etc. Fine motor functions may include finger dexterity, tactile finger skills, and tasks with precision finger movement.

The division of the gross and fine motor functions into removal and replacement tasks provides a further refinement of the types of tasks to be considered. Removal tasks have typically been considered to be easier to perform than replacement tasks. This concept is illustrated in Table 17, where the correction factors for replacement events are greater in both the gross and fine motor functions categories although the corrections for gross motor functional tasks are nearly the same. It is thought that manual dexterity and close coordination between hand and eye movements may have been the predominate reason for this observation.

4. General Discussion

Teams required more time to replace equipment than to remove it while wearing MOPPIV. With prior experience, the teams required less time to perform the tasks. In this instance, the practice obtained by completing an event once was enough to improve the time for completing the event a second time. If the event was completed in BDUs first, the time to complete the event

TABLE 17. Grouped MOPPIV Effect

Gross Motor Functions		Fine Motor Functions	
I Remove	II Replace	III Remove	IV Replace
Power Pack Transmission M109	Power Pack Transmission M109	Traverse M60 MG	Traverse M60 MG
CF= 1.2	1.3	1.8	2.4
PR= 1.0-1.5	1.1-1.6	1.5-2.0	1.8-3.0
CF= Correction factor			
PR= Probable range			

while wearing MOPPIV would be affected; likewise, if the event was first completed in MOPPIV, the time to complete the event wearing BDU would be affected. This first time effect can confuse the interpretation of the data since subsequent times are often less.

The difference between the correction factors for removal and replacement events may be influenced by other factors. One such factor is the observation that the replacement tasks apparently require more concentration than removal tasks. Fine motor functions evidently are more difficult to improve while wearing MOPPIV (bolt holes require alignment, the bolts require starting, attachments and connectors require positioning and alignment) but can be learned from a prior experience. Another consideration in making these analyses is that replacement events always followed the removal events. As a result, a team's replacement task performance benefited from having participated in removal task. A team should gain a portion of experience for each task in this manner and the resulting performance degradation due to the first-time effect would be expected to be less than that for the removal task. Performance degradation due to wearing MOPPIV, however, would be expected to be greater due to the decrease in manual dexterity.

a. **Survey Questions.** Responses from each individual were weighted by giving a numerical value to the response terms accordingly: none = 0, minor = 5, average = 10, and major = 15. The average value was then used to estimate the level of perceived difficulty due to each factor. Survey results are given in Figures 18-23. Two concerns among those questioned were the perceived heat buildup in the overgarment and perspiration buildup in the mask were primary concerns.

TABLE 18. Survey Results for M60A3 Power Pack

Factor	Teams Wearing MOPPIV					Average
	1	2	3	4	5	
Mask/ Vision	7.5	2.5	8.8	6.3	xx	5.0
Mask/ Water Build-up	11.3	10.0	13.8	7.5	xx	8.5
Mask/ Breathing	6.3	7.5	6.2	2.5	xx	4.5
Mask/ Commo	2.5	2.5	2.5	0.0	xx	1.5
Boots/ Movement	5.0	3.8	6.3	6.3	xx	4.8
Boots/ Slipping	1.2	2.5	6.3	6.3	xx	3.3
Gloves/ Operating Equipment	5.0	5.0	5.0	7.5	xx	5.6
Gloves/ Tasks	6.3	5.0	5.0	7.5	xx	6.0
Overgarment/ Bulkiness	7.5	6.3	11.3	8.8	xx	8.5
Overgarment/ Heat Bld-up	10.0	5.0	12.5	11.2	xx	9.7
Average	6.3	5.0	7.8	6.4	xx	

TABLE 19. Survey Results for M60A3 Transmission

Factor	Teams Wearing MOPPIV					Average
	1	2	Team 3	4	5	
Mask/ Vision	15.0	0.0	2.5	2.5	2.5	4.5
Mask/ Water Build-up	15.0	2.5	5.0	2.5	5.0	6.0
Mask/ Breathing	7.5	0.0	2.5	2.5	2.5	3.0
Mask/ Commo	2.5	0.0	2.5	0.0	5.0	2.0
Boots/ Movement	0.0	0.0	2.5	2.5	0.0	1.0
Boots/ Slipping	7.5	0.0	5.0	0.0	0.0	2.5
Gloves/ Operating Equipment	12.5	5.0	5.0	2.5	7.5	6.5
Gloves/ Tasks	12.5	5.0	5.0	5.0	7.5	7.0
Overgarment/ Bulkiness	5.0	2.5	0.0	2.5	5.0	3.0
Overgarment/ Heat Bld-up	15.0	5.0	0.0	12.5	7.5	8.4
Average	9.3	2.0	3.0	3.3	4.3	

TABLE 20. Survey Results for M109 Breech Block

Factor	Teams Wearing MOPPIV					Average
	1	2	Team 3	4	5	
Mask/ Vision	0.0	5.0	2.5	5.0	0.0	2.5
Mask/ Water Build-up	7.5	12.5	12.5	15.0	15.0	12.5
Mask/ Breathing	5.0	10.0	2.5	0.0	0.0	3.5
Mask/ Commo	0.0	2.5	0.0	0.0	2.5	1.0
Boots/ Movement	5.0	7.5	7.5	0.0	2.5	4.5
Boots/ Slipping	0.0	2.5	0.0	0.0	0.0	0.5
Gloves/ Operating Equipment	0.0	5.0	5.0	7.5	10.0	5.5
Gloves/ Tasks	7.5	15.0	7.5	5.0	10.0	9.0
Overgarment/ Bulkiness	7.5	7.5	12.5	2.5	5.0	7.0
Overgarment/ Heat Bld-up	10.0	10.0	10.0	5.0	10.0	9.0
Average	4.3	7.8	6.0	3.5	5.5	

TABLE 21. Survey Results for Recovery of M60A3 Tank

Teams Wearing MOPPIV						
Factor	Team					Average
	1	2	3	4	5	
Mask/ Vision	1.3	5.0	3.8	10.0	2.5	4.5
Mask/ Water Build-up	6.3	12.5	12.5	11.3	15.0	11.5
Mask/ Breathing	1.3	6.3	7.5	13.8	10.0	7.8
Mask/ Commo	2.5	2.5	6.3	10.0	8.8	6.0
Boots/ Movement	2.5	2.5	11.3	a	a	a
Boots/ Slipping	0.0	1.3	11.3	a	a	a
Gloves/ Operating Equipment	1.3	5.0	8.8	2.5	7.5	5.0
Gloves/ Tasks	2.5	6.3	10.0	2.5	8.8	6.0
Overgarment/ Bulkiness	0.0	10.0	8.8	5.0	11.3	7.0
Overgarment/ Heat Bld-up	5.0	13.8	13.8	13.8	15.0	12.3
Average	2.3	6.5	9.4	8.6	9.9	

TABLE 27. Survey Results for M60 Machine Gun

Factor	Teams Wearing MOPPIV				Average
	1	2	3	4	
Mask/ Vision	0.0	10.0	2.5	0.0	3.8
Mask/ Water Build-up	0.0	15.0	12.5	15.0	10.0
Mask/ Breathing	0.0	10.0	7.5	5.0	6.3
Mask/ Commo	5.0	10.0	0.0	0.0	3.8
Boots/ Movement	0.0	0.0	5.0	0.0	2.5
Boots/ Slipping	0.0	0.0	0.0	0.0	0.0
Gloves/ Operating Equipment	5.0	5.0	10.0	10.0	7.5
Gloves/ Tasks	5.0	5.0	7.5	15.0	8.1
Overgarment/ Bulkiness	0.0	10.0	5.0	5.0	5.0
Overgarment/ Heat Bld-up	5.0	10.0	10.0	10.0	8.8
Average	2.0	7.5	6.0	6.0	

TABLE 23. Survey Results for M901 ITV Traverse Mechanism

Factor	Teams Wearing MOPPIV					Average
	1	2	Team 3	4	5	
Mask/ Vision	5.0	5.0	5.0	0.0	0.0	3.0
Mask/ Water Build-up	5.0	15.0	15.0	5.0	10.0	10.0
Mask/ Breathing	0.0	10.0	10.0	5.0	0.0	5.0
Mask/ Commo	0.0	0.0	10.0	0.0	10.0	4.0
Boots/ Movement	5.0	0.0	5.0	0.0	5.0	3.0
Boots/ Slipping	0.0	0.0	0.0	0.0	0.0	0.0
Gloves/ Operating Equipment	5.0	10.0	15.0	10.0	15.0	11.0
Gloves/ Tasks	5.0	12.5	15.0	10.0	15.0	11.5
Overgarment/ Bulkiness	5.0	0.0	5.0	5.0	0.0	3.0
Overgarment/ Heat Bld-up	15.0	15.0	10.0	15.0	10.0	13.0
Average	4.5	6.8	9.0	5.0	6.5	

V. SUMMARY/CONCLUSIONS

The degradation of personnel performance in MOPPIV for each maintenance operation is summarized in Table 24. Events were weighted proportionally by the amount of time normally taken to complete an event and summed over all events to give an overall task performance degradation. The inverse of this degradation is the MOPPIV correction factor. The estimated time to complete a task while wearing MOPPIV can be obtained by multiplying the BDU time by the factor.

TABLE 24. Correction Factors for MOPP IV.

Task	Factor	Probable Range
M60A3 Power Pack		
Remove	1.0#	0.8-1.2
Replace	1.1	1.0-1.2
M60A3 Transmission		
Remove	1.7	1.3-2.1
Replace	1.2	1.0-1.3
M109 Breech Block		
Remove	1.4	0.7-2.1
Replace	2.2	a
M60 Machine Gun		
Barrel Group	1.0#	1.0-1.1
Trigger Group	1.0#	0.7-1.4
M901 Traverse Mechanism		
Remove	1.7	0.7-2.7
Replace	1.9	1.6-2.4
Recover M60A3	1.1*	0.9-1.3
#Probably not degraded		
*Without boots		
a = insufficient data for calculation		

Other conclusions and observations based on the results of this study are:

- Teams performing tasks while wearing MOPPIV demonstrated considerable ingenuity in overcoming difficulties. Noteworthy examples are: picking up small parts with a tool, marking poorly defined timing marks with chalk, accommodating the reduction in near vision while wearing the mask by getting closer, differentiating between small parts by improving the background contrast with light colored paper

or other material and the pre-sorting of tools.

- Fine motor performance is degraded to the same magnitude as gross motor performance.
- The protective overboot is a hazard in mud.
- Task simplification or modification to accommodate personnel wearing MOPPIV should be examined and incorporated into the training of troops in similar tasks.
- Although all tasks were completed while wearing MOPPIV, the tasks completed were short in duration. It was apparent that extended operations could have been difficult. The tasks completed in this study should be repeated utilizing a data collection methodology for extended operations as conceived with the doctrine of continuous operations.

APPENDIX A

Climatic Conditions

Daily Temperature and Relative Humidity Record

During the trials the temperature and relative humidity as well as the general atmospheric condition were recorded at 30 minute intervals. The trials were conducted at Aberdeen Proving Ground, Maryland during July and August 1985. The high, low and average temperature and relative humidity are given in Table A-1.

TABLE A-1. Temperature - Relative Humidity Summary

Day	Degrees Celsius			% Relative Humidity		
	High	Low	Average	High	Low	Average
22 Jul 85	32	23	28	88	50	66
23 Jul 85	25	19	22	58	41	47
24 Jul 85	27	17	24	88	47	58
25 Jul 85	31	24	28	90	64	75
26 Jul 85	27	24	25	93	82	88
05 Aug 85	28	17	25	90	45	60
06 Aug 85	27	17	23	93	51	70
07 Aug 85	30	22	27	91	64	74
08 Aug 85	27	22	24	96	73	86
09 Aug 85	30	23	27	91	59	74
10 Aug 85	29	23	27	91	57	71
11 Aug 85	30	23	27	96	68	80
12 Aug 85	28	20	25	75	46	57
13 Aug 85	31	20	27	89	53	68
14 Aug 85	34	25	30	95	63	74
Average	29	21	26	88	58	70

APPENDIX B

Field Data

The performance time for each event in the several maintenance tasks are included in this Appendix. A "B" represents BDU and "M" represents MOPPIV. Events completed for the first time are indicated by an "*" by the appropriate entry. The corresponding tasks and tables are given in table B-1.

TABLE B-1. Field Data Tables

Task	Table
*Remove/Replace M60A3 Power Pack	B-2, B-3
*Remove/Replace M60A3 Transmission	B-4, B-5
*Remove/Replace M109 Breech Block	B-6, B-7
*Recover M60A3 Tank	B-8
*Remove/Repair M60 Machine Gun	B-9
*Repair M901 ITV Traverse Mechanism	B-10

TABLE B-2. Remove M60A3 Power Pack

Team	Performance Time, Minutes				Total
	Event				
	1	2	3	4	
1-B*	11.7	37.0	9.6	2.0	60.3
1-M	10.0	4.0	7.0	7.0	28.0
2-B*	15.3	12.0	23.0	7.0	57.3
2-M	13.9	6.7	18.0	4.0	42.6
3-B	8.2	5.0	10.0	4.6	27.8
3-M*	15.8	5.0	23.0	6.0	49.8
4-B	3.5	4.0	8.0	2.0	17.5
4-M*	16.0	4.0	17.0	3.0	40.0
5-B*	13.6	19.1	15.0	3.0	50.7
5-M	9.3	11.7	11.0	3.0	35.0
a= No data					

TABLE B-3. Replace M60A3 Power Pack

Team	Performance Time, Minutes				
	Event				Total
	1	2	3	4	
1-B*	11.9	13.0	40.9	9.6	75.4
1-M	8.0	7.0	36.0	13.0	64.0
2-B*	10.8	17.0	53.0	8.6	89.4
2-M	a	a	a	6.5	a
3-B	24.0	10.0	28.0	4.7	66.7
3-M*	16.1	57.0	4.0	9.0	86.1
4-B	8.2	13.0	22.0	5.9	49.1
4-M*	16.9	7.0	50.0	11.5	85.4
5-B*	25.1	8.0	33.0	7.8	73.9
5-M	7.6	5.0	36.0	5.8	54.4
a= No data					

TABLE B-4. Remove M60A3 Transmission

Team	Performance Time, Minutes				
	Event				Total
	1	2	3	4	
1-B*	a	a	a	a	a
1-M	25.0	33.0	251.0	7.0	316
2-B*	4.4	19.9	22.9	1.4	48.6
2-M	3.8	14.9	44.1	1.4	64.2
3-B	3.4	12.2	9.6	1.1	26.3
	2.3	8.8	6.2	1.1	18.4
3-M*	3.5	19.4	28.8	2.8	54.5
4-B*	3.3	17.2	15.2	0.9	36.6
4-M	3.7	14.9	17.3	0.9	36.8
5-B	2.8	7.9	8.3	0.7	19.7
5-M*	2.8	13.6	11.5	1.4	29.3
a= No data					

TABLE B-5. Replace M60A3 Transmission

Team	Performance Time, Minutes				
	Event				Total
	1	2	3	4	
1-B	a	a	a	a	a
1-M	6.8	16.3	22.6	2.9	68.0
2-B*	6.8	16.3	22.6	2.9	48.6
2-M	8.1	16.8	14.0	1.7	40.6
3-B	6.6	13.7	11.0	1.9	33.2
	5.4	12.7	8.8	1.1	28.4
3-M*	8.6	19.4	17.1	2.5	47.6
4-B*	8.0	17.7	18.3	0.9	44.9
4-M	13.3	20.3	13.8	0.9	48.3
5-B	5.3	14.0	9.1	0.7	29.1
5-M*	8.8	17.9	9.0	1.6	37.3
a = no data					

TABLE B-6. Remove M109 Breech Block

Team	Performance Time, Minutes			
	Event			Total
	1	2	3	
1-B*	13.6	3.4	5.0	22.0
1-M	5.3	0.9	5.0	11.2
2-B	1.0	0.4	2.6	4.0
2-M*	3.7	0.5	16.7	20.9
3-B*	a	a	a	a
3-M	a	1.2	5.7	a
4-B	0.5	0.4	2.4	3.3
4-M*	1.9	0.4	7.8	10.1
5-B*	4.3	0.8	6.4	11.5
5-M	2.9	0.5	3.2	6.6
	2.3	0.5	1.7	4.5
a = no data				

TABLE B-7. Replace M109 Breech Block

Team	Performance Time, Minutes			
	Event			Total
	1	2	3	
1-B*	a	1.1	5.7	a
1-M	4.7	3.5	1.6	9.8
2-B	1.8	2.1	0.1	4.0
2-M*	12.6	0.1	1.5	14.2
3-B*	a	a	a	a
3-M	0.6	1.2	3.1	4.9
4-B	2.5	0.5	2.0	3.3
	5.7	0.8	2.5	9.0
4-M*	3.0	15.0	10.0	28.0
5-B*	4.0	2.7	2.0	8.7
5-M	3.2	4.3	0.9	8.4
	5.2	1.7	0.6	7.5
a = no data				

TABLE B-8. Recovery of a M60A3 Tank

Team	Performance Time, Minutes				
	Event				Total
	1	2	3	4	
1-B	10.4*	0.4*	13.9*	1.0*	25.7
	14.3	0.6	2.6	0.7	18.2
1-M	8.1	0.9	2.6	1.1	12.7
2-B	4.8	0.6	3.1	0.3	8.8
	3.9	0.2	1.3	0.2	5.6
2-M	12.0*	0.5*	5.4*	0.5*	18.4
	10.1	1.1	5.1	0.8	17.1
3-B*	6.7	0.5	9.3	0.2	16.7
3-M	10.1	0.9	4.2	1.0	16.2
4-B	3.1	3.8	2.3	0.3	9.5
	5.6	0.4	1.9	0.3	8.2
4-M*	9.5	0.5	5.2	0.4	15.6
5-B	13.8*	0.1*	4.9*	0.1*	18.9
	9.5	0.3	2.6	0.1	12.5
5-M	5.8	0.2	1.7	0.2	7.9
* first time					

TABLE B-9. Repair M60 Machine Gun

Team	Performance Time, Minutes					
	Barrel Group			Trigger Group		
	Event		Total	Event		Total
	1	2		1	2	
1-B	15.6*	3.2*	18.8	0.8*	3.3*	4.1
	3.0	3.6	6.6	0.6	3.2	3.8
	2.5	1.9	4.4	0.1	2.1	2.2
1-M	2.8	1.8	4.6	0.7	3.7	4.4
	1.2	5.9	9.1	0.4	3.8	4.2
	2.5	2.0	4.5	0.4	3.0	3.4
2-B	2.8	1.9	4.7	0.5	2.3	2.8
	2.0	0.9	2.9	0.4	1.8	2.2
	1.5	1.0	2.5	0.3	1.7	2.0
2-M	3.0*	6.0*	9.0	3.3*	1.7*	5.0
	1.5	1.5	3.0	2.9	2.4	5.3
	2.4	1.4	3.8	0.5	1.6	2.1
	1.7	0.9	2.6	0.6	2.1	2.7
3-B	2.7*	2.2*	4.9	0.8*	3.2*	4.0
	1.9	0.9	2.8	0.5	1.9	2.4
	1.6	1.5	3.1	0.1	1.4	1.5
3-M	1.8	2.3	4.1	0.7	2.2	2.9
4-B	1.6	0.8	2.4	0.5	1.9	2.4
	1.6	0.8	2.4	0.3	1.5	1.8
4-M	2.5*	2.3*	4.9	0.6*	5.0*	5.6
	1.6	2.1	3.7	0.6	3.4	4.0
5-B	3.3*	3.1*	6.4	7.0*	12.1*	19.1
	3.2	2.4	5.6	1.1	8.9	10.0
5-M	3.0	1.8	4.8	1.9	3.7	5.6
6-B	3.1*	4.4*	7.5	3.0	3.4	6.4
	1.9	2.5	4.4	0.5	3.8	4.3
6-M	3.4	4.4	8.1	1.3	5.9	7.2
* = First time						

TABLE B-10. Repair M901 ITV Traverse Mechanism

Team	Performance Time, Minutes					
	Event					
	Disassembly			Reassembly		
	1	2	Total	1	2	Total
1-B*	13.0	29.0	42.0	19.0	14.0	33.0
1-M	8.0	22.0	30.0	44.0	11.0	55.0
2-B	2.0	7.0	9.0	7.0	5.0	12.0
2-M*	26.0	32.0	58.0	27.0	14.0	41.0
3-B*	10.0	15.0	25.0	13.0	13.0	26.0
3-M	a	18.0	a	30.0	5.0	35.0
	a	19.0	a	2.0	22.0	24.0
4-B	4.0	2.0	6.0	8.0	4.0	12.0
4-M*	7.0	4.0	11.0	26.0	9.0	35.0
5-B*	8.0	26.0	34.0	12.0	18.0	30.0
5-M	a	1.0	a	15.0	7.0	22.0
a = No data						
* = First time						

APPENDIX C

Regression Results by Task and Event

The regression results by task and event are contained in this appendix. Tables include a/T_0 , or fractional increase in time due to MOPPIV for each event in each task, and regression coefficients and calculations by event for each task. Field measurements are given in appendix A. The corresponding tables and figures for each task are given in table C-1.

TABLE C-1. Tables for Regression Results

Task	Tables
■ Remove/Replace M60A3 Power Pack	C2-C3
■ Remove/Replace M60A3 Transmission	C4-C5
■ Remove/Replace M109 Breech Block	C6-C7
■ Recover M60A3 Tank	C8-C9
■ Remove/Repair M60 Machine Gun	C10-C11
■ Repair M901 ITV Traverse Mechanism	C12-C13

TABLE C-2. Remove/Replace M60A3 Power Pack

Event	Tasks
1	Cover
2	Turret Connections
3	Accessory Connections
4	Remove Power Pack
5	Replace Deck
6	Replace Battery and Engine Accessories
7	Replace Engine and Accessories
8	Replace Power Pack

TABLE C-3. Remove/Replace M60 Power Pack, Regression Coefficients

Event	Coefficients/Calculations				
	T_o	a	b	CF	PR
1	6.7	3.8 ± 1.4	6.2 ± 1.4	1.6	1.4-1.8
2	10.9	-7.6 ± 6.1	7.6 ± 6.1	0.3	a
3	8.7	3.6 ± 3.2	7.4 ± 3.2	1.4	1.1-1.8
4	3.6	0.9 ± 1.4	0.3 ± 1.4	1.3	0.9-1.7
5	4.7	4.1 ± 1.7	4.4 ± 1.7	1.9	1.5-2.2
6	24.7	11.1 ± 4.3	17.4 ± 4.3	1.5	1.3-1.6
7	11.9	-6.4 ± 2.0	0.4 ± 2.0	0.5	0.3-0.6
8	14.6	-5.4 ± 4.8	2.3 ± 4.8	0.6	0.3-1.0
a = Insufficient data for calculation					
CF = Correction Factor					
PR = Probable Range					

TABLE C-4. Remove/Replace M60A3 Transmission

Event	Task
1	Remove Shrouds
2	Remove Accessories
3	Remove Mounting Bolts
4	Separate
5	Replace Shrouds
6	Replace Accessories
7	Replace Mounting Bolts
8	Replace Transmission

TABLE C-5. Remove/replace M60A3 Transmission, Regression Coefficients

Event	Coefficients/Calculations				
	T_o	a	b	CF	PR
1	3.1	0.2±0.5	0.3±0.5	1.1	0.9-1.2
2	10.9	1.9±2.1	5.6±2.1	1.2	1.0-1.2
3	11.9	12.9±7.8	1.2±7.8	2.1	1.4-2.7
4	0.8	0.5±0.4	0.5±0.4	1.6	1.1-2.1
5	1.2	0.1±0.5	0.7±0.5	1.1	0.7-1.5
6	11.8	1.0±3.0	5.5±3.0	0.9	0.7-1.2
7	14.1	3.5±1.1	1.2±1.1	1.3	1.2-1.3
8	6.4	3.3±1.3	0.0±1.3	1.5	1.3-1.7
CF = Correction Factor					
PR = Probable Range					

TABLE C-6. Remove/Replace M109 Breech Block

Event	Task
1	Remove Damper
2	Remove Firing Mechanism
3	Remove Breech Block
4	Replace Spindle
5	Replace Breech
6	Replace Firing Mechanism/Damper

TABLE C-7. Remove/Replace M109 Breech Block

Factor	Event					
	1	2	3	4	5	6
T _O	2.5	0.7	1.4	1.1	2.7	1.1
a	-0.8±2.4	-0.3±0.6	3.3±1.8	0.7±1.5	1.1±2.1	0.7±1.5
b	3.8±2.4	0.7±0.6	5.9±1.8	3.3±1.6	3.0±2.2	3.3±1.6
CF	0.7	0.6	3.4	1.6	1.4	1.9
PR	0.3-1.6	0.3-1.4	2.1-4.6	0.3-3.0	0.6-2.2	0.3-2.9
CF = Correction factor						
PR = Probable range						

TABLE C-8. M60A3 Tank Recovery

Event	Task
1	Position M88 and Hook Tow Bar
2	Open Grill Doors and Heat Shields
3	Disconnect Final Drives
4	Secure Doors and Shield

TABLE C-9. Recover a M60A3 Tank, Regression Coefficients

Factor	Event			
	1	2	3	4
T _O	7.0	0.9	2.9	0.4
a	1.3±1.8	-0.1±0.5	-0.6±1.3	0.3±0.2
B	2.9±1.8	-0.5±0.5	5.0±1.3	-0.1±0.2
CF	1.2	0.9	0.8	1.8
PR	0.9-1.4	0.3-1.4	0.3-1.2	1.3-2.3
CF = Correction factor				
PR = Probable range				

TABLE C-10. Repair M60 Machine Gun

Event	Task
1	Remove and Disassemble Barrel Group
2	Reassemble and Replace Barrel Group
3	Remove and Disassemble Trigger Assembly
4	Reassemble and Replace Trigger Assembly

TABLE C-11. Repair M60 Machine Gun, Regression Coefficients

	Event			
	1	2	3	4
T _O	2.5	1.6	0.6	3.0
a	-0.5±0.9	0.8±0.5	0.2±0.5	-0.1±0.9
B	2.8±1.1	1.6±0.6	1.9±0.6	1.8±1.1
CF	1.2	1.5	1.3	1.0
PR	0.8-1.6	1.2-1.8	0.5-2.2	0.7-1.3
CF = Correction factor				
PR = Probable range				

TABLE C-12. Remove/Replace M901 ITV Traverse Mechanism

Event	Task
1	Remove Outer Gear, Snap Ring and Bevel Washer
2	Remove Gear
3	Reassemble Gears and Replace
4	Replace Outer Gear, Snap Ring and Bevel Washer

TABLE C-13. Remove/Replace M901 ITV Traverse Mechanism

Factor	Event			
	1	2	3	4
T _O	2.8	9.5	8.6	7.7
a	5.8±4.6	3.0±6.8	13.6±7.1	1.9±3.6
B	7.8±4.6	10.5±6.8	5.4±7.1	5.1±3.6
CF	3.1	1.3	2.6	1.3
PR	1.4-4.7	0.6-2.0	1.8-3.4	0.8-1.8
CF = Correction Factor				
PR = Probable Range				

APPENDIX D

Multiple Linear Regression

Multiple Linear Regression

Regression analyses are used to quantify the relationship between variables where the value of one is affected by changes in others. The type of uniform worn and whether or not the event was completed for the first time, either in BDU or MOPPIV, are independent variables. A multiple linear regression allows a dependent variable to be estimated by quantifying the relationship to several independent variables. In this instance, time to complete a task is the affected or dependent variable. Interactions and variables not measured are reflected in the error term and include such effects as team work and leadership. An estimate of how well the regression estimates the dependent variable is expressed by the multiple correlation coefficient. Analysis then can be used to determine the effect of MOPPIV and the first time effect on the total time to complete a task.

For troop performance studies the regression expression is represented by:

$$T = T_0 + a(x) + b(y) + e \quad (D-1)$$

Where "T" (the dependent variable) is the total time in minutes to complete a task, " T_0 ", (the intercept) is the practiced, unencumbered time, "x" (first independent variable) is the clothing type, "y" (second independent variable) is the order in which an event was started and "e" is the error term. Because it is assumed that the clothing contribution would be zero for wearing BDUs "x" is represented by either a "0" or a "1." Likewise, if a team was working an event for the first time "y" would be assigned a "1" and if the team has completed the event before a "0" would be assigned since no first time effect would be present. The expression, without the error term, then becomes:

$$T = T_0 + a + b \quad (D-2)$$

Where "a" and "b" represent the correction in minutes for MOPPIV and practiced factors, respectively. Therefore, a team completing an event for the first time in BDU is expressed as:

$$T = T_0 + b \quad (D-3)$$

A team performing an event in BDU two or more times would be represented as " T_0 ", ($T = T_0$). By wearing MOPPIV this team would add a clothing correction for MOPPIV and be expressed as:

$$T = T_0 + a \quad (D-4)$$

The event time for the same team completing the event for the first time and wearing MOPPIV would be expressed as:

$$T = T_0 + a + b \quad (D-5)$$

An example case will be replacing the shroud during the removing/replacing of the M60A3 transmission, accomplished during the Maintenance Evaluation completed under moderate temperature. All other tasks and events were likewise evaluated and are included in the results.

Replacing the shroud includes the placement of the shroud on the powerpack and the connection of the attachment bolts. The data for evaluation are given in Table D-1, where team 1 replaced the shroud twice with the first occurrence in BDU in 7.8 minutes and the second occurrence in MOPPIV in 14.2 minutes. For this example, the resulting regression coefficients in Table D-2, are " T_o ", the practiced, unencumbered time, "a", the additional time for MOPPIV, plus or minus the standard deviation and "b", the additional time needed if the event is done for the first time, plus or minus the standard deviation. Thus, the expected time for replacing the shroud is 5.8 minutes for a practiced unencumbered team. An additional 3.8 minutes is added to the total if the team was wearing MOPPIV, for an expected time of 9.6 minutes. This additional MOPPIV time could be as much as 11.5 minutes ($9.6+1.9$) or as little as 7.7 minutes ($9.6-1.9$). No correction is required for the first time effect because, in this example, the coefficient is negative (Table D-2). In other events this first time correction is calculated the same as for the MOPPIV effect.

TABLE D-1. Data Used in Example Regression

Team	BDU	MOPPIV	1st Time
1	7.8	14.2	BDU
2	4.6	24.6*	MOPP
3	5.8	10.2	BDU
4	6.4	7.4	MOPP**
5	3.6	6.3	MOPP
* Data excluded due to the removal of items not associated with trial.			
** Team is practiced in both uniforms.			

TABLE D-2. Regression Coefficients for Example

Coefficients
$T_o = 5.8$
$a = 3.8 \pm 1.9$
$b = -0.5 \pm 2.0$

The quotient resulting from " $T_o / (T_o + a)$ " represents the degradation for wearing MOPPIV. That is, the unencumbered practiced time " T_o " divided by the total time for MOPPIV " $T_o + a$." Thus a team replacing the shroud in MOPPIV is degraded to 60

percent of their practiced, unencumbered ability, $5.8/(5.8+3.8)=0.60$ (Table D-3). In a similar calculation, the degradation for doing the job for the first time results from the quotient of " $T_o/(T_o+b)$." In this example no degradation was determined for doing the event for the first time. A team is degraded to 0.63 if replacing the shroud for the first time and in MOPPIV, where both MOPPIV and first time coefficients are added in the denominator, i.e. " T_o/T_o+a+b ." The quantity " $(T_o+a)/T_o$ " (which is the inverse of the degradation factor) is called the MOPPIV Correction Factor. This factor when multiplied by " T_o " gives the expected time to complete a task in MOPPIV. For this example the correction factor is 1.66. A probable range is determined by making the correction factor calculation using plus or minus the standard deviation, given for each coefficient. The estimated time for this event is then 5.8×1.66 or 9.6 minutes. The results give a real number estimate of the effect of MOPPIV on this job performance (Table D-4).

TABLE D-3. Calculations for Example

Calculations
$T_o = 5.8$
$T_o + a = 9.6$
$T_o + b = 5.3$
$T_o + a + b = 9.1$
$T_o / (T_o + a) = 0.60$
$(T_o + a) / T_o = 1.66$
$T_o / (T_o + b) = 1.09$
$a / T_o = 0.66$

TABLE D-4. Example Results

Effect of Wearing MOPPIV on Replacing the Shroud	
Degraded Effectiveness	0.60
MOPPIV Correction Factor	1.7
Probable Range	1.3-2.0

DISTRIBUTION LIST

<u>No. of</u> <u>Copies</u>	<u>Organization</u>	<u>No. of</u> <u>Copies</u>	<u>Organization</u>
1	Office of the Secretary of Defense OATSD(AE) (Chemical Matters) Washington, DC 20301	1	Commander in Chief U.S. Special Operations Command ATTN: SOJ3-05 (Chemical Officer) MacDill AFB, FL 33608
1	Department of Defense OUSDRE(ELS) Room 3/D129, Pentagon Washington, DC 20301	1	Commander U.S. Forces Japan ATTN: J3 APO San Francisco 96301
1	Organization of Joint Chiefs of Staff ATTN: J-3 JOD (COL Tripler) Washington, DC 20301	1	Commander U.S. Forces Korea ATTN: CJ-PL-N APO San Francisco 96301
4	Director Defense Intelligence Agency ATTN: DT-5A ATTN: DX-7B ATTN: DB-4G1 ATTN: DB-1B2 Washington, DC 20301	10	C.I.A. OIR/DB/Standard GE47 HQ Washington, DC 20505
1	Director Armed Forces Medical Intelligence Center ATTN: AFMIC-ZA Fort Detrick, Frederick, MD 21701	2	Administrator Defense Technical Information Center ATTN: DTIC-FDAC Cameron Station, Bldg 5 Alexandria, VA 22304-6145
1	Commander in Chief U.S. European Command ATTN: ECJ5-N APO New York 09128	1	HQDA DAMA-ART-M Washington, DC 20310
1	Commander in Chief Pacific ATTN: J5414 (Box 15) Camp Smith, HI 96861	1	HQDA ATTN: DAMO-SWC (LTC Brown) Washington, DC 20310-102
1	Commander in Chief U.S. Atlantic Fleet ATTN: J338 Norfolk, VA 23511	1	HQDA ATTN: DASG-HCD-D (LTC Myers) Washington, DC 20310-2300
1	Commander in Chief U.S. Southern Command ATTN: SCJ3 APO Miami 34004	1	Commander in Chief U.S. Army Europe ATTN: AEAGC-NC-C APO New York 09403
1	Commander in Chief U.S. Central Command ATTN: CCJ3-X MacDill AFB, FL 33608-7001		

DISTRIBUTION LIST

<u>No. of</u> <u>Copies</u>	<u>Organization</u>	<u>No. of</u> <u>Copies</u>	<u>Organization</u>
3	Commander U.S. Army Materiel Command ATTN: AMCDRA-ST ATTN: AMCCN-M ATTN: AMCCN-C 5001 Eisenhower Avenue Alexandria, VA 22333-0001	1	Commander USATRADOCC ATTN: ATZL-TIE Fort Leavenworth, KS 66027-5130
8	Commander U.S. Army Armament Research, Development and Engineering Center ATTN: SMCAR-MSI Dover, NJ 07801-5001	1	Commander U.S. Army Transportation Center and Fort Eustis ATTN: ATSP-PD-C (Chemical Officer) Fort Eustis, VA 23604
2	Commander U.S. Army Test and Evaluation Command ATTN: SMSTE-TE-T ATTN: AMSTE-TO Aberdeen Proving Ground, MD 21005	1	Commander U.S. Army Aviation Center ATTN: ATZQ-D-MS Fort Rucker, AL 36362
2	Commander U.S. Army Training and Doctrine Command ATTN: ATCD-N ATTN: ATCD-T Fort Monroe, VA 23651	1	Commander U.S. Army Foreign Science and Technology Center ATTN: AIAST-RA-ID2 220 Seventh Street NE Charlottesville, VA 22901
1	Commander U.S. Army Forces Command ATTN: AFOP-TN Fort McPherson, GA 30330	6	Commander Army Natick R&D Center ATTN: STRNC-AC ATTN: STRNC-I ATTN: STRNC-U ATTN: STRNC-YA ATTN: STRNC-W Natick, MA 01760
1	Commander U.S. Army Western Command ATTN: APO-NC ATTN: APLG-MU Fort Shafter, HI 96858 Dover, NJ 07801-5001	1	Commander USAFKSWC ATTN: ATSU-CD-CS Fort Bragg, NC 28307-5000
1	Commander CFA (ROK/US) ATTN: C3-NBC APO San Francisco 96301	5	Commandant U.S. Army Chemical School ATTN: ATZN-CM-FECD (CS,CT,CC,NF) Fort McClellan, AL 36205
1	Commander U.S. Army Logistics Center ATTN: ATCL-MN Fort Lee, VA 23801		

DISTRIBUTION LIST

<u>No. of</u> <u>Copies</u>	<u>Organization</u>	<u>No. of</u> <u>Copies</u>	<u>Organization</u>
4	Commander U.S. Army Nuclear and Chemical Agency ATTN: MONA-NU ATTN: MONA-CM ATTN: MONA-WE ATTN: MONA-SAL 7500 Backlick Road (Building 2073) Springfield, VA 22150	1	Director U.S. AMCCOM ARDEC CCAC Benet Weapons Laboratory ATTN: SMCAR-CCB-TL Watervliet, NY 12189-4050
1	Commander U.S. Army TRADOC Systems Analysis Agency ATTN: ATOR-TDB White Sands Missile Range, NM 88002	1	Commander U.S. Army Armament, Munitions and Chemical Command ATTN: AMSMC-IMP-L Rock Island, IL 61299-7300
1	President U.S. Army Armor & Engineer Board ATTN: ATZK-AE-TR Fort Knox, KY 40121-5470	1	Commander U.S. Army Aviation Systems Command ATTN: AMSAV-ES 4300 Goodfellow Blvd St. Louis, MO 63120-1798
1	Commanding General Wright Patterson Air Force Base ATTN: AFAMRL-HE Dayton, OH 45433	4	Commander U.S. Army Dugway Proving Ground ATTN: STEDP-SD-TA-F ATTN: STEDP-SD-TA ATTN: STEDP-MT-CA-CB ATTN: STEDP-MT-C Dugway, UT 84022
3	Commandant U.S. Army Ordnance Center and School ATTN: Chemical Officer Aberdeen Proving Ground, MD 21005	1	Director U.S. Army Air Aviation Research and Technology Activity Ames Research Center Moffett Field, CA 94035-1099
7	Commander U.S. Chemical Research, Development and Engineering Center ATTN: SMCCR-TD ATTN: SMCCR-ST ATTN: SMCCR-RSP ATTN: SMCCR-PPD ATTN: SMCCR-SPS-IL ATTN: SMCCR-OPR ATTN: SMCCR-NB Aberdeen Proving Ground, MD 21010	1	Commander U.S. Army Communications - Electronics Command ATTN: AMSEL-ED Fort Monmouth, NJ 07703-5301
1	Commander U.S. Army ARDEC ATTN: SMCAR-TDC Dover, NJ 07801-5001	1	Commander CECOM R&D Technical Library ATTN: AMSEL-IM-L (Reports Section) B Fort Monmouth, NJ 07703-5000

DISTRIBUTION LIST

<u>No. of</u> <u>Copies</u>	<u>Organization</u>	<u>No. of</u> <u>Copies</u>	<u>Organization</u>
1	Commander U.S. Army Missile Command Research Development and Engineering Center ATTN: AMSMI-RD Redstone Arsenal, AL 35898-5241	1	Air Force Armament Laboratory ATTN: AFATL/DLODL (Tech Info Center) Eglin AFB, NM 32542-5438
1	Director U.S. Army Missile and Space Intelligence Center ATTN: ALAMS-YDL Redstone Arsenal, AL 35898-5500	1	AFELM, The Rand Corporation ATTN: Library-D 1700 Main Street Santa Monica, CA 90406
1	Commander U.S. Army Tank Automotive Command ATTN: AMSTA-TSL Warren, MI 48397-5000		<u>Aberdeen Proving Ground</u> Dir, USAMSAA ATTN: AMXSY-D AMXSY-MP, H. Cohen Cdr, USATECOM ATTN: AMSTE-SI-F Cdr, CRDEC, AMCCOM ATTN: SMCCR-RSP-A SMCCR-MU SMCCR-SPS-IL
1	Director U.S. Army TRADOC Analysis Center ATTN: ATOR-TSL White Sands Missile Range, NM 88002-5502		
1	Commandant U.S. Army Infantry School ATTN: ATSH-CD-CS-OR Fort Benning, GA 31905-5400		
1	Commander U.S. Army Development and Employment Agency ATTN: MODE-ORO Fort Lewis, WA 98433-5000		
2	Commandant U.S. Marine Corps ATTN: POG-31 ATTN: APW Room 2318, Arlington Annex Arlington, VA 20380		
1	Battelle Edgewood Operations ATTN: F.T. Crimmins, DIR CBIAC 2113 Emmorton Park Road Edgewood, MD 21040		
1	AFWL/SUL Kirtland AFB, NM 87117		