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HARDMAN III Analysis of the Land Warrior System

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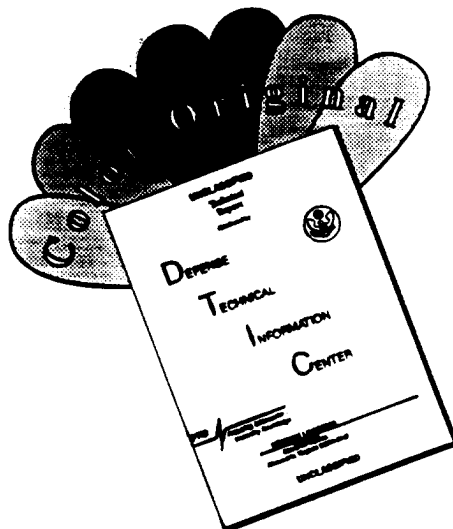
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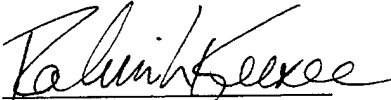
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CONTENTS

EXECUTIVE SUMMARY	5
INTRODUCTION	7
MISSION SIMULATION DEVELOPMENT	8
SAAS Taxonomy Development	8
Tasks, Functions, and Missions	15
HOS Micromodels	16
DEVELOPMENT OF LAND WARRIOR HARDMAN III MODELS	17
Mission Model Descriptions	18
Equipment Distribution	38
LAND WARRIOR OPERATOR ANALYSES	49
Description of Mission Model Differences Attributable to Equipment	50
Description of Mission Model Differences Attributable to Tasks	56
MAN-SEVAL Workload Analysis Steps	58
MAN-SEVAL Workload Analysis Results	59
PER-SEVAL Analysis Steps	64
PER-SEVAL Analysis Results	65
PER-SEVAL Analysis Conclusions	77
LAND WARRIOR MAINTENANCE ANALYSIS	78
Land Warrior Baseline Comparison System	78
MANCAP Analysis of the Land Warrior System	85
CONCLUSIONS	97
REFERENCES	99
APPENDIX	
A. WORKLOAD GRAPHS	103
DISTRIBUTION LIST	129

FIGURE

1. Modified McCracken-Aldrich Scale Values 60

TABLES

1. Capability Areas Developed Using SAAS and BOB 10

2. Potential Effects of New Equipment 11

3. SAAS Taxonomy 12

4. Land Warrior Missions, Functions, and Tasks 19

5. Current and Land Warrior Equipment and Weight Distribution for the Squad Member 39

6. Current and Land Warrior Equipment and Weight Distribution for the Squad Leader 41

7. High Workload Summary for Squad Member 61

8. High Workload Summary for Squad Leader 62

9. Squad Member Night Ambush Mission 65

10. Squad Member Movement to Contact-Attack Mission 65

11. Squad Member Reconnaissance Mission 66

12. Squad Leader Night Ambush Mission 66

13. Squad Leader Movement to Contact-Attack Mission 66

14. Squad Leader Reconnaissance Mission 67

15. Squad Member Night Ambush Mission (Heat) 67

16. Squad Member Movement to Contact-Attack Mission (Heat) 68

17. Squad Member Reconnaissance Mission (Heat) 68

18. Squad Leader Night Ambush Mission (Heat) 68

19. Squad Leader Movement to Contact-Attack Mission (Heat) 69

20. Squad Leader Reconnaissance Mission (Heat) 69

21. Squad Member Night Ambush Mission (Cold) 70

22. Squad Member Movement to Contact-Attack Mission (Cold) 70

23. Squad Member Reconnaissance Mission (Cold) 70

24. Squad Leader Night Ambush Mission (Cold) 71

25. Squad Leader Movement to Contact-Attack Mission (Cold) 71

26. Squad Leader Reconnaissance Mission (Cold) 71

27. Squad Member Night Ambush Mission (Sustained Operations) 72

28. Squad Member Movement to Contact-Attack Mission (Sustained Operations) 72

29. Squad Member Reconnaissance Mission (Sustained Operations) 73

30. Squad Leader Night Ambush Mission (Sustained Operations) 73

31. Squad Leader Movement to Contact-Attack Mission (Sustained Operations) 73

32. Squad Leader Reconnaissance Mission (Sustained Operations) 74

33. Squad Member Reconnaissance Mission (MOPP) 74

34. Squad Leader Reconnaissance Mission (MOPP) 75

35. Squad Member Night Ambush Mission (Cut-off Score) 75

36. Squad Member Movement to Contact-Attack Mission (Cut-off Score) 76

37. Squad Member Reconnaissance Mission (Cut-off Score) 76

38. Squad Leader Night Ambush Mission (Cut-off Score)	76
39. Squad Leader Movement to Contact-Attack Mission (Cut-off Score)	77
40. Squad Leader Reconnaissance Mission (Cut-off Score)	77
41. Land Warrior Baseline Comparison System	81
42. MANCAP Standard Mission Month	89
43. Mission Combat Hit Parameters	90
44. Probability of Combat Hit	91
45. Maintenance MOS Information	92
46. Maintenance Summary for Baseline and Objective Maintenance Concepts . . .	93
47. Maintenance Man-Hours by MOS for Baseline and Objective Maintenance Concepts	94
48. Maintenance Requirements by Subsystem and Maintenance Level for Baseline and Objective Maintenance Concepts	95
49. MOS Constraints Versus Requirements	97

EXECUTIVE SUMMARY

RESEARCH REQUIREMENT

The Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory (ARL) is responsible for continued development of HARDware versus MANpower (HARDMAN) III, a suite of nine software modules used for soldier resource analysis and decision aiding during system acquisition. This report documents one set of assumptions that was made in using the HARDMAN III tools in a first iteration examination of the Land Warrior System. In meeting this goal, the report (a) documents the development of the night ambush, movement to contact-attack, and reconnaissance mission models that form the basis for the operator analyses of the Land Warrior System, (b) describes the detailed analyses that were conducted of both a squad member and of a squad leader as equipped with current equipment and with Land Warrior equipment, and (c) describes the possible maintenance impact of Land Warrior equipment on a light infantry battalion. This report can serve as a starting point for future analysis of the Land Warrior System and other, more general, infantry issues, with significant resource savings.

PROCEDURE

Information concerning various Land Warrior equipment configurations and weights was collected, and infantry tasks were organized into logical groups to effectively model infantry operations. This information was then used in the human operator simulator (HOS), manpower-based system evaluation aid (MAN-SEVAL), and personnel-based system evaluation aid (PER-SEVAL) HARDMAN III tools to analyze the effects of Land Warrior equipment on mission performance.

A baseline comparison system (BCS) for Land Warrior was also constructed to use data from various currently fielded military equipment to gain insight into the possible maintenance burden imposed by fielding Land Warrior equipment in a light infantry battalion. This information was then used in the manpower capabilities (MANCAP) tool. Here, both the current maintenance concepts used for maintaining the various items chosen for the BCS and the planned maintenance concept for Land Warrior (with an emphasis on replacement of failed components rather than repair) were examined.

FINDINGS

As modeled, these simulations indicate that the addition of Land Warrior equipment provides many benefits, particularly to the squad leader in the areas of command, control, and navigation. It was also found that heat and protective clothing had the most significant impact on Land Warrior mission performance time and accuracy. Raising the selection criteria (i.e., armed services vocational aptitude battery [ASVAB] scores) for Land Warrior soldiers had little effect on squad member or squad leader mission performance.

The maintenance simulation results for a light infantry battalion show that the planned maintenance concept for the Land Warrior is supportable. If the current maintenance concept were used, however, there would be a shortage of maintenance manpower.

HARDMAN III ANALYSIS OF THE LAND WARRIOR SYSTEM

INTRODUCTION

Until recently, the development of new or improved equipment designed for the individual soldier has been a fairly compartmentalized activity. As different responsible organizations have developed new and better technologies to meet different soldier needs, these new pieces of equipment have been acquired and issued to troops in the field. The single biggest drawback to this approach has been the inability of these various pieces of equipment to work together seamlessly during various conditions. As a result, the U.S. Army has begun developing a modular integrated suite of equipment that has been designed as a system to make the soldier more effective and less vulnerable on the battlefield. This new equipment for the soldier is referred to in the Soldier Modernization Plan as *Soldier as a System* (SAAS) (Natick Research, Development and Engineering Center & U.S. Army Infantry School, 1990). SAAS calls for personal equipment and enabling technologies such as voice and data radios, computers, helmet-mounted displays, image intensifiers, and position-navigation devices to be fitted directly onto the individual soldier. Near-term development of SAAS is the Land Warrior System. The Army's Land Warrior System will provide, for the first time, a truly integrated set of equipment for the individual soldier. The acquisition of this equipment will not only enhance the current capabilities of today's soldier but will also provide new and expanded capabilities for the future. This study of the Land Warrior System was conducted at the request of and sponsored by the Human Research and Engineering Directorate (HRED) of the U.S. Army Research Laboratory (ARL).

For any materiel acquisition program, early identification of manpower, personnel, and training (MPT) constraints and requirements, as linked to mission performance, permits timely, cost-effective decisions regarding systems requirements and materiel design. These MPT issues may hold even more significance for the Land Warrior System, as this system is the first to consider the soldier and his equipment as a weapon system, and this new equipment will be fielded in an Army that has changed rapidly and significantly because of the drawdown. Potential MPT issues for Land Warrior include the impact of increased information load on required squad leader personnel characteristics (i.e., armed services vocational aptitude battery [ASVAB] scores), equipment maintenance manpower requirements and availability, and training needs. Using simulation and modeling, HARDware versus MANpower (HARDMAN) III provides a significant mechanism for assessing the MPT and performance impacts of the integrated Land Warrior System.

HARDMAN III was a major development effort of the Army Research Institute's (ARI) System Research Laboratory (which has now become part of HRED of ARL). HARDMAN III is a decision support tool that consists of a set of automated aids to assist analysts in conducting manpower-personnel integration (MANPRINT) assessments in an integrated manner during the materiel acquisition process (MAP). As Government-owned software, the HARDMAN III aids provide the means for estimating MPT constraints and requirements for new weapon systems.

The personal computer (PC)-based HARDMAN III analysis aids help integrate MPT requirements and constraints of existing and emerging weapon system designs. Some key features of the HARDMAN III aids that distinguish them from other existing aids include the following:

- ◆ Extensive MPT data libraries about existing weapon systems
- ◆ Performance-based analysis method which predicts changes in performance as a function of changes in personnel characteristics
- ◆ Prediction of performance effects of environmental stressors
- ◆ Estimation of operator workload
- ◆ Mission simulation models (task network models) that aggregate task performance
- ◆ PC-based manpower planning model
- ◆ Estimation of MPT resources at the system, unit, and force levels for both operators and maintainers

The purpose of this report is to document the one set of assumptions that was made in using the HARDMAN III tools in a first iteration examination of the Land Warrior System. In meeting this goal, the report (a) documents the development of the mission simulations that form the basis for the operator analyses of the Land Warrior System, (b) describes the detailed analyses that were conducted of both a squad member and of a squad leader as equipped with current equipment and with Land Warrior equipment, and (c) describes the possible maintenance impact of Land Warrior equipment on a light infantry battalion.

MISSION SIMULATION DEVELOPMENT

The current HARDMAN III Land Warrior System effort is based in part on work presented in HARDMAN III Analysis of Soldier as a System (SAAS) (Adkins, Murphy, & DiMaio, 1994). This earlier effort focused on equipment that was developed for the soldier integrated protective ensemble (SIPE) advanced technology transition demonstration (ATTD). For the purposes of the Land Warrior effort, it is important to review three areas that were established during the SAAS effort that are directly relevant to this study:

1. SAAS taxonomy development
2. Tasks, functions, and missions
3. Human operator simulator (HOS) micromodels

SAAS Taxonomy Development

The SAAS taxonomy was developed to provide analysts with a structured and systematic template to identify soldier tasks that would be potentially affected by new equipment. The steps that were followed in the development of this taxonomy are somewhat generic in nature and could be used to guide the development of other models. As a starting point, the tactical blueprint of the battlefield (BOB) (U.S. Army Training & Doctrine Command,

1991) was reviewed to determine which functions and generic tasks were applicable to the dismounted infantry soldier. The BOB is a Deputy Chief of Staff for Operations (DCSOPS)-approved, hierarchical listing of all tactical functions and generic tasks that are performed by the U.S. Army. This review also ensured that important infantry tasks were not inadvertently omitted from the HARDMAN III models. It is important to note that these BOB functions and tasks are not necessarily the same functions and tasks noted later concerning the HARDMAN III tools. Rather, these functions and tasks serve as their basis. The following functions, or generic tasks, from the tactical BOB were considered applicable:

- ◆ Move while dismounted
- ◆ Negotiate terrain
- ◆ Navigate
- ◆ Process direct fire targets
- ◆ Engage direct fire targets
- ◆ Conduct close combat
- ◆ Control terrain
- ◆ Receive and transmit information
- ◆ Determine action
- ◆ Collect information
- ◆ Process information
- ◆ Prepare reports
- ◆ Overcome obstacles
- ◆ Emplace obstacles
- ◆ Prepare fighting position
- ◆ Employ protective equipment
- ◆ Employ signal security
- ◆ Employ concealment techniques
- ◆ Employ deception
- ◆ Rearm
- ◆ Fix and maintain equipment
- ◆ Eat and drink
- ◆ Administer first aid
- ◆ Transport equipment
- ◆ Request and receive supplies
- ◆ Perform enemy prisoner of war (EPW) operations

Capability Areas

Once identified, the BOB functions and tasks were mapped to the five SAAS capability areas. These five areas were used to assess the soldier integrated protective ensemble

Ensemble Tactical Field Demonstration (Everett et al., 1992) and were also used in this study to assess the Land Warrior System. Table 1 lists the integrated capability areas developed using SAAS and BOB.

Table 1

Capability Areas Developed Using SAAS and BOB

<p>1. Mobility</p> <ul style="list-style-type: none"> ◆ Move while dismounted ◆ Negotiate terrain ◆ Navigate ◆ Overcome obstacles ◆ Transport equipment 	<p>4. Sustainment</p> <ul style="list-style-type: none"> ◆ Rearm ◆ Fix and maintain equipment ◆ Eat and drink ◆ Administer first aid ◆ Request and receive supplies
<p>2. Lethality</p> <ul style="list-style-type: none"> ◆ Process direct fire targets ◆ Engage direct fire targets ◆ Conduct close combat 	<p>5. Command and control</p> <ul style="list-style-type: none"> ◆ Control terrain ◆ Receive and transmit information ◆ Determine action ◆ Collect information ◆ Process information ◆ Prepare reports ◆ Emplace obstacles ◆ Perform EPW operations
<p>3. Survivability</p> <ul style="list-style-type: none"> ◆ Prepare fighting positions ◆ Employ protective equipment ◆ Employ signal security ◆ Employ concealment techniques ◆ Employ deception 	

Potential Impacts of New Equipment

Table 2 lists the possible effects that a new piece of equipment could have on a dismounted infantry soldier (squad member or squad leader). These effects could range from things like minor skin chafing to making all battlefield information instantly available. It is recommended that soldier performance assessment analysts use a list similar to this to develop a “potential effects” list. Then, using the taxonomy presented in the next section, the analyst can determine which types of tasks are most likely to be influenced by the new equipment. For example, if the new equipment changes the weight of the soldier’s load, it is likely to have an impact on mobility tasks (e.g., move while dismounted, negotiate terrain, etc.).

Table 2

Potential Effects of New Equipment

- ◆ Changes load (weight)
 - ◆ Changes volume (bulkiness)
 - ◆ Restricts or enhances body motion
 - ◆ Changes capability to manipulate
 - ◆ Changes ability to see (night vision, distance, field of view, etc.)
 - ◆ Changes ability to hear
 - ◆ Changes ability to smell
 - ◆ Changes level of "comfort" (e.g., chafes skin, strains muscles, heat, etc.)
 - ◆ Changes level of protection against elements (wind, cold, etc.)
 - ◆ Changes level of protection against threat
 - ◆ Changes amount of information available
 - ◆ Changes capability to process information
 - ◆ Changes signature (visual, auditory, electronic, etc.)
 - ◆ Changes capability to destroy or neutralize targets
 - ◆ Changes capability to communicate
 - ◆ Changes requirement for fixing or repairing
 - ◆ Changes capability for nourishment (food and water)
 - ◆ Changes capability for medical treatment
 - ◆ Changes requirement for sleep or rest
-

SAAS Taxonomy

As a final step, the BOB functions and potential effects of new equipment were mapped to the five SAAS capability areas, as shown in Table 3. The intent of the taxonomy is to provide the analyst with a structured and systematic template to identify tasks that potentially will be affected by the new equipment. After this assessment, analysts can then start to modify performance estimates of the applicable tasks in their mission models. To use this taxonomy, analysts would first identify a characteristic of the new equipment. For example, the new equipment may change the soldier's capability to see (either enhances or restricts). The analyst would then go through the tasks in the taxonomy to determine which ones are likely to be affected (e.g., move while dismounted, engage direct fire targets, etc.). It is very likely that a piece of new equipment will enhance performance of some tasks and decrease the performance of others. For example, a new rifle may improve performance in engaging direct fire targets but may reduce movement rate because of weight or bulkiness. The mission models in HARDMAN III

then capture the enhancements and decrements in task performance and estimate the effects on overall mission performance.

Table 3
SAAS Taxonomy

1. Mobility

1.1 Move while dismounted

- 1.1.1 Changes in load or weight
- 1.1.2 Changes in volume or bulkiness
- 1.1.3 Changes in restriction of body motion
- 1.1.4 Changes in level of comfort
- 1.1.5 Changes in ability to see

1.2 Negotiate terrain

- 1.2.1 Changes in load or weight
- 1.2.2 Changes in volume or bulkiness
- 1.2.3 Changes in restriction of body motion
- 1.2.4 Changes in level of comfort
- 1.2.5 Changes in ability to see

1.3 Navigate

- 1.3.1 Changes in ability to see
- 1.3.2 Changes in amount of information available
- 1.3.3 Changes in ability to process information
- 1.3.4 Changes in capability to communicate

1.4 Overcome obstacles

- 1.4.1 Changes in load or weight
- 1.4.2 Changes in volume or bulkiness
- 1.4.3 Changes in restriction of body motion
- 1.4.4 Changes in level of comfort
- 1.4.5 Changes in ability to see

1.5 Transport equipment

- 1.5.1 Changes in load or weight
- 1.5.2 Changes in volume or bulkiness
- 1.5.3 Changes in restriction of body motion
- 1.5.4 Changes in level of comfort

2. Lethality

2.1 Process direct fire targets

- 2.1.1 Changes in ability to see

- 2.1.2 Changes in amount of information available
- 2.1.3 Changes in capability to process information
- 2.1.4 Changes in capability to communicate

2.2 Engage direct fire targets

- 2.2.1 Changes in ability to see
- 2.2.2 Changes in capability to destroy or neutralize targets

2.3 Conduct close combat

- 2.3.1 Changes in load or weight
- 2.3.2 Changes in volume or bulkiness
- 2.3.3 Changes in restriction of body motion
- 2.3.4 Changes in level of comfort
- 2.3.5 Changes in ability to see
- 2.3.6 Changes in level of protection against threat

3. Survivability

3.1 Prepare fighting positions

- 3.1.1 Changes in restriction of body motion
- 3.1.2 Changes in capability to manipulate
- 3.1.3 Changes in level of protection against threat

3.2 Employ protective equipment

- 3.2.1 Changes in restriction of body motion
- 3.2.2 Changes in capability to manipulate
- 3.2.3 Changes in level of protection against threat
- 3.2.4 Changes in level of protection against elements

3.3 Employ signal security

- 3.3.1 Changes in signature

3.4 Employ concealment techniques

- 3.4.1 Changes in signature

3.5 Employ deception

- 3.5.1 Changes in signature

4. Sustainment

4.1 Rearm

- 4.1.1 Changes in load or weight
- 4.1.2 Changes in capability to destroy or neutralize targets

4.2 Fix and maintain equipment

- 4.2.1 Changes in requirements for fixing or repairing

4.3 Eat and drink

4.3.1 Changes in capability for nourishment

4.4 Administer first aid

4.4.1 Changes in capability for medical treatment

4.5 Request and receive supplies

4.5.1 Changes in capability to communicate

4.5.2 Changes in load

4.5.3 Changes in requirement for fixing or repairing

5. Command and Control

5.1 Control terrain

5.1.1 Changes in level of protection against threat

5.1.2 Changes in ability to see

5.1.3 Changes in amount of information available

5.1.4 Changes in capability to process information

5.1.5 Changes in signature

5.1.6 Changes in capability to destroy or neutralize targets

5.1.7 Changes in capability to communicate

5.1.8 Changes in requirement for sleep

5.2 Receive and transmit information

5.2.1 Changes in amount of information available

5.2.2 Changes in capability to process information

5.2.3 Changes in capability to communicate

5.2.4 Changes in signature

5.3 Determine action

5.3.1 Changes in amount of information available

5.3.2 Changes in capability to process information

5.3.3 Changes in capability to communicate

5.4 Collect information

5.4.1 Changes in amount of information available

5.4.2 Changes in capability to process information

5.4.3 Changes in capability to communicate

5.5 Process information

5.5.1 Changes in amount of information available

5.5.2 Changes in capability to process information

5.5.3 Changes in capability to communicate

5.6 Prepare reports

- 5.6.1 Changes in amount of information available
- 5.6.2 Changes in capability to process information
- 5.6.3 Changes in capability to communicate

5.7 Emplace obstacles

- 5.7.1 Changes in load or weight
- 5.7.2 Changes in volume or bulkiness
- 5.7.3 Changes in restriction of body motion
- 5.7.4 Changes in level of comfort
- 5.7.5 Changes in ability to see
- 5.7.6 Changes in level of protection against threat

5.8 Perform enemy prisoners of war (EPW) operations

- 5.8.1 Changes in load or weight
 - 5.8.2 Changes in volume or bulkiness
 - 5.8.3 Changes in restriction of body motion
 - 5.8.4 Changes in level of comfort
 - 5.8.5 Changes in ability to see
 - 5.8.6 Changes in level of protection against threat
 - 5.8.7 Changes in capability to communicate
 - 5.8.8 Changes in capability for nourishment
 - 5.8.9 Changes in requirement for sleep
-

Tasks, Functions, and Missions

The HARDMAN III tools use a framework of tasks, functions, and missions to analyze operator actions. The tasks, functions, and missions that were developed for the SAAS effort were based on a number of different sources. The primary source of task information was ARTEP 7-8-MTP, Mission Training Plan for the Infantry Rifle Platoon and Squad (Commandant, U.S. Army Infantry School, 1988).

Once this initial listing of tasks had been compiled, the SAAS taxonomy shown in Table 3 was used to ensure the completeness of the task listing. (Two former U.S. Army infantry officers who were most involved in developing the final listing have a combined total of 50 years of Army experience and 5 years of combined combat experience.) Then, related tasks were placed into related groups to form functions. Lastly, these functions were grouped into three missions: night ambush, movement to contact-attack, and reconnaissance. Through this process, critical infantry activities were addressed across different conditions, such as darkness or nuclear, biological, and chemical (NBC) contamination and the wearing of mission-oriented protective posture (MOPP) clothing. These same SAAS tasks, functions, and missions are the basis for the HARDMAN III Land Warrior System operator analyses.

HOS Micromodels

HOS is a HARDMAN III tool that is used to develop improved estimates for task time and accuracy. HOS has built-in models of particular subtasks (called micromodels), such as "hand movement," which help analysts to better estimate how long it would take an operator to do a certain task (in this case, by entering such information as how far the hand has to be moved and how big the target location is). "HOS... includes a simulation engine that uses stochastic modeling techniques to combine the task element performance estimates in order to develop an estimate for the original parent task." (Dynamics Research Corporation and Micro Analysis & Design, 1993). For the SAAS effort, four new micromodels were developed to account for infantry-specific tasks: walk, negotiate obstacles, detect direct fire targets, and hit direct fire targets. The HARDMAN III analysis of the Land Warrior System used each of these models as well. These models, as used in HOS are as follow:

1. Walk

Time(Min) =

$$F / (((A \times .067) + (B \times .0533) + (C \times .04) + (D \times .067)) - (.0055 \times ((E - 40) / 10)))$$

A = 1 if movement at night and cross country, otherwise A=0

B = 1 if movement at night and on road, otherwise B=0

C = 1 if movement during day and cross country, otherwise C=0

D = 1 if movement during day and on road, otherwise D=0

E = Weight (in pounds) of soldier's load

F = Distance (in kilometers) of soldier's move

This equation is a combination of information given in Field Manual (FM) 21-18, Foot Marches, (3-9, 5-4) (Commandant, U.S. Army Infantry School, 1990). In this way, HOS is able to account for both the terrain and time of day of the soldier's movement as well as the amount of weight that he is carrying. The curve created by this equation has been extrapolated in order to account for soldier loads that may exceed 90 lb. All distances in this study were assumed to be 1 km. It is important to note that the PER-SEVAL portion of this analysis addresses such movement-related issues as temperature, humidity, sustained operations, and the effects of protective clothing (refer to pages 65 through 78 of this report).

2. Negotiate Obstacle

$$\text{Time(Min)} = (((A - 40) / A) \times B) + B$$

A = Total soldier load

B = Baseline task time

This equation combines information from page 5-4 of FM 21-18 (Commandant, U.S. Army Infantry School, 1990). This HOS equation accounts for the effect of weight over a baseline level and its effect on time required to negotiate an obstacle.

3. Detect Direct Fire Targets

$$\text{Probability of Detection} = ((A \times .57) + (B \times .60) + (C \times .44) + (D \times .46))$$

- A = 1 if conditions are day and non-NBC, otherwise A=0
- B = 1 if conditions are day and NBC, otherwise B=0
- C = 1 if conditions are night and non-NBC, otherwise C=0
- D = 1 if conditions are night and NBC, otherwise D=0

This HOS equation accounts for the difficulty a soldier experiences in detecting direct fire targets under various conditions. The equation is derived from data taken during the SIPE ATTD that can be found on page 6 of the Test and Evaluation Report - Abbreviated Evaluate, Early User Test and Experimentation, Soldier Integrated Protective Ensemble (SIPE) (U.S. Army Test and Experimentation Command, 1993).

4. Hit Direct Fire Targets

$$\text{Probability of Hit} = ((A \times .15) + (B \times .08) + (C \times .14) + (D \times .03))$$

- A = 1 if conditions are day and non-NBC, otherwise A=0
- B = 1 if conditions are day and NBC, otherwise B=0
- C = 1 if conditions are night and non-NBC, otherwise C=0
- D = 1 if conditions are night and NBC, otherwise D=0

This HOS equation accounts for the difficulty that a soldier experiences in hitting direct fire targets during various conditions. The equation is derived from data taken during the SIPE ATTD presented on page 6 of the Test and Evaluation Report - Abbreviated Evaluate, Early User Test and Experimentation, Soldier Integrated Protective Ensemble (SIPE) (U.S. Army Test and Experimentation Command, 1993).

DEVELOPMENT OF LAND WARRIOR HARDMAN III MODELS

The Land Warrior mission models were developed in the HARDMAN III manpower-based system evaluation aid (MAN-SEVAL) using the SAAS mission models as a starting point. Given this beginning, a search of pertinent literature was done to determine those additional tasks that should be examined for the squad leader and to ensure that critical squad member tasks had not been inadvertently omitted.

- ◆ Land Warrior System Specification (U.S. Army Communications Electronics Command, 1994b)
- ◆ Operational Requirements Document (ORD) for the Land Warrior System (U.S. Army Training and Doctrine Command, 1987)
- ◆ Land Warrior Operational Mode Summary/Mission Profile (Dismounted Battlespace Battle Lab, 1994)

- ◆ FM 7-70, Light Infantry Platoon/Squad (Department of the Army, 1986)
- ◆ FM 21-18, Foot Marches (Commandant, U.S. Army Infantry School, 1990)
- ◆ FM 7-11B1, Soldier's Manual, MOS 11B Infantryman Skill Level 1 (Commandant, U.S. Army Infantry School, 1982)
- ◆ FM 7-11B24-SM, Soldier's Manual, MOS 11B Infantryman Skill Level 2/3/4 (Commandant, U.S. Army Infantry School, 1985)
- ◆ ARTEP 7-8-MTP, Mission Training Plan for the Infantry Rifle Platoon and Squad (Commandant, U.S. Army Infantry School, 1988)
- ◆ STP-21-1-SMCT, Soldier's Manual of Common Tasks (Department of the Army, 1985b)
- ◆ "Task Analysis Matrix" from Panel on Human Factors in the Design of Tactical Display Systems for the Individual Soldier (Dismounted Battlespace Battle Lab, 1994)

Mission Model Descriptions

Table 4 describes the 12 missions that were developed for Land Warrior and is a listing of the functions and tasks in each particular mission. It is important to note that the functions and tasks presented in Table 4 are the result of a survey of doctrinal literature viewed through the framework of the SAAS taxonomy in Table 3. This listing does not necessarily reflect the order in which the functions or tasks are conducted (see pages 59-60 of this report). "Junction" tasks are used within MAN-SEVAL for organizing the order in which tasks are conducted. Three each of the missions (night ambush, movement to contact-attack, and reconnaissance) were developed for

- ◆ Squad member with current equipment
- ◆ Squad member with Land Warrior equipment
- ◆ Squad leader with current equipment
- ◆ Squad leader with Land Warrior equipment

The general assumptions that apply to all the missions are

- ◆ All analyses are based on a light infantry squad member or squad leader in combat.
- ◆ All missions take place initially in a temperate environment with no special environmental equipment needed. (The effects of heat, cold, sustained operations, and protective clothing are addressed on pages 65-79 of this report.)

Table 4

Land Warrior Missions, Functions, and Tasks

Functions	Tasks
Current Equipment Squad Member Night Ambush Mission	
Prepare for ambush	Maintain weapon Perform function check of M16A2 rifle Maintain night sight Receive warning order Mount night sight Zero night sight AN/PVS-4 to an M16A2 rifle Receive operations order Conduct pre-combat checks
Rehearse	Participate in sand table rehearsal Camouflage self and individual equipment Check equipment and load Load weapon
Move to ambush site	Junction1 Junction2 Use signaling techniques Walk Move as a member of a fire team Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify objective rally point (ORP) feature(s)
Prepare ambush site	Establish security Identify firing position Identify sector of fire Prepare firing position Construct field expedient firing aids Employ an M18A1 Claymore mine
Get into firing position	Get into firing position Operate an AN/PVS-4 Perform search & scan procedures
Initiate ambush	Recognize ambush signal Detonate mines-special equipment

Acquire targets	Search for target Detect target Identify target Select firing mode Aim-sight weapon
Engage enemy	Engage targets with an M16A2 rifle using AN/PVS-4 Employ hand grenades Assess target damage Target neutralized
Report status	Send a report
Search ambush site	Search ambush site Process enemy personnel and equipment
Move to ORP	Junction1 Junction2 Use signaling techniques Walk Move as a member of a fire team Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)

Land Warrior Squad Member Night Ambush Mission

Prepare for ambush	Maintain modular weapon Perform function check on modular weapon Maintain modular weapon sights (4) Maintain land warrior equipment Receive warning order Tailor land warrior equipment to mission Initialize land warrior equipment Receive operations order Conduct pre-combat checks
Rehearse	Participate in sand table rehearsal Camouflage self and individual equipment Check equipment and load Load modular weapon
Move to ambush site	Junction1 Junction2 Walk Move as a member of a fire team Maintain modular weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment

	Maintain noise & light discipline Identify ORP feature(s)
Prepare ambush site	Establish security Identify firing position Identify sector of fire Prepare firing position Construct field expedient firing aids Employ an M18A1 Claymore mine
Get into firing position	Get into firing position Operate thermal weapons sight Perform search & scan procedures
Initiate ambush	Recognize ambush signal Detonate mines-special equipment
Acquire targets	Search for target Detect target Identify target Select firing mode Aim-sight modular weapon
Engage enemy	Engage targets with modular weapon Employ hand grenades Assess target damage Target neutralized
Report status	Send a report using computer-radio
Search ambush site	Search ambush site Process enemy personnel and equipment
Move to ORP	Junction1 Junction2 Walk Move as a member of a fire team Maintain modular weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)
Communicate	Communicate using computer-radio

Current Equipment Squad Member Movement to Contact-Attack Mission

Move tactically 1	Junction1 Junction2 Use signaling techniques Walk Move as a member of a fire team Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)
Move over, around obstacles	Recognize obstacle Determine how obstacle will be negotiated Adjust load-equipment for negotiation Negotiate obstacle Readjust load-equipment for march order
Move tactically 2	Junction1 Junction2 Use signaling techniques Walk Move as a member of a fire team Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)
React to enemy fire	Seek immediate cover-concealment Soldier hit by enemy fire Soldier killed by enemy fire Locate general direction of enemy fire Identify enemy position Identify threat weapons Report enemy information Engage targets with an M16A2 rifle (suppressive) Move under direct fire React to indirect fire Select temporary fighting position
Acquire targets	Search for target Detect target Identify target Determine range to target Select firing mode Aim-sight weapon

Engage enemy	Engage targets with an M16A2 rifle Assess target damage Target neutralized
Move tactically 3	Junction1 Junction2 Use signaling techniques Walk Move as a member of a fire team Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)
Seize objective	Recognize objective Recognize maneuver route to objective Move toward objective Avoid hostile fire Use cover and concealment Maintain contact with other fire team members Recognize when supporting fires have been lifted Assault objective Fire weapon Junction Move through objective area Verify all enemy have been neutralized
Consolidate	Evaluate a casualty Report casualties Report ammo status Cross-level supplies

Land Warrior Squad Member Movement to Contact-Attack Mission

Move tactically 1	Junction1 Junction2 Walk Move as a member of a fire team Maintain modular weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)
Move over, around obstacles	Recognize obstacle Determine how obstacle will be negotiated Adjust load-equipment for negotiation Negotiate obstacle Readjust load-equipment for march order

Move tactically 2

Junction1
Junction2
Walk
Move as a member of a fire team
Maintain modular weapon ready for combat
Maintain all-around security
Evaluate terrain for cover & concealment
Maintain noise & light discipline
Identify ORP feature(s)

React to enemy fire

Seek immediate cover-concealment
Soldier hit by enemy fire
Soldier killed by enemy fire
Locate general direction of enemy fire
Identify enemy position
Identify threat weapons
Report enemy information
Engage targets with a modular weapon
Move under direct fire
React to indirect fire
Select temporary fighting position

Acquire targets

Search for target
Detect target
Identify target
Determine range to target
Query identify friend or foe (IFF)
Select firing mode
Aim-sight modular weapon

Engage enemy

Engage targets with modular weapon
Assess target damage
Target neutralized

Move tactically 3

Junction1
Junction2
Walk
Move as a member of a fire team
Maintain modular weapon ready for combat
Maintain all-around security
Evaluate terrain for cover & concealment
Maintain noise & light discipline
Identify ORP feature(s)

Seize objective

Recognize objective
Recognize maneuver route to objective
Move toward objective
Avoid hostile fire
Use cover and concealment
Maintain contact with other fire team members
Recognize when supporting fires have been
lifted
Assault objective
Fire modular weapon

	<ul style="list-style-type: none"> Junction Move through objective area Verify all enemy have been neutralized
Consolidate	<ul style="list-style-type: none"> Evaluate a casualty Report casualties Report ammo status Cross-level supplies
Communicate	<ul style="list-style-type: none"> Communicate using computer-radio
<p>Current Equipment Squad Member Reconnaissance Mission</p>	
Put on NBC protective garments	<ul style="list-style-type: none"> Put on M-40 protective mask Put on NBC overgarment Put on NBC boots Put on NBC gloves
Move to ORP1	<ul style="list-style-type: none"> Junction1 Junction2 Use signaling techniques Walk Move as a member of a fire team Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)
Occupy ORP1	<ul style="list-style-type: none"> Use challenge and password Assume covered and concealed position Observe assigned sector for enemy activity Listen for enemy activity Maintain contact with adjacent team members Maintain noise & light discipline
Reconnoiter zone using fan method	<ul style="list-style-type: none"> Walk Follow assigned recon route Use cover and concealment Search for enemy activity Maintain noise & light discipline Use M8/M9 detector paper to identify chemical agent Mark NBC contaminated area Drink water while in MOPP4 Use latrine while wearing MOPP4 Recognize and react to chemical agent
Disseminate recon information	<ul style="list-style-type: none"> Disseminate recon information

Move to ORP2	Junction1 Junction2 Use signaling techniques Walk Move as a member of a fire team Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise and light discipline Identify ORP feature(s)
Occupy ORP2	Use challenge and password Assume covered and concealed position Observe assigned sector for enemy activity Listen for enemy activity Maintain contact with adjacent team members Maintain noise & light discipline
Remove NBC protective garments	Decontaminate skin and personal equipment Remove and store M-40 protective mask Remove NBC gloves Remove NBC boots Remove NBC overgarment
Locate objective area	Locate objective area
Observe and record priority of intelligence reporting (PIR)	Observe terrain Record information about terrain Observe enemy size, activity, location, unit, time, equipment (SALUTE) Record information about enemy activity

Land Warrior Squad Member Reconnaissance Mission

Put on NBC protective garments	Put on XM-47 protective mask Put on NBC shell garment Put on NBC gaiters Put on NBC gloves
Move to ORP1	Junction1 Junction2 Walk Move as a member of a fire team Maintain modular weapon ready for combat Maintain all-around security Evaluate terrain for cover and concealment Maintain noise & light discipline Identify ORP feature(s)

Occupy ORP1	<ul style="list-style-type: none"> Use challenge and password Assume covered and concealed position Observe assigned sector for enemy activity Listen for enemy activity Maintain contact with adjacent team members Maintain noise & light discipline
Reconnoiter zone using fan method	<ul style="list-style-type: none"> Walk Follow assigned recon route Use cover and concealment Search for enemy activity Maintain noise & light discipline Use M8/M9 detector paper to identify chemical agent Mark NBC contaminated area Drink water while in MOPP4 Use latrine while Wearing MOPP4 Recognize and react to chemical agent
Disseminate recon information	Disseminate recon information
Move to ORP2	<ul style="list-style-type: none"> Junction1 Junction2 Walk Move as a member of a fire team Maintain modular weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s)
Occupy ORP2	<ul style="list-style-type: none"> Use challenge and password Assume covered and concealed position Observe assigned sector for enemy activity Listen for enemy activity Maintain contact with adjacent team members Maintain noise & light discipline
Remove NBC protective garments	<ul style="list-style-type: none"> Decontaminate skin and personal equipment Remove and store XM-47 protective mask Remove NBC gloves Remove NBC gaiters Remove NBC shell garment
Locate objective area	Locate objective area
Observe and record PIR	<ul style="list-style-type: none"> Observe terrain Record information about terrain Observe enemy activity (SALUTE) Record information about enemy activity
Communicate	Communicate using computer-radio

Current Equipment Squad Leader Night Ambush Mission

Prepare for ambush	Maintain weapon Perform function check of weapon Maintain night sight Issue a warning order Assign equipment to squad members Mount night sight Zero night sight AN/PVS-4 to an M16A2 rifle Receive operations order Conduct pre-combat checks
Rehearse	Participate in sand table rehearsal Camouflage self and individual equipment Check own equipment and load Check squad members' equipment and load Load weapon
Move to ambush site	Junction1 Junction2 Junction3 Use signaling techniques Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground by terrain association Conduct a leader's reconnaissance
Prepare ambush site	Establish security Identify firing position Identify sector of fire Prepare squad sector sketch Prepare firing position Construct field expedient firing aids Employ an M18A1 Claymore mine Check squad positions
Get into firing position	Get into firing position Operate an AN/PVS-4 Perform search & scan procedures
Initiate ambush	Conduct point ambush by squad Control organic fires Detonate mines-special equipment

Acquire targets	Search for target Detect target Identify target Select firing mode Aim-sight weapon
Engage enemy	Engage targets with an M16A2 rifle using AN/PVS-4 Employ hand grenades Assess target damage Target neutralized Receive squad status report
Report status	Send a report
Search ambush site	Search ambush site Process enemy personnel and equipment
Move to ORP	Conduct link-up by squad Junction1 Junction2 Junction3 Use signaling techniques Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground by terrain association

Land Warrior Squad Leader Night Ambush Mission

Prepare for Ambush	Maintain modular weapon Perform function check of modular weapon Maintain modular weapon sights (4) Maintain Land Warrior equipment Issue a warning order Assign equipment to squad members Tailor Land Warrior equipment to mission Initialize Land Warrior equipment Receive operations order Conduct pre-combat checks
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Rehearse	<ul style="list-style-type: none"> Participate in sand table rehearsal Camouflage self and individual equipment Check own equipment and load Check squad members' equipment and load Load modular weapon
Move to ambush site	<ul style="list-style-type: none"> Junction1 Junction2 Junction3 Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route Maintain modular weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground Conduct a leader's reconnaissance
Prepare ambush site	<ul style="list-style-type: none"> Establish security Identify firing position Identify sector of fire Prepare squad sector sketch Prepare firing position Construct field expedient firing aids Employ an M18A1 Claymore mine Check squad positions
Get into firing position	<ul style="list-style-type: none"> Get into firing position Operate thermal weapons sight Perform search & scan procedures
Initiate ambush	<ul style="list-style-type: none"> Conduct point ambush by squad Control organic fires Detonate mines-special equipment
Acquire targets	<ul style="list-style-type: none"> Search for target Detect target Identify target Select firing mode Aim-sight modular weapon
Engage enemy	<ul style="list-style-type: none"> Engage targets with modular weapon Employ hand grenades Assess target damage Target neutralized Receive squad status report
Report status	<ul style="list-style-type: none"> Send a report using computer-radio

Search ambush site

Search ambush site
Process enemy personnel and equipment

Move to ORP

Conduct link-up by squad
Junction1
Junction2
Junction3
Conduct the maneuver of a squad
Walk
Orient a map
Navigate from one point to another
Select a movement route
Maintain modular weapon ready for combat
Maintain all-around security
Evaluate terrain for cover & concealment
Maintain noise & light discipline
Identify ORP feature(s)
Determine location on the ground

Communicate

Communicate using computer-radio

Current Equipment Squad Leader Movement to Contact-Attack Mission

Move tactically 1

Junction1
Junction2
Junction3
Use signaling techniques
Conduct the maneuver of a squad

Walk
Orient a map
Navigate from one point to another
Select a movement route
Maintain weapon ready for combat
Maintain all-around security
Evaluate terrain for cover & concealment
Maintain noise & light discipline
Identify ORP features(s)
Determine location on the ground by terrain
association

Move over, around obstacles

Recognize obstacle
Determine how obstacle will be negotiated
Adjust load-equipment for negotiation
Negotiate obstacle
Readjust load-equipment for march order

Move tactically 2	<ul style="list-style-type: none"> Junction1 Junction2 Junction3 Use signaling techniques Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP features(s) Determine location on the ground by terrain association
React to enemy fire	<ul style="list-style-type: none"> Seek immediate cover-concealment Soldier hit by enemy fire Soldier killed by enemy fire Locate general direction of enemy fire Identify enemy position Identify threat weapons Report enemy information Engage targets with an M16A2 rifle (suppressive) Move under direct fire React to indirect fire Select temporary fighting position
Acquire targets	<ul style="list-style-type: none"> Search for target Detect target Identify target Determine range to target Select firing mode Aim-sight weapon
Engage enemy	<ul style="list-style-type: none"> Engage targets with an M16A2 rifle Assess target damage Target neutralized
Move tactically 3	<ul style="list-style-type: none"> Consolidate a squad Reorganize a squad Junction1 Junction2 Junction3 Use signaling techniques Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route

Maintain weapon ready for combat
Maintain all-around security
Evaluate terrain for cover & concealment
Maintain noise & light discipline
Identify ORP features(s)
Determine location on the ground by terrain association

Seize objective

Recognize objective
Recognize maneuver route to objective
Move toward objective
Avoid hostile fire
Use cover and concealment
Junction1
Fire pre-planned indirect fire target
Locate target for indirect fire
Call for indirect fire
Adjust indirect fire
Direct employment of smoke
Recognize when supporting fires have been lifted
Assault objective
Fire weapon
Junction
Move through objective area
Verify all enemy have been neutralized

Consolidate

Evaluate a casualty
Report casualties
Report ammo status
Cross-level supplies

Land Warrior Squad Leader Movement to Contact-Attack Mission

Move tactically 1

Junction1
Junction2
Junction3
Conduct the maneuver of a squad
Walk
Orient a map
Navigate from one point to another
Select a movement route
Maintain weapon ready for combat
Maintain all-around security
Evaluate terrain for cover & concealment
Maintain noise & light discipline
Identify ORP feature(s)
Determine location on the ground

Move over, around obstacles	<ul style="list-style-type: none"> Recognize obstacle Determine how obstacle will be negotiated Adjust load-equipment for negotiation Negotiate obstacle Readjust load-equipment for march order
Move tactically 2	<ul style="list-style-type: none"> Junction1 Junction2 Junction3 Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground
React to enemy fire	<ul style="list-style-type: none"> Seek immediate cover-concealment Soldier hit by enemy fire Soldier killed by enemy fire Locate general direction of enemy fire Identify enemy position Identify threat weapons Report enemy information Engage targets with modular weapon (suppressive) Move under direct fire React to indirect fire Select temporary fighting position
Acquire targets	<ul style="list-style-type: none"> Search for target Detect target Identify target Determine range to target Query IFF Select firing mode Aim-sight weapon
Engage enemy	<ul style="list-style-type: none"> Engage targets with modular weapon Assess target damage Target neutralized
Move tactically 3	<ul style="list-style-type: none"> Consolidate a squad Reorganize a squad Junction1 Junction2 Junction3 Conduct the maneuver of a squad

	<ul style="list-style-type: none"> Walk Orient a map Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground
Seize objective	<ul style="list-style-type: none"> Recognize objective Recognize maneuver route to objective Move toward objective Avoid hostile fire Use cover and concealment Junction1 Fire pre-planned indirect fire target Locate target for indirect fire Use laser rangefinder to forward target location Call for indirect fire Adjust indirect fire Direct employment of smoke Recognize when supporting fires have been lifted Assault objective Fire weapon Junction Move through objective area Verify all enemy have been neutralized
Consolidate	<ul style="list-style-type: none"> Evaluate a casualty Report casualties Report ammo status Cross-level supplies
Communicate	<ul style="list-style-type: none"> Communicate using computer-radio

Current Equipment Squad Leader Reconnaissance Mission

Put on NBC protective garments	<ul style="list-style-type: none"> Put on M-40 protective mask Put on NBC overgarment Put on NBC boots Put on NBC gloves
Move to ORP1	<ul style="list-style-type: none"> Junction1 Junction2 Junction3 Use signaling techniques Conduct the maneuver of a squad Walk Orient a map

	<p>Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground by terrain association</p>
Occupy ORP1	<p>Use challenge and password Assume covered and concealed position Observe assigned sector for enemy activity Listen for enemy activity Maintain noise & light discipline</p>
Reconnoiter zone using fan method	<p>Walk Follow assigned recon route Use cover and concealment Search for enemy activity Maintain noise & light discipline Use M8/M9 detector paper to identify chemical agent Mark NBC contaminated area Drink water while in MOPP4 Use latrine while wearing MOPP4 Recognize and react to chemical agent</p>
Disseminate recon information	<p>Disseminate recon information</p>
Move to ORP2	<p>Junction1 Junction2 Junction3 Use signaling techniques Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground by terrain association</p>
Occupy ORP2	<p>Use challenge and password Assume covered and concealed position Observe assigned sector for enemy activity Listen for enemy activity Maintain noise & light discipline</p>

Remove NBC protective garments

Decontaminate skin and personal equipment
Remove and store M-40 protective mask
Remove NBC gloves
Remove NBC boots
Remove NBC overgarment

Locate objective area

Locate objective area

Observe and record PIR

Observe terrain
Record information about terrain
Observe enemy activity (SALUTE)
Record information about enemy activity

Land Warrior Squad Leader Reconnaissance Mission

Put on NBC protective garments

Put on XM-47 protective mask
Put on NBC shell garment
Put on NBC gaiters
Put on NBC gloves

Move to ORP1

Junction1
Junction2
Junction3
Conduct the maneuver of a squad
Walk
Orient a map
Navigate from one point to another
Select a movement route
Maintain weapon ready for combat
Maintain all-around security
Evaluate terrain for cover & concealment
Maintain noise & light discipline
Identify ORP feature(s)
Determine location on the ground

Occupy ORP1

Use challenge and password
Assume covered and concealed position
Observe assigned sector for enemy activity
Listen for enemy activity
Maintain noise & light discipline

Reconnoiter zone using fan method

Walk
Follow assigned recon route
Use cover and concealment
Search for enemy activity
Maintain noise & light discipline
Use M8/M9 detector paper to identify
chemical agent
Mark NBC contaminated area
Drink water while in MOPP4
Use latrine while Wearing MOPP4
Recognize and react to chemical agent

Disseminate recon information	Disseminate recon information
Move to ORP2	Junction1 Junction2 Junction3 Conduct the maneuver of a squad Walk Orient a map Navigate from one point to another Select a movement route Maintain weapon ready for combat Maintain all-around security Evaluate terrain for cover & concealment Maintain noise & light discipline Identify ORP feature(s) Determine location on the ground
Occupy ORP2	Use challenge and password Assume covered and concealed position Observe assigned sector for enemy activity Listen for enemy activity Maintain noise & light discipline
Remove NBC protective garments	Decontaminate skin and personal equipment Remove and store XM-47 protective mask Remove NBC gloves Remove NBC Gaiters Remove NBC shell garment
Locate objective area	Locate objective area
Observe and Record PIR	Observe terrain Record information about terrain Observe enemy activity (SALUTE) Record information about enemy activity
Communicate	Communicate using computer-radio

Equipment Distribution

The next step in the development of the HARDMAN III Land Warrior System models was the determination of the distribution of equipment for both the squad member and squad leader, with both current and Land Warrior equipment. This process was important in that it helped establish the different loads for use in the analyses as well as ensure that the analysts were familiar with all equipment and capabilities. Additionally, this process helped to ensure that tasks associated with particular items of equipment were accounted for in the mission models. First a detailed description of all Land Warrior equipment is provided. Of this equipment, the wiring harness and software subsystem are assumed to be accounted for by the weights of the various Land Warrior components themselves and the computer-radio subsystem,

respectively, and therefore are not listed in the equipment distributions for the squad member and squad leader shown in Tables 5 and 6 (see pages 40 through 45). The video processor and audio amplifier are accounted for by the computer-radio subsystem, and the headset-microphone is accounted for by the integrated helmet assembly subsystem; these components are likewise not listed in Tables 5 and 6.

Table 5

Current and Land Warrior Equipment and Weight Distribution for the Squad Member

Current equipment	Weight (lb)	Land Warrior equipment	Weight (lb)	Mission*
Weapons				
Rifle, M16A2 with 30 rounds	8.9	Modular weapon with 30 Rounds	8.9	BAR
Cleaning kit, weapons	0.5	Cleaning kit, weapons	0.5	BAR
Bayonet, M9 with scabbard	1.8	Bayonet, M9 with scabbard	1.8	BAR
Ammunition				
Magazine, 30 rounds, 5.56 mm (6)	6.6	Magazine, 30 rounds, 5.56 mm (6)	6.6	BAR
Grenade, hand, fragmentation (2)	2	Grenade, hand, fragmentation (2)	2	BAR
Antitank (AT) weapon (LAW)	5.2	AT weapon (LAW)	5.2	
Mine, Claymore	3.5	Mine, Claymore	3.5	B
Land Warrior equipment				
Sight, night vision PVS/4	3.5	Thermal weapons sight (TWS)	4.5	BAR
		Visible laser aiming light	0.55****	BAR
		Close combat optic	1.5	BAR
		Computer-radio subsystem	4.25	BAR
		Intrasquad radio communications security (COMSEC)	0.25	BAR
		Global positioning system (GPS) receiver	0.25	BAR
		Remote input pointing device	0.25	BAR
Helmet, personal armor system for ground troops (PASGT)	3.5	Integrated helmet assembly subsystem	4.5	BAR
		Night display/I ²	1	BAR
		Ballistic and laser eye protection	0.2	BAR
Glasses, ballistic	0.2	Ballistic and laser eye protection	0.2	BAR
Vest, PASGT	8.5	Modular body armor	7.75	BAR
		Laser detector	0.5	BAR
		Combat identification transponder	1	BAR
Personal equipment				
Load-bearing equipment (LBE) with first aid kit	2.7	Land Warrior (LW) fighting load, load-carrying equipment (LCE)	2.7	BAR
Backpack, internal frame***	8	LW approach march load LCE**		
Net, camouflage***	0.3	LW sustainment load LCE***		
Net, camouflage***	0.3	Net, camouflage***	0.3	
Matches, box	0.2	Matches, box	0.2	BAR
Watch, wrist	0.3	Watch, wrist	0.3	BAR
Compass, Lensatic	0.2	Compass, Lensatic***	0.2	BAR

Flashlight	0.8	Flashlight	0.8	BAR
Kit, first aid***	1.1	Kit, first aid***	1.1	
Entrenching tool & carrier***	2.5	Entrenching tool & carrier***	2.5	
Sleeping bag***	7	Sleeping bag, modular, patrol bag***	4.5	
Mat sleeping***	1.25	Mat sleeping***	1.25	
Toilet articles, personal***	2.5	Toilet articles, personal***	2.5	
Towel, brown***	0.4	Towel, brown***	0.4	
Face paint, camouflage	0.1	Face paint, camouflage	0.1	BAR

Food and water

Meal, ready-to-eat (MRE)	1.5	Meal, ready-to-eat (MRE)	1.5	BAR
Pogey bait***	1.5	Pogey bait***	1.5	
Canteen, 1 quart with water	3.4	Canteen, 1 quart with water	3.4	BAR
Canteen, 2 quart with water***	6.7	Canteen, 2 quart with water***	6.7	
Tablets, water purification	0.1	Tablets, water purification	0.1	BAR

Clothing

Cap, woodland	0.3	Cap, woodland	0.3	
Battle dress uniform (BDU) Coat	2.1	Coat, advanced combat uniform**	2.1	BAR
BDU trousers	1.7	Trousers, advanced combat uniform**	1.7	BAR
Drawers, man's, cotton	0.1	Drawers, man's, cotton	0.1	BAR
Undershirt, man's, cotton	0.1	Undershirt, man's, cotton	0.1	BAR
Boots, combat, leather	4.1	Boots, combat, leather	4.1	BAR
Socks, man's, cushion	0.8	Socks, man's, cushion	0.8	BAR
Glove, shells, leather	0.2	Glove, shells, leather	0.2	BAR
Glove, insert, wool	0.2	Glove, insert, wool	0.2	BAR
Coat, cold weather	3.2	Coat, cold weather	3.2	AB
Liner, cold weather	0.86	Liner, cold weather	0.86	BAR
Poncho, wet weather	1.5	Poncho, wet weather	1.5	BAR
Liner, wet weather***	1.5	Liner, wet weather***	1.5	

NBC Protection equipment

NBC mask M-40	3.8	Protective mask, XM-47	3.8	R
Chemical suit lightweight	6.2	Lightweight battledress over-garment	4.2	R
Chemical biological (CB) gloves (14mil)	0.3	CB gloves	0.4	R
Overshoes, green vinyl (GV)	3.2	CB foot covers	4.4	R
CB helmet cover	0.1	CB helmet cover	0.1	R
Chemical detector paper M8/M9	0.5	Chemical detector paper M8/M9	0.5	R
Decontamination kit, M258	0.3	Decontamination kit, M258	0.3	R
Detector card, M256	0.2	Detector card, M256	0.2	R
Antidote injector, Mark I	0.495	Antidote injector, Mark I	0.495	R
Miscellaneous equipment				

Battery, LW computer-radio (2) 4 BAR

*Carried on: B-night ambush mission, A-movement to contact-attack mission, R-reconnaissance mission. Those items with no mission listed were shown in various sources that were not required for these missions.

**Approach march load - These items are not carried on the mission.

***Sustainment load - These items are not carried on the mission.

****Assumed value

Table 6

Current and Land Warrior Equipment and Weight Distribution for the Squad Leader

Current equipment	Weight (lb)	Land Warrior equipment	Weight (lb)	Mission*
Weapons				
Rifle, M16A2 with 30 rounds	8.9	Modular weapon with 30 rounds	8.9	BAR
Cleaning kit, weapons	0.5	Cleaning kit, weapons	0.5	BAR
Bayonet, M9 with scabbard	1.8	Bayonet, M9 with scabbard	1.8	BAR
Ammunition				
Magazine, 30 rounds, 5.56mm (6)	6.6	Magazine, 30 rounds, 5.56mm (6)	6.6	BAR
Grenade, hand, fragmentation (2)	2	Grenade, hand, fragmentation (2)	2	BAR
Grenade, smoke, red-green	2.8	Grenade, smoke, red or green	2.8	BAR
Signal rocket, white star	0.5	Signal rocket, white star	0.5	BAR
Land Warrior equipment				
Sight, night vision PVS/4	3.5	Thermal weapons sight (TWS)	4.5	BAR
		Laser rangefinder-digital compass	1	BAR
		Infrared (IR) laser aiming light, AN/PAQ-4B	0.5	B
		Visible laser aiming light	0.55****	BAR
		Close combat optic	1.5	BAR
		Video camera unit	0.375	BAR
		Computer-radio subsystem	4.25	BAR
		Intrasquad radio communications security (COMSEC)	0.25	BAR
		Global positioning system (GPS) receiver	0.25	BAR
		Remote input pointing device	0.25	BAR
		Intersquad radio	1	BAR
		Intersquad radio COMSEC	0.25	BAR
		Keyboard	1	BAR
		Hand-held flat panel display	1.5	BAR
Helmet, personal armor system for ground troops (PASGT)	3.5	Integrated helmet assembly subsystem	4.5	BAR
		Night display/I ²	1	BAR
Glasses, ballistic	0.2	Ballistic and laser eye protection	0.2	BAR
Vest, PASGT	8.5	Modular body armor	7.75	BAR
		Laser detector	0.5	BAR
		Combat identification transponder	1	BAR
Personal equipment				
Load-bearing equipment (LBE) with first aid kit	2.7	Land Warrior (LW) fighting load load-carrying equipment (LCE) LW approach march load LCE**	2.7	BAR
Backpack, int frame***	8	LW sustainment load LCE***		
Net, camouflage***	0.3	Net, camouflage***	0.3	
Knife, personal	0.4	Knife, personal	0.4	BAR
Matches, box	0.2	Matches, box	0.2	BAR
Watch, wrist	0.3	Watch, wrist	0.3	BAR

Compass, Lensatic	0.2	Compass, Lensatic***	0.2	BAR
Flashlight	0.8	Flashlight	0.8	BAR
Kit, first aid***	1.1	Kit, first aid***	1.1	
Bag, waterproof***	0.75	Bag, waterproof***	0.75	
Entrenching tool & carrier***	2.5	Entrenching tool & carrier***	2.5	
Sleeping bag***	7	Sleeping bag, modular, patrol bag***	4.5	
Mat sleeping***	1.25	Mat sleeping***	1.25	
Toilet articles, personal***	2.5	Toilet articles, personal***	2.5	
Towel, brown***	0.4	Towel, brown***	0.4	
Face paint, camouflage	0.1	Face paint, camouflage	0.1	BAR

Food and water

Meal, ready-to-eat (MRE)	1.5	Meal, ready-to-eat (MRE)	1.5	BAR
Pogey bait***	1.5	Pogey bait***	1.5	
Canteen, 1 quart with water	3.4	Canteen, 1 quart with water	3.4	BAR
Canteen, 2 quart with water***	6.7	Canteen, 2 quart with water***	6.7	
Tablets, water purification	0.1	Tablets, water purification	0.1	BAR

Clothing

Cap, woodland***	0.3	Cap, woodland***	0.3	
Battle dress uniform (BDU) coat	2.1	Coat, advanced combat uniform	2.1**	BAR
BDU trousers	1.7	Trousers, advanced combat uniform	1.7**	BAR
Drawers, man's, cotton	0.1	Drawers, man's, cotton	0.1	BAR
Undershirt, man's, cotton	0.1	Undershirt, man's, cotton	0.1	BAR
Boots, combat, leather	4.1	Boots, combat, leather	4.1	BAR
Socks, man's, cushion	0.8	Socks, man's, cushion	0.8	BAR
Glove, shells, leather	0.2	Glove, shells, leather	0.2	BAR
Glove, insert, wool	0.2	Glove, insert, wool	0.2	BAR
Coat, cold weather	3.2	Coat, cold weather	3.2	BAR
Liner, cold weather	0.86	Liner, cold weather	0.86	AB
Poncho, wet weather	1.5	Poncho, wet weather	1.5	BAR
Liner, wet weather***	1.5	Liner, wet weather***	1.5	

NBC Protection Equipment

NBC mask M-40	3.8	Protective mask, XM-47	3.8	R
Chemical suit lightweight	6.2	Lightweight battledress overgarment	4.2	R
Chemical biological (CB) gloves (14mil)	0.3	CB gloves	0.4	R
Overshoes, green vinyl (GV)	3.2	CB foot covers	4.4	R
CB helmet cover	0.1	CB helmet cover	0.1	R
Chemical detector paper M8/M9	0.5	Chemical detector paper M8/M9	0.5	R
Decontamination kit, M258	0.3	Decontamination kit, M258	0.3	R
Detector card, M256	0.2	Detector card, M256	0.2	R
Antidote injector, Mark I	0.495	Antidote injector, Mark I	0.495	R

Miscellaneous equipment

		Battery, LW computer-radio (2)	4	BAR
Binoculars (7X35)	3.2	Binoculars (7X35)	3.2	BAR
Panel, signal VS-7	0.3	Panel, signal VS-7	0.3	BAR

*Carried on: B-night ambush mission, A-movement to contact-attack mission, R-reconnaissance mission. Those items with no mission listed were shown in various sources that were not required for these missions.

**Approach march load - These items are not carried on the mission.

***Sustainment load - These items are not carried on the mission.

****Assumed value

Sources are

- ◆ Land Warrior Draft RFP, Appendix B Land Warrior Configurations (U.S. Army Communications-Electronics Command, 1994a)
- ◆ Technology Demonstration for Lightening the Soldier's Load (Sampson, 1988)
- ◆ Operational Requirements Document for the M4/M16 Close Combat Optics Program (U.S. Army Infantry School, 1993)
- ◆ Letter Requirement for an Infrared Aiming Light (U.S. Army Training and Doctrine Command, undated)
- ◆ Operational Requirements Document for Battlefield Combat Identification System (1993)
- ◆ Land Warrior System Specification (U.S. Army Communications-Electronics Command, 1994b)
- ◆ Operational Requirements Document for the Modular Weapon (U.S. Army Infantry School, 1994)

Land Warrior System Equipment

The Land Warrior System comprises five subsystems (weapon subsystem, computer-radio subsystem, software subsystem, integrated helmet assembly subsystem, and protective clothing and individual equipment subsystem), which are linked by a wiring harness. These subsystems and their components are described in detail below (U.S. Army Communications - Electronics Command 1994b):

Weapon Subsystem

The weapon subsystem integrates target acquisition, target location, and target marking capabilities with the modular weapon. The subsystem consists of the following components: modular weapon, AN/PAS-13 thermal weapons sight, close combat optic, AN/PAQ-4B IR laser aiming light, visible laser aiming light, video camera, and laser rangefinder-digital compass. The weapon subsystem, when integrated with the computer-radio subsystem and integrated helmet assembly subsystem (described below) will increase soldier lethality by increasing the speed and accuracy of direct and indirect fire engagements. The weapon subsystem also provides an improved intelligence collection capability via its imaging devices and supports fire planning and navigation with the capabilities of the laser rangefinder-digital compass.

Modular weapons (M16A2E4 and M4E2) are gas operated, shoulder fired, air cooled, magazine fed, and selective fire, with a caliber of 5.56 mm. The modular weapons provide additional mounting surfaces for accessory devices and lower the mounting position of night vision sights to enhance the firing position. A mount is provided under the rifle barrel for attachment of the M203 grenade launcher.

AN/PAS-13 thermal weapons sight provides improved target acquisition capabilities during reduced visibility conditions. The sight is used by leaders for surveillance and fire control. Weapons operators employ the sight to scan, detect, select, and engage targets. The sight mounts on the modular weapon and does not interfere with other sighting devices.

Close combat optic provides a short- to medium-range sighting capability that is operable in all mission scenarios and environmental conditions. The close combat optic provides an illuminated colored dot reticle and provides adequate clearing for use while wearing ballistic laser eye protection (see integrated helmet assembly subsystem).

AN/PAQ-4B IR laser aiming light projects an aiming point as far away as 600 meters. The aiming light mounts on the modular weapon and does not interfere with other sighting devices.

Visible laser aiming light is an eye-safe steady beam laser that emits visible light. The light mounts on the modular weapon, does not interfere with other sighting devices, and has an effective range of 25 to 50 meters in overcast or twilight illumination.

Video camera is a black-and-white video camera for daylight use that weighs less than 6 ounces and is mounted on the modular weapon. The camera connects to the Land Warrior wiring harness, which supplies power and control signals to the camera while routing the video signal to the computer-radio subsystem. Additionally, the camera signal output can be reconfigured to feed directly to the integrated helmet assembly subsystem.

Laser rangefinder-digital compass mounts on the modular weapon. The laser rangefinder determines the distance to a target during specified atmospheric conditions to within 5 meters of the measured range over distances from 25 meters to 2500 meters. The digital compass compensates for the magnetic effects of the Land Warrior equipment and determines the azimuth to targets within 15 mils of the surveyed (grid) azimuth. The digital compass also determines the vertical angle to targets within 10 mils of the surveyed angle.

Computer-Radio Subsystem

The computer-radio subsystem serves as the primary electronics unit of Land Warrior and provides computation, control, and communications to improve the soldier's information collection, processing, and distribution capability. The computer-radio subsystem processes input from sensors and integrates the information via software and visual displays to enhance the soldier's combat effectiveness. The computer-radio subsystem consists of the following components: computer, soldier radio, squad radio, global positioning system (GPS) receiver, video processor, audio amplifier, communications security (COMSEC), remote input-pointing device, hand-held flat panel display, and keyboard.

Computer provides the processing capability to integrate sensors, communications, planning, messages, and warnings. In addition to such computer components as various input and output ports, memory, data storage, and an operating system, the computer

will contain electronic field manuals (FM's) and training manuals (TM's). The computer also has three removable devices that provide computer access, mission data, and mission data logs.

Soldier radio provides digital voice and data communications between members of a dismounted infantry squad. The soldier radio also transmits video images, thermal weapon sight pictures, combat graphics, and textual data. The soldier radio has a minimum communications range of 1.3 kilometers.

Squad radio assists in integrating Land Warrior command and control communications with higher levels of command, as well as transmitting and receiving data between squad leaders and the platoon leader and provides secure and non-secure voice and data communications single channel ground and airborne radio system (SINCGARS) compatibility in the single channel mode. The squad radio has a minimum communications range of 5 kilometers.

GPS receiver provides positioning and navigation data for use by Land Warrior. The GPS receiver provides both horizontal (location) and vertical (altitude) information.

Video processor translates video input signals generated by Land Warrior programs and sensors (such as the thermal weapons sight) for display on Land Warrior video display devices.

Audio amplifier mixes computer audio output and the audio output of the Land Warrior (and other external) radios and provides the output to the audio headset (see integrated helmet assembly subsystem below). The audio amplifier also controls the overall audio volume level and a means to provide emphasis (increased volume) to one audio signal.

COMSEC for both the soldier radio and the squad radio is provided by a removable encryption device. The encryption device for the squad radio is compatible with SINCGARS radio encryption devices.

Remote input-pointing device controls the movement of the cursor or pointer on the computer-radio subsystem. The device allows selection of menu options, activation of controls, and free-hand manipulation of the pointer for drawing overlays and graphics. It also includes the radio volume and push-to-talk controls.

Hand-held flat panel display provides a remote display of the information presented on the helmet-mounted sensor display. The display connects with and accepts signals from the computer.

Computer-radio subsystem keyboard has a standard QWERTY key layout with 12 programmable function keys. Key size and spacing is such that input with gloves is possible. A pointing device is also integrated into the keyboard.

Software Subsystem

The software subsystem controls communications, processes sensor data and images, displays maps and overlays, automates location reporting, and processes digital message traffic and reports. The software provides the control logic that enables dismounted soldiers and units to interface with the Army digitization architecture. The software also automates a wide range of unique infantry tasks, including range cards, direct fire planning, indirect fire planning, and hasty mine field reporting. The software subsystem consists of system software, application software, utility software, and performance enhancement software.

System software consists of the POSIX operating system, device drivers, X-Windows graphical user interface, help system, systems clocks, initialization, anti-virus protection, access control, soldier profiles, power management, and a macro programming language. The operating system provides the basic software for the computer. Taken as a whole, the system software manages the interaction of Land Warrior equipment, the soldier, and the computer-radio subsystem.

Application software integrates thermal weapons sight and video camera images, laser rangefinder-digital compass data, global positioning system information, and digital maps with software to increase soldier command and control, communications, lethality, mobility, and survivability.

Utility software consists of a word processing program, checklist program, event timers, and a diagnostics program.

Performance enhancement software consists of computer-based training delivery system, training management software, and a reference documentation display program. This software provides a means for soldiers to maintain proficiency during field deployments by managing and conducting individual training sessions and accessing reference material in the field.

Integrated Helmet Assembly Subsystem

The integrated helmet assembly subsystem integrates an improved ballistic helmet with a day visual display, a night display with image intensifier, and an audio headset (microphone-speaker) for communications. It also integrates ballistic laser eye protection and the XM-47 NBC protective mask. The lightweight ballistic helmet incorporates a modular design that allows soldiers to configure and operate any combination of integrated helmet assembly subsystem components together in an operationally viable configuration. The integrated helmet assembly subsystem interfaces with the computer-radio subsystem to obtain computer displays and audio for display or playback to the soldier. The integrated helmet assembly subsystem consists of a lightweight ballistic helmet with suspension, headset-microphone, ballistic laser eye protection, day display (helmet-mounted display), night display/I² display (also a helmet-mounted display), and the XM-47 protective mask.

Lightweight ballistic helmet provides protection for the head, temple, ear, and neck areas to reduce serious and lethal wounds caused by ballistic munitions. The helmet also serves as the mounting platform for the display and sensor components.

Headset-microphone provides a microphone and speaker(s) to enable the soldier to receive and transmit voice communications from the radios and computer-generated tones and voice output from the computer-radio subsystem.

Ballistic laser eye protection protects the soldier's eyes from both ballistic and laser threats and provides some environmental protection as well. The ballistic laser eye protection is interoperable with the other components of the integrated helmet assembly subsystem.

Day display incorporates a monochrome image source to display messages, sight reticles, video images, maps, graphics, and other data while the soldier wears the ballistic laser eye protection and chemical protective equipment.

Night display/I² increases the soldier's mobility at night via image intensification and image display. The I² subcomponent is capable of detecting a man-sized target at 75 meters minimum and enables soldiers to read maps in starlight. The night display incorporates a monochrome image source to display messages, sight reticles, video images, maps, graphics, and other data while the soldier wears the ballistic laser eye protection and chemical protective equipment.

XM-47 protective mask provides NBC protection for dismounted infantry soldiers. This mask has improved fit and provides the proper eye relief for integration with the other integrated helmet assembly subsystems. The mask contains a microphone for connection to the Land Warrior communications system.

Protective Clothing and Individual Equipment Subsystem

The protective clothing and individual equipment subsystem is the clothing that provides the soldier protection from battlefield hazards and the load-carrying equipment that is used to transport combat equipment during mission execution. The clothing and individual equipment are modular to facilitate reconfiguration to meet METT-T (mission, enemy, terrain, troops available, and time) conditions. The protective clothing and individual equipment subsystem consists of modular body armor, laser detector, environmental protective ensemble, modular load carrying equipment, NBC protective clothing, and combat ID transponder.

Modular body armor is a protective covering of the soldier's torso to reduce the number of serious and lethal wounds caused by battlefield ballistic munitions. A baseline vest and modular upgrade provides protection against fragmentation, handguns, and small arms. The modular body armor is functionally integrated with modular load-carrying equipment.

Laser detector detects laser pulses and alerts the soldier with an aural beep through the headset and a visual warning on the helmet-mounted display. The laser detector is

attached to (or built into) the soldier's clothing and/or equipment and does not interfere with combat-required equipment.

Environmental protective ensemble consists of the garments, handwear, and footwear required to comfortably protect soldiers from environmental conditions (including temperature, camouflage, relative humidity, rain, wind, and snow) that exist in -32° C to + 52° C climates and associated terrain.

Modular load-carrying equipment consists of mounting harness-infrastructure and an array of various sized compartments and attachment features to carry equipment including Land Warrior components, ammunition, squad assets, individual combat equipment and sustainment items. The modular load-carrying equipment consists of the following components: fighting load with modular patrol pack, frame-infrastructure, approach march pack, and sustainment pack. The modular load-carrying equipment does not interfere with any integrated helmet assembly subsystem components and is fully compatible with the modular body armor.

NBC protective clothing available for the Land Warrior System are the lightweight battledress overgarment for short term and hot weather use and the advanced battledress overgarment, which provides increased protection against biological and chemical agents. The advanced battledress overgarment also improves heat strain management for soldiers in mission-oriented protective posture (MOPP) IV. The XM-47 protective mask interfaces with the hoods on both garments.

Combat ID transponder provides battlefield identification (similar to IFF - identify friend or foe equipment on aircraft) for the Land Warrior soldier.

Wiring Harness

The wiring harness links the various Land Warrior System subsystems and components together for both power and data sharing. The wiring harness minimizes weight and tangling while maximizing strength.

The weights of the various pieces of equipment were then added to determine the equipment load for each soldier (squad member or squad leader) on each mission (night ambush, movement to contact-attack, reconnaissance) for these analyses. The weights listed below were then used in HOS to determine movement times for the various missions (see "Walk" HOS micromodel on page 16 of this report).

<u>Squad Member</u>	<u>Current equipment (lb)</u>	<u>Land Warrior (lb)</u>
Night ambush	63.6	78.2
Movement to contact-attack	60.1	74.7
Reconnaissance	72.0	82.1

<u>Squad Leader</u>	<u>Current equipment (lb)</u>	<u>Land Warrior (lb)</u>
Night ambush	66.9	87.0
Movement to contact-attack	66.9	86.6
Reconnaissance	78.8	97.2

In this study, every effort was made to minimize the amount of equipment carried by the individual. Depending on the mission, some of the above equipment could be jettisoned during combat (fighting load). Also, some equipment would not be required for all missions, but other required equipment might equal or exceed the weight not being taken. Lastly, the conditioning of the soldiers involved as well as improved load balance and placement may allow somewhat greater loads to be carried. Nevertheless, all of the current equipment loads as calculated above exceed FM 21-18's recommended weight of 48 pounds of "essential combat items of environmental protection, threat protection, and mission loads required to achieve success once in contact with the enemy...[Fighting Load]" (Commandant, U.S. Army Infantry School, 1990, Glossary-6). The Land Warrior equipment load, however, is of even greater concern, as all these loads exceed FM 21-18's recommended weight of 72 pounds of "items of environmental protection, threat protection, and mission load selected according to METT-T for approach marches where contact with the enemy is unlikely [Approach March Load]" (Commandant, U.S. Army Infantry School, 1990, Glossary-4).

LAND WARRIOR OPERATOR ANALYSES

The Land Warrior operator analyses compared the performance of an infantry squad member and squad leader with current equipment to that of the same squad member and squad leader equipped with Land Warrior subsystems. Two tools from HARDMAN III, MAN-SEVAL and PER-SEVAL were used to conduct the analyses.

MAN-SEVAL (manpower-based system evaluation aid) was used to assess workload. The workload assessment aid within MAN-SEVAL integrates two key technologies: MicroSAINT simulation and modified McCracken-Aldrich workload assessment methodology. MicroSAINT is used to construct and execute task network models that simulate Land Warrior operational procedures. Each task within the network is performed by the squad member or squad leader. The modified McCracken-Aldrich workload assessment methodology is used to assess four workload components (visual, auditory, cognitive, and psychomotor) for each operator. Each task is assigned a scaled value for the four workload components. When the simulation is run, operator workload is tracked over time and can be displayed graphically. Periods during which operators experience either high or low workload can be identified easily by comparing workload levels in each workload component separately or in combination with an established baseline level.

One of the other HARDMAN III aids called PER-SEVAL (personnel-based system evaluation aid) was used to assess crew performance in terms of time and accuracy. PER-SEVAL has three major components that are used to predict crew performance:

- ◆ Performance-shaping functions that predict task times and accuracies based on personnel characteristics (e.g., armed forces qualification test or AFQT) and estimated sustainment training frequencies.
- ◆ Stressor degradation algorithms that diminish task performance to reflect the presence of heat, cold, noise, lack of sleep, and mission-oriented protective posture (MOPP) gear.
- ◆ Simulation models that aggregate estimates of individual task performance and produce system performance estimates.

PER-SEVAL also is used to perform trade-off analyses among the variables that influence task performance and among the critical tasks that influence overall mission performance.

Description of Mission Model Differences Attributable to Equipment

In estimating performance time estimates and workload values for squad members or squad leaders (operators) equipped with Land Warrior equipment, adjustments were made in the task information for the currently equipped soldier. It is important to note that these changes represent “best guesses” about the effects of new equipment on performance. In some cases, the performance improvement brought about by new technology may be mitigated somewhat by the new equipment’s weight or the level of difficulty involved in its operation. All time changes are in minutes, and workload changes equate to values in the modified McCracken-Aldrich Scale on page 60 of this report. A summary of these changes follows:

Squad Member Missions

Night Ambush Mission

Maintain Modular Weapon Sights (4) task time reflects an increase due to the maintenance of four Land Warrior sights versus one for the squad member with current equipment. The “most likely” time increased from 2.00 to 5.00; similarly, “fastest” time increased from 1.00 to 2.00. The “(4)” notation refers to the four Land Warrior sights.

Maintain Land Warrior Equipment is used only by the Land Warrior squad member and accounts for the increased workload associated with maintaining complex equipment.

Mount Night Sight is used only by the squad member equipped with current equipment and accounts for the higher level of difficulty associated with using this equipment as compared to using Land Warrior equipment.

Zero Night Sight AN/PVS-4 to an M16A2 Rifle is used only by the squad member equipped with current equipment and accounts for the higher level of difficulty associated with using this equipment as compared to using Land Warrior equipment.

Tailor Land Warrior Equipment to Mission is used only by the Land Warrior squad member and accounts for the additional workload associated with selecting the appropriate mix of modular Land Warrior equipment for the mission.

Initialize Land Warrior Equipment is used only by the Land Warrior squad member and accounts for the additional workload associated with starting and performing checks of the various Land Warrior subsystems and components.

Use Signaling Techniques is used only by the squad member equipped with current equipment. It is assumed that the Land Warrior soldier would use the headset-microphone to communicate.

Check Equipment and Load task time was increased based on the additional complexity and amount of equipment carried by the Land Warrior squad member. The "most likely" time increased from 2.00 to 3.00; similarly, "fastest" time increased from 1.80 to 2.70.

Walk task times (day) increased because of the additional load carried by the Land Warrior squad member. The "most likely" time increased from 37.0 to 52.7; similarly, "fastest" time increased from 33.30 to 47.43. This change affected all tasks under the Move to Ambush Site function. These times were calculated using HOS.

Walk task times (night) increased because of the additional load carried by the Land Warrior squad member. The "most likely" time increased from 37.0 to 54.0; similarly, "fastest" time increased from 33.3 to 48.6. This change affected all tasks under the Move to ORP function. These times were calculated using HOS.

Communicate Using Computer-Radio is used only by the Land Warrior squad member and accounts for the increased workload inherent with the availability of constant radio communications.

Movement to Contact-Attack Mission

Use Signaling Techniques is used only by the squad member equipped with current equipment. It is assumed that the Land Warrior squad member would use the headset-microphone to communicate.

Walk task times increased because of the additional load carried by the Land Warrior squad member. The "most likely" time increased from 34.5 to 47.8; similarly, "fastest" time increased from 31.05 to 43.02. This change affected all tasks under the Move Tactically functions. These times were calculated using HOS.

Negotiate Obstacle task time was increased based on the additional load carried by the Land Warrior squad member. The "most likely" time increased from 2.67 to 2.93; similarly, "fastest" time increased from 2.40 to 2.64. These times were calculated using HOS.

Report Enemy Information requires more psychomotor workload because of the use of the soldier computer to send reports; thus, the psychomotor workload was increased from 1.0 to 2.2.

Query IFF is only used by the squad member equipped with Land Warrior equipment.

Verify All Enemy Have Been Neutralized requires less cognitive workload and more auditory workload because of the positive control offered by the soldier radio; thus, the cognitive workload was decreased from 4.6 to 3.7, and the auditory workload was increased from 0.0 to 1.0.

Report Ammo Status requires less cognitive workload because of the reports offered by the computer; thus, cognitive workload was decreased from 4.6 to 1.2. The psychomotor workload, however, was increased from 1.0 to 2.2 to account for the soldier entering the information into the report as opposed to verbally giving the information.

Communicate Using Computer-Radio is used only by the Land Warrior squad member and accounts for the increased workload inherent with the availability of constant radio communications.

Reconnaissance Mission

Put on NBC Gaiters task time was decreased because of expected design improvements over the current NBC boot. The “most likely” time decreased from 2.00 to 1.00; similarly, “fastest” time decreased from 1.80 to 0.90.

Use Signaling Techniques is used only by the squad member equipped with current equipment. It is assumed that the Land Warrior squad member would use the headset-microphone to communicate.

Walk task times increased because of the additional load carried by the Land Warrior squad member. The “most likely” time increased from 44.6 to 57.1; similarly, “fastest” time increased from 40.14 to 51.39. This change affected all tasks under the Move to ORP and Reconnoiter Zone using Fan Method functions. These times were calculated using HOS.

Disseminate Recon Information requires less cognitive workload because of the use of built-in reports; thus, the cognitive workload was decreased from 5.3 to 1.2.

Remove NBC Gaiters task time was decreased because of the improvements in the design over the old NBC boots. The “most likely” time decreased from .10 to .05; similarly, “fastest” time decreased from .09 to .05.

Locate Objective Area requires less cognitive and visual workload because of the precise navigational information offered by the GPS receiver; thus, the cognitive workload was decreased from 4.6 to 1.0 and the visual workload from 5.0 to 1.0.

Record Information on Terrain requires less psychomotor workload and more cognitive workload, as the information is recorded in the computer; thus, the psychomotor workload decreased from 4.6 to 2.2, and the cognitive workload increased from 0.0 to 1.0.

Communicate Using Computer-Radio is used only by the Land Warrior squad member and accounts for the increased workload inherent with the availability of constant radio communications.

Squad Leader Missions

Night Ambush Mission

Maintain Modular Weapon Sights (4) task time reflects an increase because of the maintenance of four Land Warrior sights versus one for the squad leader with current equipment. The "most likely" time increased from 2.00 to 5.00; similarly, "fastest" time increased from 1.00 to 2.00.

Maintain Land Warrior Equipment is used only by the Land Warrior squad leader and accounts for the increased workload associated with maintaining complex equipment.

Assign Equipment to Squad Members task time reflects an increase because of the quantity of Land Warrior equipment and its modular design. The "most likely" time increased from 8.00 to 10.00; similarly, "fastest" time increased from 5.00 to 8.00.

Mount Night Sight is used only by the squad leader equipped with current equipment and accounts for the higher level of difficulty associated with using this equipment as compared to using Land Warrior equipment.

Zero Night Sight AN/PVS-4 to an M16A2 Rifle is used only by the squad leader equipped with current equipment and accounts for the higher level of difficulty associated with using this equipment as compared to using Land Warrior equipment.

Tailor Land Warrior Equipment to Mission is used only by the Land Warrior squad leader and accounts for the additional workload associated with selecting the appropriate mix of modular Land Warrior equipment for the mission.

Initialize Land Warrior Equipment is used only by the Land Warrior squad leader and accounts for the additional workload associated with starting and performing checks of the various Land Warrior subsystems and components.

Use Signaling Techniques is used only by the squad member equipped with current equipment. It is assumed that the Land Warrior squad leader would use the headset-microphone to communicate.

Check Own Equipment and Load task time was increased based on the additional complexity and amount of equipment carried by the Land Warrior squad leader. The “most likely” time increased from 2.00 to 3.00; similarly, “fastest” time increased from 1.80 to 2.70.

Check Squad Members’ Equipment and load task time was increased based on the additional complexity and amount of equipment carried by the Land Warrior squad. The “most likely” time increased from 15.00 to 20.00; similarly, “fastest” time increased from 12.00 to 18.00.

Walk task times (day) increased because of the additional load carried by the Land Warrior squad leader. The “most likely” time increased from 39.7 to 64.0; similarly, “fastest” time increased from 35.7 to 57.6. This change affected all tasks under the Move to Ambush Site function. These times were calculated using HOS.

Walk task times (night) increased because of the additional load carried by the Land Warrior squad leader. The “most likely” time increased from 39.7 to 73.0; similarly, “fastest” time increased from 35.7 to 65.7. This change affected all tasks under the Move to ORP function. These times were calculated using HOS.

Send a Report Using Computer-Radio requires less cognitive workload and more psychomotor workload because of the use of the computer-radio; thus, the cognitive workload was decreased from 6.8 to 1.2, and the psychomotor workload was increased from 1.0 to 2.2.

Communicate Using Computer-Radio is used only by the Land Warrior squad member and accounts for the increased workload inherent with the availability of constant radio communications.

Movement to Contact-Attack Mission

Use Signaling Techniques is used only by the squad leader equipped with current equipment. It is assumed that the Land Warrior squad leader would use the headset-microphone to communicate.

Walk task times increased because of the additional load carried by the Land Warrior squad leader. The “most likely” time increased from 39.7 to 63.0; similarly, “fastest” time increased from 35.7 to 56.7. This change affected all tasks under the Move Tactically functions. These times were calculated using HOS.

Negotiate Obstacle task time was increased based on the additional load carried by the Land Warrior squad leader. The "most likely" time increased from 2.80 to 3.08; similarly, "fastest" time increased from 2.52 to 2.77. These times were calculated using HOS.

Report Enemy Information requires more psychomotor workload because of the use of the soldier computer to send reports; thus, the psychomotor workload was increased from 1.0 to 2.2.

Query IFF is used only by the squad leader equipped with Land Warrior equipment.

Fire Pre-planned Indirect Fire Targets requires less auditory workload because of the use of the computer; thus, auditory workload was decreased from 4.9 to 0.0.

Use Laser Rangefinder to Forward Target Location is used only by the squad leader equipped with Land Warrior equipment.

Call for Indirect Fire, Adjust Indirect Fire, and Direct Employment of Smoke each require less auditory workload due to the use of the computer; thus, auditory workload for each task was decreased from 4.9 to 0.0.

Recognize When Supporting Fires Have Been Lifted requires less cognitive workload because of the information received through the squad radio and computer. Auditory workload, however, is increased because of the use of the squad and soldier radios. Thus, cognitive workload decreased from 3.7 to 1.0 and auditory workload increased from 0.0 to 1.0.

Verify All Enemy Have Been Neutralized requires less cognitive workload and more auditory workload because of the positive control offered by the Squad and Soldier Radios; thus, the cognitive workload was decreased from 4.6 to 3.7, and the auditory workload was increased from 0.0 to 1.0.

Evaluate a Casualty requires more cognitive and visual workload because of the additional capabilities offered by on-line manuals and/or first aid procedures; thus, the cognitive workload was increased from 1.0 to 3.7, and the visual workload was increased from 1.0 to 3.7.

Report Ammo Status requires less cognitive workload because of the reports offered by the computer; thus, cognitive workload was decreased from 4.6 to 1.2. The psychomotor workload, however, was increased from 1.0 to 2.2 to account for the soldier entering the information into the report as opposed to verbally giving the information.

Communicate Using Computer-Radio is used only by the Land Warrior squad leader and accounts for the increased workload inherent with the availability of constant radio communications.

Reconnaissance Mission

Put on NBC Gaiters task time was decreased because of expected design improvements over the current NBC Boot. The “most likely” time decreased from 2.00 to 1.00; similarly, “fastest” time decreased from 1.80 to 0.90.

Use Signaling Techniques is used only by the squad leader equipped with current equipment. It is assumed that the Land Warrior squad leader would use the headset-microphone to communicate.

Walk task times increased because of the additional load carried by the Land Warrior squad leader. The “most likely” time increased from 51.91 to 78.80; similarly, “fastest” time increased from 46.72 to 70.90. This change affected all tasks under the Move to ORP and Reconnoiter Zone using Fan Method functions. These times were calculated using HOS.

Disseminate Recon Information requires less cognitive workload because of the use of built-in reports; thus, the cognitive workload was decreased from 5.3 to 1.2.

Remove NBC Gaiters task time was decreased because of the improvements in the design over the old NBC boots. The “most likely” time decreased from .10 to .05; similarly, “fastest” time decreased from .09 to .05.

Locate Objective Area requires less cognitive and visual workload because of the precise navigational information offered by the GPS Receiver; thus, the cognitive workload was decreased from 4.6 to 1.0 and the visual workload from 5.0 to 1.0.

Record Information on Terrain requires less psychomotor workload and more cognitive workload, as the information is recorded in the computer; thus, the psychomotor workload decreased from 4.6 to 2.2, and the cognitive workload increased from 0.0 to 1.0.

Record Information on Enemy Activity requires less psychomotor workload and more cognitive workload, as the information is recorded in the computer; thus, the psychomotor workload decreased from 4.6 to 2.2 and the cognitive workload increased from 0.0 to 1.0.

Communicate Using Computer-Radio is used only by the Land Warrior squad leader and accounts for the increased workload inherent with the availability of constant radio communications.

Description of Mission Model Differences Attributable to Tasks

When comparing the results obtained from the MAN-SEVAL analyses for the squad member with those obtained for the squad leader, it is important to note that although most tasks are contained in each of the mission models, there are some differences. These differences are usually attributable to the different leadership and tactical responsibilities of the squad member

as compared to the squad leader. Note that the tasks listed here reflect the differences between models that are attributable to the different responsibilities of the squad member and squad leader. These task differences do not, in themselves, reflect the differences caused by the presence of current or Land Warrior equipment. Following is a summary (listed by mission) of those differences that are not accounted for by equipment differences:

Night Ambush Mission

Squad Member Only Tasks

- Move as a member of a fire team
- Receive warning order
- Recognize ambush signal

Squad Leader Only Tasks

- Assign equipment to squad members
- Check squad members' equipment and load
- Check squad positions
- Conduct a leader's reconnaissance
- Conduct link-up by squad
- Conduct point ambush by squad
- Conduct the maneuver of a squad
- Control organic fires
- Determine location on the ground
- Issue a warning order
- Navigate from one point to another
- Orient a map
- Prepare squad sector sketch
- Receive squad status report
- Select a movement route

Movement to Contact-Attack Mission

Squad Member Only Tasks

- Maintain contact with other fire team members
- Move as a member of a fire team

Squad Leader Only Tasks

- Adjust indirect fire
- Call for indirect fire
- Conduct the maneuver of a squad
- Consolidate a squad
- Determine location on the ground
- Direct employment of smoke
- Fire pre-planned indirect fire targets
- Locate target for indirect fire
- Navigate from one point to another

Orient a map
Reorganize a squad
Select a movement route

Reconnaissance Mission

Squad Member Only Tasks

Maintain contact with adjacent team members
Move as a member of a fire team

Squad Leader Only Tasks

Conduct the maneuver of a squad
Determine location on the ground
Navigate from one point to another
Orient a map
Select a movement route

MAN-SEVAL Workload Analysis Steps

The primary analytical aid used to assess workload in this study was HARDMAN III's manpower-based system evaluation aid (MAN-SEVAL).

The steps for conducting the workload analysis using MAN-SEVAL follow:

1. Define conditions. The METT-T conditions during which the tasks must be performed are documented.
2. Develop function list. All the functions to be performed are listed. The functions are then placed in the sequence in which they would be performed during actual operations. The sequencing can be done in the following manner:
 - ◆ A function is always followed by only one other function.
 - ◆ A function is always followed by two or more functions.
 - ◆ A function is probablistically followed by another function.
 - ◆ A function repeats itself.
3. Develop task list. All tasks requiring human interaction are listed for each function. The tasks are also placed in sequence in the same manner as were the functions.
4. Identify crew positions. All operator positions are listed. In this effort, the operator was either the squad member or the squad leader.
5. Assign tasks to jobs. Two things are done. First, all operators who could perform each task are identified. This is determined by which operators have access to the controls, displays, etc., necessary to perform the task. After the operators capable of performing the

tasks are identified, the task is assigned to one specific operator. In this effort, all tasks were assigned to the squad member or to the squad leader, depending on the mission.

6. Define performance parameters. Several things are done. First, all tasks are assigned a most likely and fastest time to perform them. Then each task is assigned workload scale values for all four workload channels (i.e., visual, auditory, cognitive, and psychomotor). The actual interval scales values that were derived originally from the McCracken-Aldrich workload assessment methodology (McCracken & Aldrich, 1984) and later from the task analysis-workload (TAWL) methodology (Hamilton, Bierbaum, & Fulford, 1991) are shown in Figure 1. Additionally, in this step, high workload is defined mathematically. Traditionally, a workload value in any one channel that exceeds an absolute value of 7.0 is considered too high and should be reduced if possible.

7. Execute simulation run. The task network simulation model defined in Steps 2 and 3 is run using MicroSAINT.

8. Analyze results. Workload graphs that display each crew member's workload in each of the four channels, over time, are developed. Tasks causing high workload are displayed and can be reallocated to other crew members either automatically or manually. Summary reports (e.g., percentage of time each crew member is in a high workload condition) are also available.

MAN-SEVAL Workload Analysis Results

For purposes of this analysis, a state of "high workload" was defined as any point in time that a value of greater than 7.0 occurred in any one of the four channels (i.e., auditory, cognitive, psychomotor, and visual). Both the number of points where high workload occurred and the percentage of time in a high workload state were measured. It is important to note that there is no direct correlation between the "percent time in high workload" and the "number of points in high workload." The "percent time in high workload" is a function of the percentage of the total mission time that a high workload condition existed. The "number of points in high workload," on the other hand, is an indicator of how often conditions of high workload and low, or manageable, workload alternated. Table 7 shows the results for the current equipment squad member and the Land Warrior squad member for three types of missions. Separate workload profile graphs for each channel and mission are included in Appendix A.

Scale value	Descriptor
Visual Scale	
0.0	No Visual Activity
1.0	Visually Register-Detect (detect occurrence of image)
3.7	Visually Discriminate (detect visual difference)
4.0	Visually Inspect-Check (discrete inspection-static condition)
5.0	Visually Locate-Align (selective orientation)
5.4	Visually Track-Follow (maintain orientation)
5.9	Visually Read (symbol)
7.0	Visually Scan-Search-Monitor (continuous-serial inspection, multiple conditions)
Cognitive Scale	
0.0	No Cognitive Activity
1.0	Automatic (simple association)
1.2	Alternative Selection
3.7	Sign-Signal Recognition
4.6	Evaluation-Judgment (consider single aspect)
5.3	Encoding-Decoding, Recall
6.8	Evaluation-Judgment (consider several aspects)
7.0	Estimation, Calculation, Conversion
Auditory Scale	
0.0	No Auditory Activity
1.0	Detect-Register Sound (detect occurrence of sound)
2.0	Orient to Sound (general orientation-attention)
4.2	Orient to Sound (selective orientation-attention)
4.3	Verify Auditory Feedback (detect occurrence of anticipated sound)
4.9	Interpret Semantic Content (speech)
6.6	Discriminate Sound Characteristics (detect auditory differences)
7.0	Interpret Sound Patterns (pulse rates, etc.)
Psychomotor Scale	
0.0	No Psychomotor Activity
1.0	Speech
2.2	Discrete Actuation (button, toggle, trigger)
2.6	Continuous Adjustive (flight control, sensor control)
4.6	Manipulative
5.8	Discrete Adjustive (rotary, vertical thumbwheel, lever position)
6.5	Symbolic Production (writing)
7.0	Serial Discrete Manipulation (keyboard entries)

Figure 1. Modified McCracken-Aldrich scale values.

As Table 7 indicates, the Land Warrior squad member was in a state of high workload more than the current equipment squad member for all three missions. The primary reason for this was the addition of the computer-radio to the squad member's equipment. The additional attention demanded by that equipment was often enough to cause high workload. Although there is not a large difference in the percent time in high workload between the Land Warrior and current equipment squad members, there is a large difference in number of points in high workload. This reflects the frequent communications tasks required of the Land Warrior squad member.

Table 7

High Workload Summary for Squad Member

Mission	Current equipment squad member		Land Warrior squad member	
	Percent time in high workload	Number of points in high workload	Percent time in high workload	Number of points in high workload
Ambush	2.1	2	3.5	62
Attack	.1	2	1.7	47
Recon	32.7	5	34.6	152

In the ambush mission, high workload occurred for both the Land Warrior and current equipment squad member when there was a requirement to search the ambush site and process enemy personnel. An obvious solution to reduce the workload would be to assign dedicated individuals to process enemy prisoners and let the rest of the squad search the ambush site.

In the movement to contact-attack mission, high visual workload occurred for both the Land Warrior and current equipment squad member when there was a requirement to visually recognize the objective area and identify the maneuver route to the objective. It is probably not realistic to expect these two tasks to occur simultaneously. Most likely the squad member would do one and then the other or would shift his attention between the two tasks in an iterative manner.

In the reconnaissance mission, high overload occurred for both Land Warrior and current equipment squad member when there was a requirement to do any one of the following:

- ◆ Observe a sector and maintain contact with an adjacent position.
- ◆ Listen for enemy, maintain noise and light discipline, and communicate.
- ◆ Search for the enemy and follow an assigned route.

In the reconnaissance mission it is probably not a good strategy to have the squad member try to search for the enemy and try to navigate an assigned route. It may be better to have dedicated searchers and dedicated navigators.

After modeling and comparing the squad member with and without Land Warrior equipment, the squad leader (who has more command and control type tasks than the rifleman) was analyzed. Table 8 shows the results for the squad leader with Land Warrior equipment and with current equipment for three types of missions.

Table 8
High Workload Summary for Squad Leader

Mission	Current equipment squad leader		Land Warrior squad leader	
	Percent time in high workload	Number of points in high workload	Percent time in high workload	Number of points in high workload
Ambush	23.4	6	3.5	184
Attack	44.9	11	2.5	150
Recon	61.5	6	26.9	287

As Table 8 indicates, the current equipment squad leader was in a state of high workload for a higher percentage of time than was the Land Warrior squad leader for all three missions. As the data also indicate, the current equipment squad leader was in high workload for longer intervals than was the Land Warrior squad leader. The primary reason for this was the requirement for the current equipment squad leader to navigate and control the movement of the squad. The Land Warrior squad leader is able to rely more on the GPS for position location and also has radio contact with his squad members, which helps him control their movement without having to maintain visual contact.

From a workload perspective, the computer-radio gets mixed reviews. It reduces the squad leader's workload but increases the squad member's workload. It actually shifts some of the squad leader's workload (e.g., keeping visual contact with his squad and signaling

instructions) to the squad member (e.g., receiving and sending messages). Additionally, there is some cost associated with providing radio communications capabilities to all members of the squad. In particular, an individual's ability to hear things of importance in his immediate environment will be degraded. The improved communications and sensor (i.e., thermal) capabilities will serve to mitigate this impact, but this degradation may be significant in certain combat situations.

During the ambush mission, high workload occurred for the Land Warrior squad leader when he was required to communicate during any of the following:

- ◆ Issuing a warning order
- ◆ Receiving an operations order
- ◆ Participating in a sand table rehearsal
- ◆ Conducting a leader's reconnaissance
- ◆ Processing enemy personnel and equipment
- ◆ Preparing a squad sector sketch

During the ambush mission, signaling, moving, navigating, and controlling squad members caused visual and cognitive high workload for the current equipment squad leader. Also, searching the ambush site and processing enemy prisoners at the same time caused high overload for both Land Warrior and current equipment squad leaders.

For the attack mission, visually identifying the objective and a maneuver route caused high workload for the Land Warrior squad leader. Again, signaling, navigating, and controlling squad members caused visual and cognitive high workload for both Land Warrior and current equipment squad leaders. Also, moving to the final assault line caused high visual and cognitive workload for the current equipment squad leader.

In the reconnaissance mission, high workload occurred when there was

- ◆ A requirement for the Land Warrior to attend to both the squad net and the platoon net (this is also true for the other two missions);
- ◆ A requirement to communicate while observing enemy activity and observing terrain;
- ◆ A requirement for the squad leader to move, navigate, and direct the rest of the squad.

In summary, it would appear that the benefits, from a workload perspective, provided by Land Warrior equipment to the squad leader are substantial. This is particularly true for command, control, and navigation type tasks. These benefits outweigh the minor increases in workload experienced by the Land Warrior rifleman. It also appears that there will be a strong need to develop communications discipline within the squad net. Training should emphasize this discipline and provide procedures for exercising communications discipline.

PER-SEVAL Analysis Steps

The other primary analytical aid used to assess crew performance was another of the HARDMAN III tools: PER-SEVAL. The steps in using PER-SEVAL to analyze performance are as follow:

1. Describe tasks. Operator and maintainer tasks to be used in the analysis are defined. The tasks from the workload models used in MAN-SEVAL are imported into PER-SEVAL. When this is done, the tasks are automatically assigned a task type and a best and most likely time to complete the task. The tasks that are imported from the MAN-SEVAL workload models do not have performance accuracy values assigned to them. The task accuracy estimates must be assigned in this step.

2. Describe stressors. Stressor conditions that may cause degradation in performance of the operator and maintainer tasks can be chosen. The stressors can be applied to all the tasks performed by a crew member or selected tasks. The effect of applying stressors will be less accurate task performance and longer times to complete the tasks. The stressors used in this analysis were heat, cold, sustained operations, and MOPP.

3. Describe training frequency. Assumed sustainment training frequency for any or all the tasks can be assigned. Obviously, predicted performance will improve as training frequency increases. There are five levels of sustainment training frequency from which to choose. Training frequency was not analyzed in this effort.

4. Describe personnel characteristics. The ASVAB cut-off scores or the assumed armed forces qualification test (AFQT) levels for each of the operator and maintainer military occupational specialties (MOSs) can be adjusted. When a different ASVAB cut-off score or AFQT level is assigned, the distribution of personnel characteristics for the MOS changes. This, in turn, influences how well the personnel in the MOS will be able to perform various types of tasks. In general, the higher the ASVAB cut-off score or AFQT level, the better those in the MOS can be expected to perform.

5. Run performance simulation. The simulation models that replicate operational missions that a system and its crew would perform are executed. The simulation allows performance assessments at higher levels, rather than on an individual task-by-task basis.

6. Resolve performance discrepancies. An attempt is made to resolve any performance discrepancies. Essentially, there are four strategies for improving performance: increase sustainment training frequencies, improve the quality of the people performing the task, remove stressors, and change the type of task required by recommending design changes.

PER-SEVAL Analysis Results

Mission Performance Results

The three mission models (night ambush, movement to contact-attack, and reconnaissance) were run in PER-SEVAL with current equipment and then with Land Warrior equipment for both the squad member and the squad leader. Each mission model was run 50 times to obtain estimates for mission time and success rates (from both a statistical and an applied aspect, 50 runs is adequate to produce "good" estimates). The squad member results are presented below in Tables 9 through 11, and the squad leader results are presented in Tables 12 through 14.

Table 9

Squad Member Night Ambush Mission

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	100%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	100%	100%
Average mission time	242 minutes	285 minutes
Mission time criteria	250 minutes	300 minutes

Table 10

Squad Member Movement to Contact-Attack Mission

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	100%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	100%	100%
Average mission time	211 minutes	279 minutes
Mission time criteria	225 minutes	300 minutes

Table 11

Squad Member Reconnaissance Mission

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	100%
Mission success rate (accuracy)	100%	98%
Mission success rate (both)	100%	98%
Average mission time	222 minutes	260 minutes
Minimum mission time	250 minutes	275 minutes

Table 12

Squad Leader Night Ambush Mission

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	56%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	100%	56%
Average mission time	347 minutes	425 minutes
Mission time criteria	375 minutes	425 minutes

Table 13

Squad Leader Movement to Contact-Attack Mission

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	100%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	100%	100%
Average mission time	258 minutes	378 minutes
Mission time criteria	275 minutes	400 minutes

Table 14
Squad Leader Reconnaissance Mission

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	100%
Mission success rate (accuracy)	90%	100%
Mission success rate (both)	90%	100%
Average mission time	246 minutes	329 minutes
Minimum mission time	250 minutes	500 minutes

Heat Stressor Mission Performance Results

The three mission models (night ambush, movement to contact-attack, and reconnaissance) were run in PER-SEVAL with current equipment and then with Land Warrior equipment for both the squad member and the squad leader with the heat stressor applied. The assumed heat conditions applied to these missions were 95° F to 103° F and 91% to 100% humidity. This temperature range (95° to 103° F) corresponds to a menu selection of 113° to 130° F in PER-SEVAL. This discrepancy was identified as part of the validation, verification, & accreditation (VV&A) of HARDMAN III. This discrepancy has been addressed in the integrated MANPRINT tool (IMPRINT), which is the follow-on tool to HARDMAN III. The squad member results are presented below in Tables 15 through 17, and the squad leader results are presented in Tables 18 through 20.

Table 15
Squad Member Night Ambush Mission (Heat)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	0%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	0%
Average mission time	382 minutes	381 minutes
Mission time criteria	250 minutes	300 minutes

Table 16

Squad Member Movement to Contact-Attack Mission (Heat)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	0%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	0%
Average mission time	332 minutes	445 minutes
Mission time criteria	225 minutes	300 minutes

Table 17

Squad Member Reconnaissance Mission (Heat)

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	100%
Mission success rate (accuracy)	0%	0%
Mission success rate (both)	0%	0%
Average mission time	N/A	N/A
Minimum mission time	250 minutes	275 minutes

Table 18

Squad Leader Night Ambush Mission (Heat)

Performance measure	Current	Land Warrior
Mission success rate (time)	8%	0%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	8%	0%
Average mission time	478 minutes	509 minutes
Mission time criteria	375 minutes	425 minutes

Table 19

Squad Leader Movement to Contact-Attack Mission (Heat)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	4%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	4%
Average mission time	418 minutes	526 minutes
Mission time criteria	275 minutes	400 minutes

Table 20

Squad Leader Reconnaissance Mission (Heat)

Performance measure	Current	Land Warrior
Mission success rate (time)	100%	100%
Mission success rate (accuracy)	0%	0%
Mission success rate (both)	0%	0%
Average mission time	N/A	N/A
Minimum mission time	250 minutes	500 minutes

Cold Stressor Mission Performance Results

The three mission models (night ambush, movement to contact-attack, and reconnaissance) were run in PER-SEVAL with current equipment and then with Land Warrior equipment for both the squad member and the squad leader with the cold stressor applied. The assumed cold conditions applied to these missions were 14° F to -3° F and 0 to 10 knots of wind. (At -3° F and a wind of 10 knots, the equivalent temperature is approximately -28° F.) The squad member results are presented below in Tables 21 through 23, and the squad leader results are presented in Tables 24 through 26.

Table 21

Squad Member Night Ambush Mission (Cold)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	6%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	6%
Average mission time	260 minutes	308 minutes
Mission time criteria	250 minutes	300 minutes

Table 22

Squad Member Movement to Contact-Attack Mission (Cold)

Performance measure	Current	Land Warrior
Mission success rate (time)	20%	22%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	20%	22%
Average mission time	228 minutes	304 minutes
Mission time criteria	225 minutes	300 minutes

Table 23

Squad Member Reconnaissance Mission (Cold)

Performance measure	Current	Land Warrior
Mission success rate (time)	96%	8%
Mission success rate (accuracy)	100%	96%
Mission success rate (both)	96%	8%
Average mission time	241 minutes	283 minutes
Minimum mission time	250 minutes	275 minutes

Table 24

Squad Leader Night Ambush Mission (Cold)

Performance measure	Current	Land Warrior
Mission success rate (time)	60%	0%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	60%	0%
Average mission time	373 minutes	455 minutes
Mission time criteria	375 minutes	425 minutes

Table 25

Squad Leader Movement to Contact-Attack Mission (Cold)

Performance measure	Current	Land Warrior
Mission success rate (time)	14%	8%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	14%	8%
Average mission time	279 minutes	410 minutes
Mission time criteria	275 minutes	400 minutes

Table 26

Squad Leader Reconnaissance Mission (Cold)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	100%
Mission success rate (accuracy)	100%	96%
Mission success rate (both)	0%	96%
Average mission time	268 minutes	361 minutes
Minimum mission time	250 minutes	500 minutes

Sustained Operations Stressor Mission Performance Results

The three mission models (night ambush, movement to contact-attack, and reconnaissance) were run in PER-SEVAL with current equipment and then with Land Warrior equipment for both the squad member and the squad leader with the sustained operations stressor applied. The assumed sustained operations conditions applied to these missions were 24 to 47 hours of operations. The squad member results are presented below in Tables 27 through 29, and the squad leader results are presented in Tables 30 through 32.

Table 27

Squad Member Night Ambush Mission (Sustained Operations)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	0%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	0%
Average mission time	267 minutes	315 minutes
Mission time criteria	250 minutes	300 minutes

Table 28

Squad Member Movement to Contact-Attack Mission (Sustained Operations)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	2%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	2%
Average mission time	235 minutes	311 minutes
Mission time criteria	225 minutes	300 minutes

Table 29

Squad Member Reconnaissance Mission (Sustained Operations)

Performance measure	Current	Land Warrior
Mission success rate (time)	73%	78%
Mission success rate (accuracy)	27%	22%
Mission success rate (both)	0%	0%
Average mission time	284 minutes	298 minutes
Minimum mission time	250 minutes	275 minutes

Table 30

Squad Leader Night Ambush Mission (Sustained Operations)

Performance measure	Current	Land Warrior
Mission success rate (time)	6%	0%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	6%	0%
Average mission time	384 minutes	478 minutes
Mission time criteria	375 minutes	425 minutes

Table 31

Squad Leader Movement to Contact-Attack Mission (Sustained Operations)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	0%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	0%
Average mission time	298 minutes	440 minutes
Mission time criteria	275 minutes	400 minutes

Table 32

Squad Leader Reconnaissance Mission (Sustained Operations)

Performance measure	Current	Land Warrior
Mission success rate (time)	72%	100%
Mission success rate (accuracy)	28%	28%
Mission success rate (both)	0%	28%
Average mission time	291 minutes	385 minutes
Minimum mission time	250 minutes	500 minutes

MOPP Stressor Mission Performance Results

One mission model (reconnaissance) was run in PER-SEVAL with current equipment and then with Land Warrior equipment for both the squad member and the squad leader with the MOPP stressor applied. Of the three mission models, only reconnaissance addresses chemical contamination and the need for NBC protection. MOPP Level 4 conditions were assumed and applied to the current equipment reconnaissance mission. The effects of improved Land Warrior protective equipment were accounted for by applying MOPP Level 3 to the Land Warrior reconnaissance mission. The squad member results are presented in Table 33, and the squad leader results are presented in Table 34.

Table 33

Squad Member Reconnaissance Mission (MOPP)

Performance measure	Current	Land Warrior
Mission success rate (time)	2%	4%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	2%	4%
Average mission time	352 minutes	357 minutes
Minimum mission time	250 minutes	275 minutes

Table 34

Squad Leader Reconnaissance Mission (MOPP)

Performance measure	Current	Land Warrior
Mission success rate (time)	0%	74%
Mission success rate (accuracy)	100%	100%
Mission success rate (both)	0%	74%
Average mission time	398 minutes	484 minutes
Minimum mission time	250 minutes	500 minutes

Impacts of Raising Composite (CO) Cut-off Score Mission Performance Results

The three mission models (night ambush, movement to contact-attack, and reconnaissance) were run in PER-SEVAL with current equipment and then with Land Warrior equipment for both the squad member and the squad leader. The impact of raising the current ASVAB CO cut-off score for the infantryman from the current level of 90 through all possible scores (in increasing increments of 5) until and including 135 was explored. The decrease in mission times between the current level of 90 and the maximum level of 135 are displayed for the squad member in Tables 35 through 37 and for the squad leader in Tables 38 through 40.

Table 35

Squad Member Night Ambush Mission (cut-off score)

Performance measure	Current	Land Warrior
Average mission time (cut-off 90)	242 minutes	285 minutes
Average mission time (cut-off 135)	240 minutes	281 minutes
Percentage change	.8%	1%
Mission time criteria	250 minutes	300 minutes

Table 36

Squad Member Movement to Contact-Attack Mission (cut-off score)

Performance measure	Current	Land Warrior
Average mission time (cut-off 90)	211 minutes	279 minutes
Average mission time (cut-off 135)	209 minutes	277 minutes
Percentage change	1%	.7%
Mission time criteria	225 minutes	300 minutes

Table 37

Squad Member Reconnaissance Mission (cut-off score)

Performance measure	Current	Land Warrior
Average mission time (cut-off 90)	222 minutes	260 minutes
Average mission time (cut-off 135)	220 minutes	257 minutes
Percentage change	.9%	1%
Mission time criteria	250 minutes	275 minutes

Table 38

Squad Leader Night Ambush Mission (cut-off score)

Performance measure	Current	Land Warrior
Average mission time (cut-off 90)	347 minutes	425 minutes
Average mission time (cut-off 135)	343 minutes	419 minutes
Percentage change	1%	1%
Mission time criteria	375 minutes	425 minutes

Table 39

Squad Leader Movement to Contact-Attack Mission (cut-off score)

Performance measure	Current	Land Warrior
Average mission time (cut-off 90)	258 minutes	378 minutes
Average mission time (cut-off 135)	256 minutes	376 minutes
Percentage change	.7%	.5%
Mission time criteria	275 minutes	400 minutes

Table 40

Squad Leader Reconnaissance Mission (cut-off score)

Performance measure	Current	Land Warrior
Average mission time (cut-off 90)	246 minutes	329 minutes
Average mission time (cut-off 135)	243 minutes	327 minutes
Percentage change	1%	.5%
Mission time criteria	250 minutes	500 minutes

PER-SEVAL Analysis Conclusions

The degradation of mission performance because of environmental stressors can be understood best by looking at each stressor separately for the squad member and the squad leader outfitted with both current equipment and Land Warrior equipment.

Heat (95° F to 103° F and 91% to 100% humidity). Heat had the most significant impact of all the stressors on mission performance for both the squad member and the squad leader. Mission times were increased by an average of almost 57% for the squad member and almost 40% for the squad leader. Additionally, mission success rates decreased to zero for almost every mission. Lastly, the successful performance rates of tasks requiring high degrees of accuracy (i.e., "recognize and react to chemical agent") were significantly reduced. These results occur because of the effect of heat on task time and accuracy performance. For most of these tasks, degraded accuracy causes a task to be repeated with a corresponding increase in time. Other tasks, such as "decontaminate skin and personal equipment" cause the entire mission to fail if they are not performed to accuracy standards. These effects point out the possible serious burden that could be imposed on Land Warrior soldiers in a hot and humid environment because of their increased equipment loads. Efficient (high performance and light weight) cooling systems might be needed in such an environment. Alternatively, leaders may find it necessary to rapidly tailor the various loads that their soldiers carry, depending on mission conditions.

Cold (14° F to -3° F and 0 to 10 knots of wind). Cold had only a moderate effect on mission performance times. Mission times were increased by an average of 8% for both the squad member and the squad leader. The mission success rates in Tables 21 through 26 in this report indicate the success rate when the original time standard is used. The 8% average increase in mission time is a more revealing indicator of the moderate effect of the cold stressor.

Sustained operations (24 to 47 hours of operations). Sustained operations had a moderate effect on mission performance times. Mission times were increased by an average of 14% for the squad member and by 15% for the squad leader.

MOPP (mission-oriented protective posture Level 4). MOPP had a very significant impact on mission performance times. MOPP Level 4 was applied to the current equipment reconnaissance missions, while MOPP Level 3 was applied to the Land Warrior reconnaissance missions. In this way, the improved Land Warrior protective equipment was accounted for. Mission times were increased by an average of 48% for the squad member and by 64% for the squad leader.

Cut-off score. Raising the ASVAB cut-off score of the rifleman had very little impact on the performance of any mission. Mission success rates were improved only slightly for two missions, and mission performance times decreased an average of only 1%. This is to be expected for the squad member as his tasks are predominantly psychomotor (physical) and visual in nature. The squad leader, on the other hand, has a higher percentage of tasks that are cognitive or involve decision making. These tasks, however, are of relatively short duration; so the improved performance of these tasks brought about by raising the squad leader's ASVAB cut-off score has little impact on the overall mission.

LAND WARRIOR MAINTENANCE ANALYSIS

Land Warrior Baseline Comparison System

The Land Warrior maintenance analysis is composed of two major sections: Land Warrior baseline comparison system (BCS) and Land Warrior manpower capabilities (MANCAP) analysis. In the first section, a BCS for the Land Warrior System is documented. The BCS is used to analyze the MPT resource requirements of a planned new system. As noted in MIL-STD-1388-1A, Military Standard Logistics Support Analysis (Department of Defense, 1983), the BCS is a notional system construct for performing analyses and is not intended to be a fully integrated design; rather, the BCS is a composite of existing systems, subsystems, and other system components (such as support and test equipment) that perform the new system functions and approximate new system performance requirements and design.

The BCS is a benchmark based in the present, in which key supportability requirements are known. Some of these known parameters include reliability and maintainability (R&M), MOS skills and knowledge, MOS characteristics, and MOS training requirements. Comparisons between the new system and the BCS are made throughout the acquisition process as the new system design evolves and design alternatives are considered. Comparison of the BCS to the

proposed system requirements in the early phases of the acquisition process helps identify technical risks. In later phases, comparison of the contractor design alternatives to the BCS helps identify risk areas (i.e., areas for which required improvements are significantly better than what is currently being achieved). Comparison of the BCS and the new system can also identify sources of existing supportability high drivers, which can be most effectively avoided early in the design process.

Construction of the BCS involves evaluating candidate existing systems, subsystems, and other system components in terms of three criteria:

1. Performance and use characteristics,
2. Design similarity, and
3. R&M data quality.

This approach ensures that the BCS represents a construct that most closely resembles the performance and design characteristics of the new system, while ensuring that the R&M data (a key driver of MPT resources) are complete and accurately represent historic requirements.

Table 41 documents the BCS that was developed for the Land Warrior System. The BCS accounts for all Land Warrior subsystems and components as listed on pages 38 through 49 of this report with the exception of individual software components, NBC protective clothing, and combat ID transponder which are assumed to have no maintenance workload. The fields that are used in the table are as follow:

Control Number - Shows the relationships between primary Land Warrior subsystems (i.e., Weapon Subsystem) and their components (e.g., modular weapon, close combat optic, etc.).

Nomenclature - The name of the particular Land Warrior subsystem or component.

BCS Candidate - The general name of the fielded equipment that will represent the Land Warrior equipment in this portion of the analysis.

BCS Designation - The specific item type that will be used.

BCS Line Item # (LIN) - An identification number used by the U.S. Army to identify a particular item.

Mean Time Between Failures (MTBF) - The time (hours, rounds, or lases) between maintenance failures.

Frequency - The inverse of the MEAN TIME BETWEEN FAILURES number that provides the probability of maintenance failure per hour of operation, round fired, or lase fired.

Org Mos - Organizational maintenance military occupational specialty.

MTTR Org - Mean time to repair the item at the organizational maintenance level.

DS MOS 1/DS MOS 2 - Direct support maintenance military occupational specialty (accounts for different types of repair personnel).

MTTR DS - Mean time to repair the item at the direct support maintenance level.

GS MOS - General support maintenance military occupational specialty.

MTTR GS - Mean time to repair the item at the general support maintenance level.

Comments - The source and rationale for the information in the table for a given item.

In some cases, because of the configuration of the Land Warrior equipment, maintenance requirements for some components are accounted for by other components or subsystems. For example, the maintenance associated with the video processor component of the computer radio is accounted for by the maintenance of the computer itself. Also, some components of the Land Warrior System are assumed to have no maintenance workload associated with them. For these components, the vast majority of maintenance that is performed is by the operator and involves only simple actions such as cleaning and operator inspections. In cases when the MOS listed for a particular component would not normally be available for maintenance operations in an infantry organization, suitable replacement MOSs are listed in parentheses. The MOSs listed in this table are

- 29E Radio Repairer
- 29J Telecommunications Terminal Device Repairer
- 31U Signal Support Systems Specialist
- 39E Special Electronics Devices Repairer
- 45B Small Arms-Artillery Repairer
- 45G Fire Control Repairer
- 63J Quartermaster and Chemical Equipment Repairer
- 67R AH-64 Attack Helicopter Repairer
- 68N Avionic Mechanic
- 92Y Unit Supply Specialist (*Department of the Army, 1994*)

Table 41

Land Warrior Baseline Comparison System

Control Number	Nomenclature	BCS candidate	BCS designation	BCS line item No.	Mean time (hours, rounds, or lases) between failures	Frequency	Org MOS	MTTR Org (hours)	DS MOS 1	DS MOS 2	MTTR DS (hours)	GS MOS	MTTR GS	Comments
1.1.1	Weapon	N/A												
1.1.1.1	Modular weapon	Rifle	M16A2	Z03737	8000 rounds	.000125/ round	92Y	.5	45G		.5	45B	N/A	Reliability, and availability, and maintainability (RAM) data source: MIL-R-63997B (U.S. Army Armament, Munitions and Chemical Command, 1993).
1.1.1.2	Thermal weapons sight	Lightweight thermal weapon sight	AN/PAS-13	Z38272	500	.002	31U	.0833	39E		.5			RAM data source: Night Vision and Electro-Optics Directorate. BCS component called out in LW System Specification (U.S. Army Communications Electronics Command, 1995).
1.1.1.3	Close combat optic	None												Assume no maintenance required. Item is an illuminated sight-engineering analysis
1.1.1.4	Infrared laser aiming light	Night vision sight	AN/PVS-4	N04732	2000	.0005			39E		.5	39E	N/A	RAM data source: Night Vision and Electro-Optics Directorate. BCS Item used in SIPE testing.
1.1.1.5	Visible laser aiming light	See 1.1.1.4												Workload for this item is accounted for in Component 1.1.1.4.

1.1.1.1.6	Laser rangefinder-digital compass	Laser infrared observation set	AN/PVS-6	Z58615	40000 lases	.000025/ Lase	31U	.3	45G	.5			Mini-eye-safe laser infrared observation sight (MELIOS). Data source is Night-Vision and Electro-Optics Directorate.
1.1.1.1.7	Video camera	Pilot's night vision imaging system	AN/AVS-6	N06420	7500	.000133	68N (31U)	.3	39E	.5	39E	N/A	Video camera data not available. Item selected as surrogate for function and complexity.
1.1.2	Computer-radio	N/A											
1.1.2.1	Computer	Computer mortar ballistic	AN/PYC-1	C60294	16585	.0000603			29J	.5			RAM data source: MIL-C-70489 (U.S. Army Armament, Munition and Chemical Command, 1986).
1.1.2.10	Audio amplifier	See 1.1.2.1											Workload for this item is accounted for in Component 1.1.2.1.
1.1.2.11	Video processor	See 1.1.2.1											Workload for this item is accounted for in Component 1.1.2.1.
1.1.2.2	Soldier radio	Radio set SINGGARS	AN/PRC-126	R55336	786	.00127	31U	.5	29E	1.7	29E	N/A	RAM Data source: <u>Maneuver Control System (MCS) Integrated Logistics Support Plan (ILSP) (Project Manager Operations Tactical Data Systems, 1992).</u>
1.1.2.3	Soldier radio COMSEC	See 1.1.2.2											Workload for this item is accounted for in Component 1.1.2.2.
1.1.2.4	Squad radio	Radio Set SINGGARS	AN/PRC-126	R55336	786	.00127	31U	.5	29E	1.7	29E	N/A	RAM Data source: <u>Maneuver Control System (MCS) Integrated Logistics Support Plan (ILSP) (Project Manager Operations Tactical Data Systems, 1992).</u>

1.1.2.5	Squad radio COMSEC	See 1.1.2.4											Workload for this item is accounted for in Component 1.1.2.4.
1.1.2.6	Global positioning system receiver	Precision lightweight GPS receiver (PLGR)	AN/PSN-11		11514	.00008685	31U	.167	29E	.5	29E	N/A	BCS item is government-furnished equipment (GFE) for L/W early operational experimentation (EOE). RAM data from Night Vision and Electro-Optics Directorate.
1.1.2.7	Remote input-pointing device	See 1.1.2.1											Workload for this item is accounted for in Component 1.1.2.1.
1.1.2.8	Hand-held flat panel display	See 1.1.2.1											Workload for this item is accounted for in Component 1.1.2.1.
1.1.2.9	Keyboard	See 1.1.2.1											Workload for this item is accounted for in Component 1.1.2.1.
1.1.3	Software	None											Assume no workload.
1.1.4	Integrated helmet assembly	Helmet integrated		Z33570	7000	.000143	67R (31U)	.5	29E	1.7			RAM data source: Manpower Authorization Requirement Criteria (MARC) Data Base (U.S. Army Force Integration Support Agency, 1994).
1.1.4.1	Ballistic helmet	See 1.1.4											Workload for this item is accounted for in Component 1.1.4.
1.1.4.2	Headset-microphone	See 1.1.4											Workload for this item is accounted for in Component 1.1.4.
1.1.4.3	Ballistic laser eye protection	None											Assume no workload.
1.1.4.4	Day display	See 1.1.4											Workload for this item is accounted for in Component 1.1.4.

MANCAP Analysis of the Land Warrior System

The second portion of the maintenance analysis of the Land Warrior System was conducted using the MANCAP for Windows tool. MANCAP enables users to evaluate maintenance requirements for a proposed new system by creating a model of a new system, the unit that will be using that new system, and the combat scenario in which the system will be used. In addition, various model parameters, from specific component maintenance characteristics, such as the mean time between failures, to the impact of combat and damaged system components can be analyzed.

The BCS discussed in the previous section of this report serves as the foundation of this MANCAP analysis. Two different principal scenarios were investigated. In the first, or baseline scenario, the components in the BCS were used in MANCAP, as listed, with various maintenance actions taking place at both the organizational and direct support levels (no general support maintenance actions are listed in the BCS).

In the second, or objective scenario, all components except the modular weapon are assumed to have been "designed for discard, rather than repair by higher echelon maintenance units" (U.S. Army Communications and Electronics Command, 1994b, p. 32). The Land Warrior System's modular weapon is a modified M16 with the addition of four mounting rails and is known as the M16A2E4. The current maintenance system is already staffed to adequately support the maintenance of the M16 series rifle and should be able to similarly support the Land Warrior modular weapon. Thus, there should be little change in either the maintenance requirements or the maintenance concept used to maintain this particular piece of equipment. As for the maintenance of the other Land Warrior components, "[t]here shall be no increase in force structure, and no new MOS or personnel requirements generated above current unit TOE-TDA [Table of Organization & Equipment-Table of Distribution & Allowances] authorizations by the fielding of [Land Warrior]" (U.S. Army Communications and Electronics Command, 1994b, p. 32). As a result, the objective scenario only allows for the maintenance of the modular weapon and assumes that all other maintenance failures will be addressed through the replacement of the failed component through supply channels.

Together, these two scenarios provide insight into the possible impacts of both the maintenance of the Land Warrior components themselves and of the way in which they will either be repaired (baseline scenario) or replaced (objective scenario). The remainder of this portion of the analysis will address the steps that are taken in conducting a MANCAP analysis, the general and specific assumptions made for this analysis, and the results of the MANCAP maintenance analysis.

MANCAP Analysis Steps

This section provides an overview of the general steps taken in conducting this MANCAP analysis. It is important to note that this order is not imposed by MANCAP.

Step 1: Developing the component maintenance parameters. Each system being analyzed must be broken into its major subsystems, and then those subsystems must be broken into their components. For each of the components, the following parameters must be entered:

- ◆ The maintenance type (preventative or corrective).
- ◆ The MOS that will perform the maintenance.
- ◆ How often the maintenance will be required.
- ◆ How long it will take to perform the maintenance.
- ◆ The probability that the need for this maintenance will cause the system to abort an ongoing mission.

Step 2: Developing the combat profile. The second step in MANCAP is to define the parameters that describe how the combat is to be modeled. It is important to note that MANCAP is not a combat modeling tool. The parameters that are entered in this step serve only to determine the maintenance burden imposed by combat and combat damage. The combat parameters that need to be entered to complete this step include

- ◆ Defining the operational mode summary or mission profile.
- ◆ Developing a sequence of combat activities for the simulation.
- ◆ Defining rules for when non-abort repair actions can occur during combat.
- ◆ Defining the survivability of the system.
- ◆ Defining the probability of combat damage for each component given a combat hit and identifying whether the contact team can perform the maintenance.

Step 3: Identifying the unit organization. In this step, details about the type and size of the unit being modeled are identified. This includes the number of systems in the unit, the unit level, and the number of direct maintenance man-hours available per work shift at each maintenance level. The manpower resources available for each unit level also have to be entered. Three substeps must be taken to identify the unit organizations:

- ◆ Identify the unit configuration in terms of size, type, level, and direct maintenance man-hours available at each maintenance level.
- ◆ Identify the MOS and number for each crew position for the system.
- ◆ Identify the number of each MOS at each maintenance level and for the contact team.

Step 4: Developing the simulation scenario. In this step, the conditions during which the maintenance simulation model is to be executed are described. The scenario includes the following items:

- ◆ Identify scenario parameters, such as how long the simulation is to run, whether there is combat damage, how often to replace killed systems, and the parameters related to the use of maintenance contact teams.

- ◆ Identify travel time between maintenance levels.
- ◆ Identify the probability that spare parts are available and the wait time for any unavailable parts.

Step 5: Execute maintenance simulation. MANCAP uses the information from Steps 1 through 4 to create and execute a simulation model in this step.

Step 6: View simulation results. In this step, the results of the model's execution can be seen. MANCAP reports include the following:

- ◆ The number of operational personnel required.
- ◆ A histogram of headcount requirements for each MOS and maintenance level.
- ◆ The average number of each MOS required at each level.
- ◆ The maximum number of each MOS that was ever needed.
- ◆ The total man-hours required for each MOS and maintenance task.
- ◆ Daily ranges of maintenance man-hours for each MOS and level.
- ◆ The use of each MOS by maintenance level.
- ◆ Inherent, achieved, operational, and readiness availability.
- ◆ System maintainability.
- ◆ Combat damage by day, by combat hit, or by component.

Land Warrior MANCAP General Assumptions

Before the Land Warrior MANCAP analysis began, a number of assumptions were made to establish the general parameters of the study:

- ◆ This analysis addressed the maintenance requirements of a light infantry battalion in combat for 120 days. A light infantry battalion was chosen as a representative unit because of its rather limited current maintenance requirements; therefore, the addition of the Land Warrior System to such an organization would have a more significant impact on this unit's logistics than it would on a mechanized infantry battalion with its substantial inherent maintenance and transportation capabilities.

- ◆ Four hundred fifty-three Land Warrior Systems were used within the battalion. This number was based on the number of combat personnel at Strength Level 1 in the three rifle companies in the battalion (TOE 07017L0) and in the battalion headquarters and headquarters company (HHC) (TOE 07016L0) (Department of the Army, 1993).

- ◆ Every soldier in the battalion was outfitted with every item of Land Warrior equipment that is listed in the BCS. This worst case scenario was necessary because of the constraints of the MANCAP tool.

- ◆ Supervisory personnel who are responsible for managing maintenance workload and other administrative tasks were not accounted for in the model.
- ◆ No maintenance contact teams were used. This assumption accounted for a worst case scenario and eliminated potential discrepancies across units that might have different contact team arrangements.
- ◆ All replacement components were assumed to be available for use 100% of the time.
- ◆ There was no travel time for the movement of damaged or broken components between different maintenance levels (operator to organizational, and organizational to direct support).

Land Warrior MANCAP Modeling Decisions

At nearly every step of the MANCAP modeling process, specific decisions concerning the nature of the analysis were made. These decisions account for both the requirements of the analysis and the data needs of MANCAP itself. The documentation of these decisions is in the same order as the MANCAP analysis steps presented above. The assumptions listed above account for all Step 4 activities.

Step 1: Developing the component maintenance parameters. This step involved establishing the bulk of the maintenance information about the Land Warrior System, its subsystems, and their components. It was assumed that all maintenance actions would be corrective. Specific maintenance information concerning mean operational units between failures and mean times to repair were taken from Table 41 of this report, with no changes. To account for combat damage (see Step 2) the software subsystem (1.1.3 in Table 41) was assumed to have the same maintenance parameters as the computer (1.1.2.1 in Table 41).

Step 2: Developing the combat profile. Four different combat missions were used in the Land Warrior MANCAP analysis: attack, defense, reserve, and unengaged. Unengaged can best be thought of as an administrative period during which the unit can rest and refit. Field Manual 101-5-1, Operational Terms and Symbols defines the other combat missions used in this analysis as follows:

- ◆ Attack - "An offensive action characterized by movement supported by fire." (Department of the Army, 1985a, p. 1-8)
- ◆ Defense - "A coordinated effort by a force to defeat an attacker and prevent him from achieving his objectives." (Department of the Army, 1985a, p. 1-23)
- ◆ Reserve - "[T]hat portion of a force withheld from action at the beginning of an engagement so as to be available for commitment at a decisive moment." (Department of the Army, 1985a, p. 1-62)

These four different combat missions were combined by subject matter experts (SMEs) to form the standard mission month in Table 42 for use in this MANCAP analysis.

Table 42

MANCAP Standard Mission Month

Days	Mission
1-2	Reserve
3	Attack
4-6	Defense
7	Attack
8-9	Reserve
10-11	Attack
12-14	Defense
15	Unengaged
16-17	Reserve
18-19	Attack
20-22	Defense
23	Reserve
24-25	Defense
26	Attack
27-28	Reserve
29-30	Defense

This standard mission month was used for four consecutive iterations to form a single 120-day period of operations. All Land Warrior components, except the modular weapon and the laser rangefinder were assumed to be in operation for the entire duration of each mission. To simulate usage of the modular weapon and the laser rangefinder, different firing rates were established for each mission. No rounds were fired during the unengaged mission:

- ◆ Attack - 124 rounds (first day), 67 rounds (all subsequent days)
- ◆ Defense - 148 rounds (first day), 90 rounds (all subsequent days)
- ◆ Reserve - 24 rounds (assumed) (*Department of the Army, 1987*)

For each instance of a mission, SMEs defined the probability of being hit and being able to continue the mission. In this analysis, attack, defense, reserve and unengaged each had one set of parameters. First, the probability of a combat hit per hour was set. If a hit did occur, the probability that the hit was so severe that the system could not be repaired (fatal hit) was entered. For this analysis, a fatal hit was defined as a system being so severely damaged as to not be repairable, usable for the remainder of the mission, or capable of being broken into

usable components. Second, the time to replace this fatally hit system was entered. Alternatively, if the system received a hit that could be repaired, the probability that it was able to continue was entered. For this analysis, the probability that the Land Warrior soldier with damaged equipment would continue with his mission was set at 100%. This allows for the soldier, with some degraded capabilities, to complete the mission in MANCAP as he would in actual combat. Likewise, maintenance repairs are only conducted during the reserve and unengaged missions. This accounts for the transportation difficulties that light infantry organizations often experience. Table 43 summarizes these parameters.

Table 43
Mission Combat Hit Parameters

	Attack	Defense	Reserve	Unengaged
Combat hit-hour probability	1%	0.7%	0.1%	0%
Fatal hit probability	90%	90%	90%	90%
Replacement time (hours)	24	24	24	24
Repair probability	10%	10%	10%	10%
Continue mission probability	100%	100%	100%	100%
Abort mission probability	0%	0%	0%	0%

The last parameter that was established in this step was the probability of combat damage by component. Each Land Warrior component is assumed to have a ground damage percentage associated with it. These percentages account for the maintenance burden imposed by combat damage, as shown in Table 44. Probabilities of combat hit are based on SMEs' opinions, relative sizes and locations of components, and wound distribution data from battle injuries that occurred during the Falklands, Panama, and Desert Storm operations (Gauker, Anderson, & Blood, 1994).

Step 3: Identifying the unit organization. For both the baseline scenario and the objective scenario, it was assumed that all maintainers were available for one 24-hour shift as needed. This accounts for the urgency of the repair of combat-critical pieces of equipment. The available maintenance personnel are listed in Table 45. It is important to note that the personnel listed for organizational are those that are actually available to perform maintenance. For example, at the organizational level (the light infantry battalion), there are nine 92Y personnel. Of these, however, only four are available to repair weapons (armorers). In addition, the personnel listed for direct support include all personnel of that particular MOS who are available to support all units within a light infantry division. Thus, the actual availability of support personnel at direct support would be less than depicted here.

Table 44

Probability of Combat Hit

Subsystem	Component	Probability of combat hit (%)
Weapon subsystem	Modular weapon	3
	Thermal weapons sight	.5
	Close combat optic	.5
	IR laser aiming light	.5
	Visible laser aiming light	.5
	Laser rangefinder-digital compass	.5
	Video camera	.5
Computer-radio	Computer	1
	Soldier radio	.5
	Squad radio	.5
	GPS receiver	.5
	Video processor	.5
	Audio amplifier	.5
	Soldier radio COMSEC	.5
	Squad radio COMSEC	.5
	Remote input-pointing device	.5
	Hand-held flat panel display	.5
	Keyboard	.5
Software	3	
Integrated helmet assembly	Lightweight ballistic helmet	5
	Headset-microphone	.5
	Ballistic laser eye protection	.5
	Day display	.5
	Night display/I ²	.5
	XM-47 protective mask	3
Protective clothing and individual equipment	Modular body armor	15
	Laser detector-combat ID transponder	5
	Environmental protective ensemble	15
	Modular load-carrying equipment	5
	NBC protective clothing	15
	Lightweight battledress uniform	15
Wiring harness	5	

Table 45

Maintenance MOS Information

MOS	Description	Organizational	Direct Support
29E10	Radio repairer	0	7
29E20	Radio repairer	0	5
29E30	Radio repairer	0	2
29J10	Telecommunications terminal device repairer	0	2
29J20	Telecommunications terminal device repairer	0	1
29J30	Telecommunications terminal device repairer	0	1
31U10	Signal support systems specialist	1	0
39E10	Special electronics device repairer	0	8
39E20	Special electronics device repairer	0	2
39E30	Special electronics device repairer	0	1
45G10	Fire control repairer	0	1
92Y10	Unit supply specialist	4	0

The information in Table 45 has been taken from TOE Published Tables, Section I and II (Department of the Army, 1993). The listing includes information from the following units:

TOE 07016L000 Headquarters and Headquarters Company
Infantry Battalion,
Light Infantry Division

TOE 07017L000 Rifle Company
Infantry Battalion,
Light Infantry Division

TOE 43046L000 Headquarters and Headquarters Company
Maintenance Battalion, Support Command,
Light Infantry Division

TOE 43048L000 Main Support Company
Maintenance Battalion, Support Command
Light Infantry Division

Land Warrior MANCAP Analysis Results

This section explains the simulations that were conducted using MANCAP and presents results from those simulations. In addition, the results are discussed, and conclusions and recommendations are presented.

Simulation Procedures

Two different situations were simulated using MANCAP. The first situation was a simulation of the BCS under the baseline maintenance concept, which assumes that corrective maintenance for failed or damaged equipment would be performed at organizational and direct support levels. It further assumes that current MOSs in the battalion and division maintenance organizations would perform the maintenance.

The second situation was simulation of the BCS under the objective maintenance concept. This concept assumes that all failed or damaged equipment (with the exception of the rifle) would be replaced by the infantryman and no repairs would be made.

In both situations, 120 days of combat were simulated with a positive probability of combat damage to the equipment. A light infantry battalion (TOE 07016L000) with 453 fully equipped Land Warrior soldiers was simulated for both situations. It was assumed that each soldier had all of the Land Warrior equipment described in Table 41.

Simulation Results

This section presents the results from the simulations described above. Table 46 shows the total number of maintenance actions required and the total maintenance man-hours expended for the two different simulations (i.e., baseline and objective maintenance concepts).

Table 47 shows total maintenance man-hours by MOS for the baseline and objective maintenance concepts.

Table 46

Maintenance Summary for Baseline and Objective Maintenance Concepts

Maintenance concept	Total number of maintenance actions	Total number of maintenance man-hours	Maintenance man-hours per action
Baseline	18407	12815.37	.696
Objective	13085	3415.62	.261

Table 47

Maintenance Man-Hours by MOS for Baseline and Objective Maintenance Concepts

MOS	Baseline ORG	Baseline DS	Objective ORG	Objective DS
11B	0	0	1744.1	0
29E	0	4735.1	0	0
29J	0	58.5	0	0
31U	3258.3	0	0	0
39E	0	1421.0	0	0
45B	0	0	0	0
45G	0	1688.0	0	0
63J	0	0	0	0
67R	0	0	0	0
68N	0	0	0	0
92Y	1656.5	0	1671.5	0

Table 48 shows the number of maintenance actions and man-hours for each subsystem and maintenance level (i.e., organizational and direct support) for the baseline and objective maintenance concepts.

Discussion of Simulation Results

The first and most obvious conclusion that can be made from looking at the results in the previous section is that the objective maintenance concept requires about one quarter of the maintenance man-hours that the baseline concept requires. This, of course, is by design since the objective concept has no direct support maintenance and is based on a remove and replace policy.

The supply issues that the objective concept may raise have not been addressed. Those issues are by no means trivial since the simulation indicates that over a 120-day period, a light infantry battalion could have 13,085 incidents that require a decision on whether to remove and replace an item. On a daily basis, this equates to about 35 per company, 110 per battalion, and 1000 per division.

Table 48

Maintenance Requirements by Subsystem and Maintenance Level for Baseline and Objective
Maintenance Concepts

Nomenclature	Number of maintenance actions				Number of maintenance man-hours			
	Baseline		Objective		Baseline		Objective	
	Org	DS	Org	DS	Org	DS	Org	DS
Weapon								
Modular weapon	3313	3277	6613	0	1656.5	1638.5	3306.5	0
Thermal weapon sight	1963	1938	1965	0	1635.2	969	32.8	0
Close combat optic	16	0	8	0	0	0	.13	0
Infrared laser aiming light	0	560	560	0	0	280	9.4	0
Visible laser aiming light	0	15	11	0	0	7.5	.18	0
Laser rangefinder-digital compass	113	99	115	0	33.9	49.5	1.9	0
Video camera	162	172	170	0	48.6	86.0	2.8	0
Computer-radio								
Computer	0	69	84	0	0	34.5	1.4	0
Soldier radio	1376	1329	1302	0	688	2259.3	21.7	0
Soldier radio COMSEC	13	13	12	0	22.1	22.1	.2	0
Squad radio	1377	1336	1354	0	688.5	2271.2	22.6	0
Squad radio COMSEC	19	10	10	0	9.5	17.0	.17	0
Global positioning system receiver	111	104	111	0	18.5	52.0	1.85	0
Remote input- pointing device	0	14	13	0	0	7.0	.22	0
Hand-held flat panel display	0	8	15	0	0	4.0	.25	0
Keyboard	0	10	10	0	0	5.0	.17	0
Software	0	16	23	0	0	8.0	.38	0
Integrated helmet assembly								
Integrated helmet assembly component	169	162	187	0	84.5	81.0	3.1	0
Ballistic helmet	14	20	15	0	7.0	10.0	.25	0
Headset-microphone	27	19	20	0	13.5	9.5	.33	0
Ballistic & laser eye protection	13	0	8	0	0	0	.13	0
Day display	19	26	19	0	9.5	13.0	.32	0
Night display/I ²	0	157	144	0	0	78.5	2.4	0
XM-47 protective mask	0	152	169	0	0	0	2.8	0
Protective clothing								
Modular body armor	46	0	25	0	0	0	.42	0
Laser detector	18	0	18	0	0	0	.30	0
Environmental protective ensemble	40	0	35	0	0	0	.58	0
Modular load-carrying equipment	25	0	18	0	0	0	.30	0
Lightweight battledress uniform	42	0	36	0	0	0	.60	0
Wiring harness	25	0	15	0	0	0	.25	0

The level at which items are removed and replaced is important and involves trade-offs. If whole assemblies (such as a thermal sight) are replaced, the cost of the replacement parts, storage, and transportation are increased. If replacements are made at lower levels (such as a circuit card) the costs mentioned above may decrease, but there is an increased reliance on diagnostics (either hardware and software or human) and there may be a need for increased training. Also, lower level remove and replace actions normally become more difficult in the infantryman's dirty environment.

From Table 48, it appears that there are several "high drivers" in terms of maintenance man-hour requirements. Using the data from the baseline maintenance concept, when subsystem man-hours required as a percentage of the total man-hours required is computed, the following subsystems appear to be high drivers:

<u>Subsystem</u>	<u>Percent of Total Man-hours</u>
Modular weapon	26%
Thermal weapons sight	20%
Soldier radio	3%
Squad radio	<u>23%</u>
Total	92%

Table 47 showed required maintenance man-hours by MOS. If the objective maintenance concept is implemented, there should be no maintenance manpower shortages since the current manpower available exceeds manpower requirements. If the current maintenance concept were implemented, however, there could very well be a shortage of maintenance manpower.

When maintenance manpower requirements for Land Warrior under the current maintenance concept are compared with the maintenance manpower available in a light infantry division, there appears to be a shortage within certain MOSs. If the maintenance man-hour requirements for a light infantry battalion are multiplied by 9 (the number of light infantry battalions in a division) and then converted to manpower using the manpower requirements criteria (MARC) annual available MOS productive man-hours (AAMP) conversion factors (organizational = 4161 and direct support = 2336) (Department of the Army, 1992), the requirements are as shown in Table 49.

As shown, there is a substantial shortage in MOSs 45G and 29E. It should be remembered also that the requirements are for Land Warrior only and do not reflect maintenance requirements for the numerous other systems in the division that these same MOSs support. Also, this assumes that each infantry battalion spends only 120 days a year (in combat) using the Land Warrior equipment. If equipment other than Land Warrior were considered and times longer than 120 days were spent in combat, the requirements in Table 49 would most likely be substantially larger.

Conclusions and Recommendations

The simulation results show that, from a maintenance manpower perspective, the objective maintenance concept for Land Warrior is supportable. The results also show that under the current maintenance concept there would be a shortage of maintenance manpower in the light infantry division to support Land Warrior.

Table 49

MOS Constraints Versus Requirements

MOS	Maintenance level	Number available (constraints)	Number required (requirements)
92Y	Org	36	4
31U	Org	9	7
45G	DS	1	7
39E	DS	10	6
29J	DS	3	1
29E	DS	12	19

The supply issues associated with the objective maintenance concept were not modeled or analyzed. It is highly recommended that this be done early in the program to fully identify costs associated with component replacement and component transportation before starting to implement the concept.

There may be other maintenance alternatives between the baseline and objective concepts that could be used to support Land Warrior. The optimum maintenance concept for Land Warrior may actually be a combination of the baseline and objective scenarios explored here, with most components being removed and replaced by the operator and complicated or expensive components being repaired by Army maintenance personnel. If other alternatives are identified, they need to be specified, modeled, and analyzed as well.

Finally, this analysis needs to be updated as more definitive information becomes available in the Land Warrior program.

CONCLUSIONS

In this effort, it was found that the addition of Land Warrior equipment to the infantry squad provides many benefits, particularly to the squad leader, in the areas of command, control, and navigation. These benefits, however, do come with some cost. In general, Land Warrior-equipped soldiers may need to carry equipment and supplies that weigh more than recommended levels for various types of movement. For the squad member, these costs are principally in

terms of the added communications tasks that must be conducted. For the squad leader, these costs consist chiefly of communications management difficulties, as multiple radio nets must be monitored.

In terms of the impact of various environmental stressors, it was found that heat and MOPP equipment had the most significant impact on Land Warrior mission performance time and accuracy, while cold and sustained operations has less significant effects. Raising the ASVAB cut-off score had little effect on squad member or squad leader mission performance.

The simulation results for a light infantry battalion show that the objective maintenance concept for the Land Warrior is supportable. If the current maintenance concept were used, however, there would be a shortage of maintenance manpower.

For those interested in more detail, copies (i.e., exports) of the HARDMAN III mission models can be obtained from

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This report has documented the assumptions that were made during this first HARDMAN III analysis of the Land Warrior System. If it is found that any of these assumptions are invalid because of new information, changes in Land Warrior requirements, acquisition decisions, or differing opinions among experts, the models produced in this effort can be used as a starting point for follow-on analyses. This report can also serve as a starting point for analyzing more general infantry issues. In this way, the insights gained here can provide benefit today and can continue to serve as a useful baseline for future efforts with significant resource savings.

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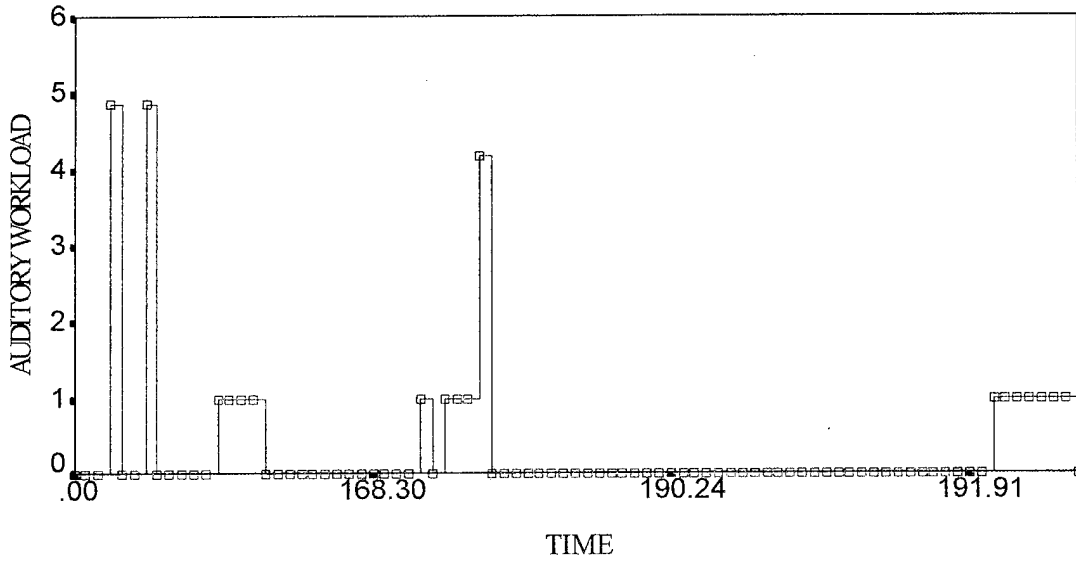
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APPENDIX A
WORKLOAD GRAPHS

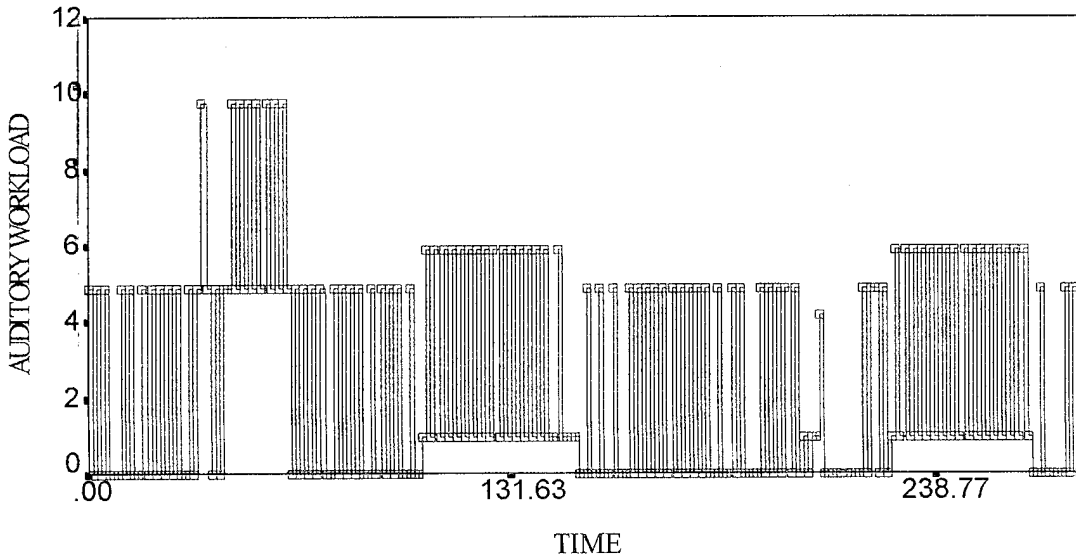
APPENDIX A

WORKLOAD GRAPHS

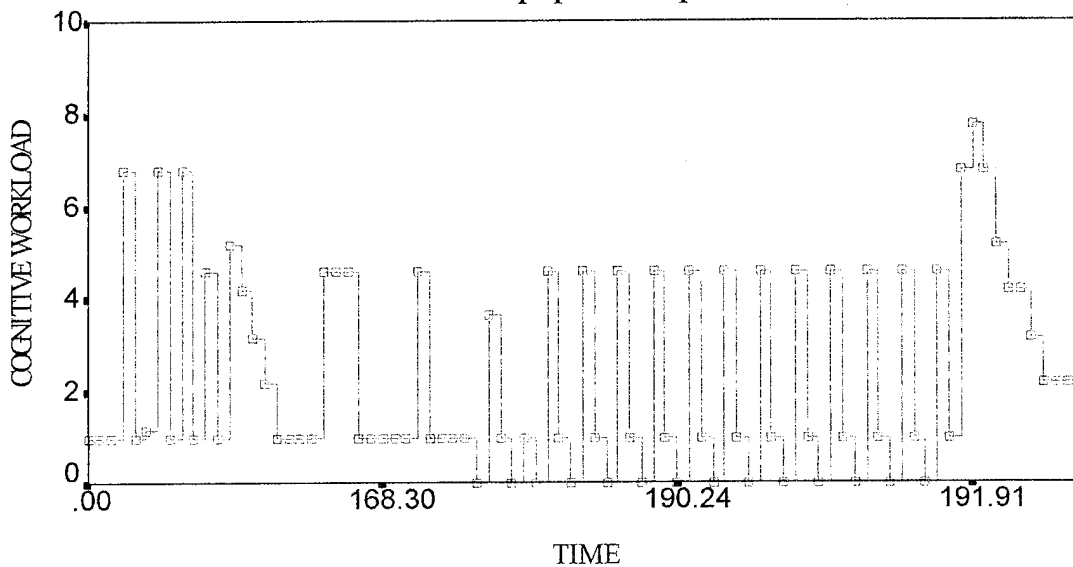
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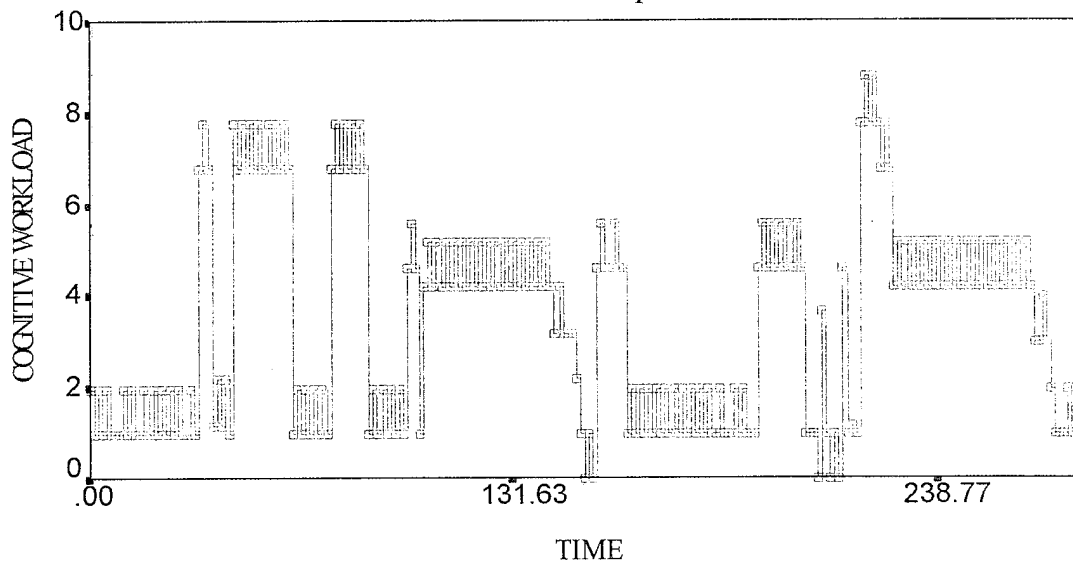
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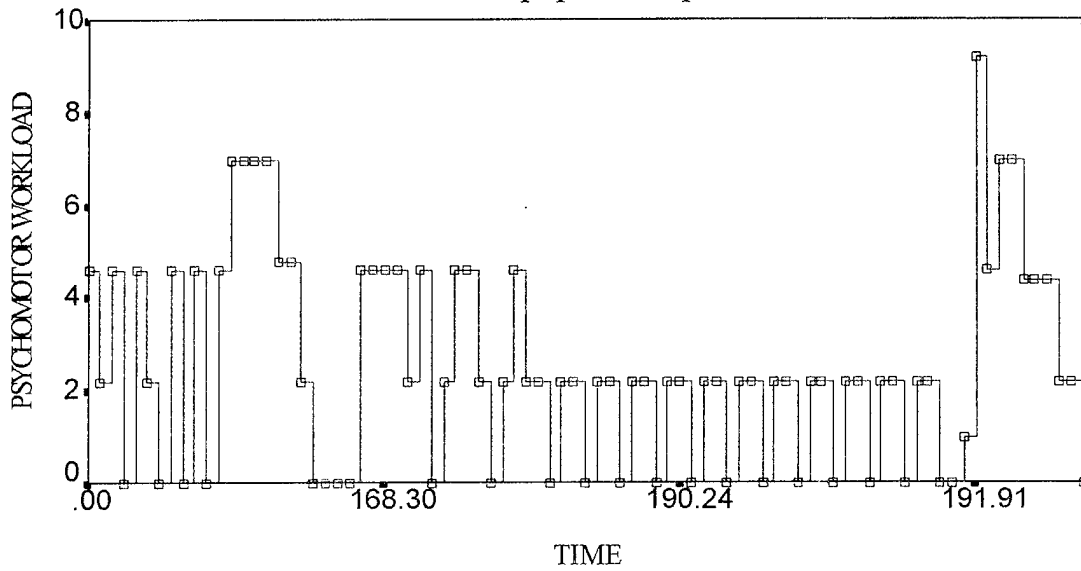
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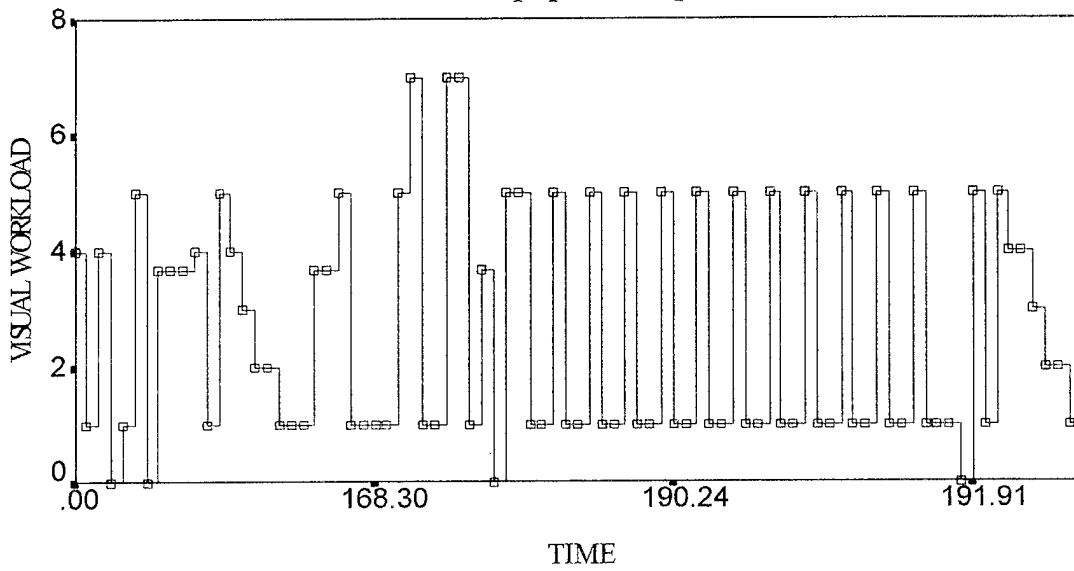
Cognitive Workload - Ambush Land Warrior Squad Member



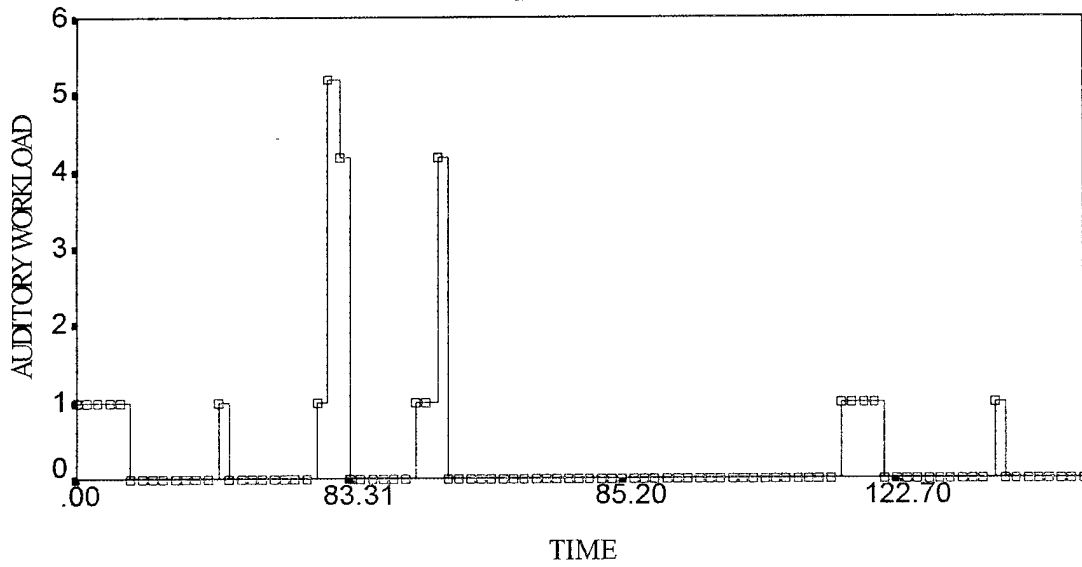
Psychomotor Workload - Ambush Current Equipment Squad Member



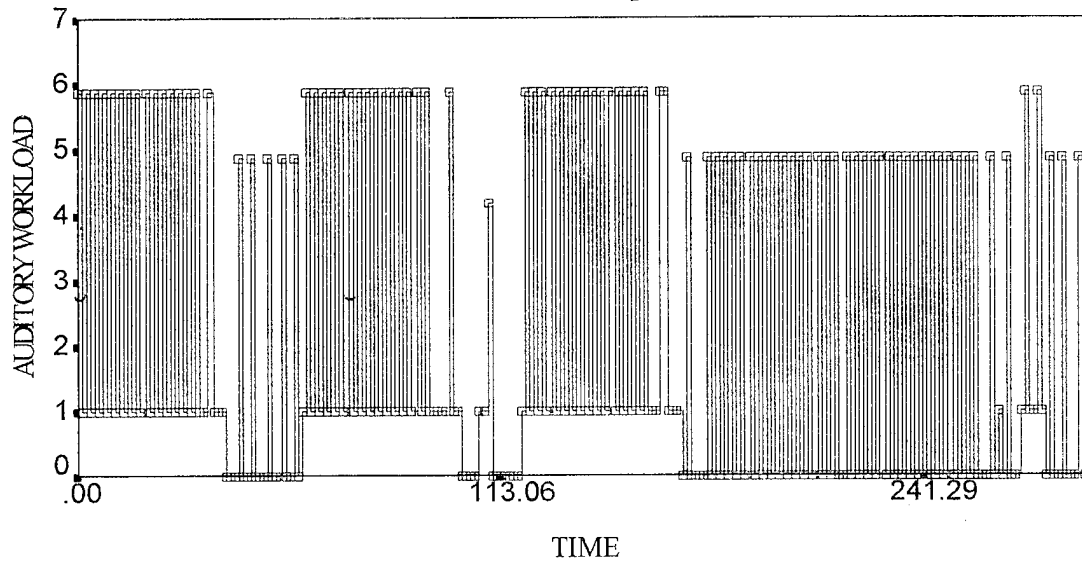
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Current Equipment Squad Member



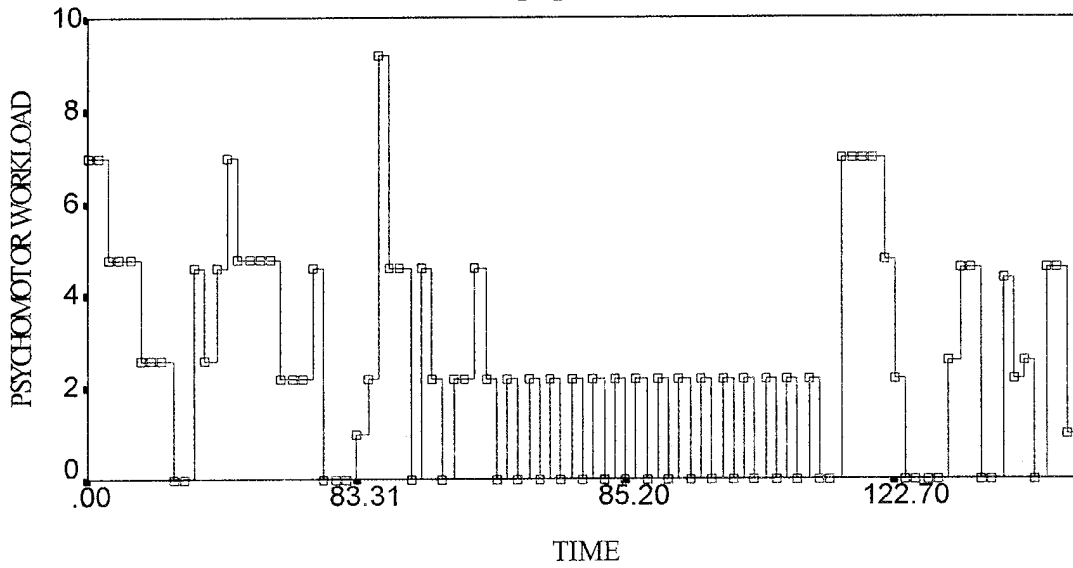
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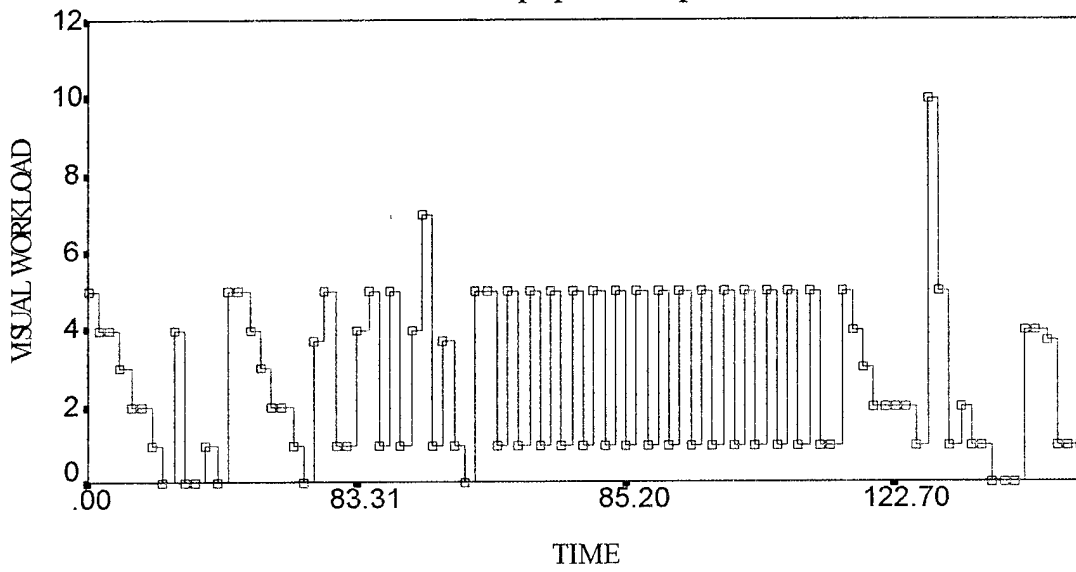
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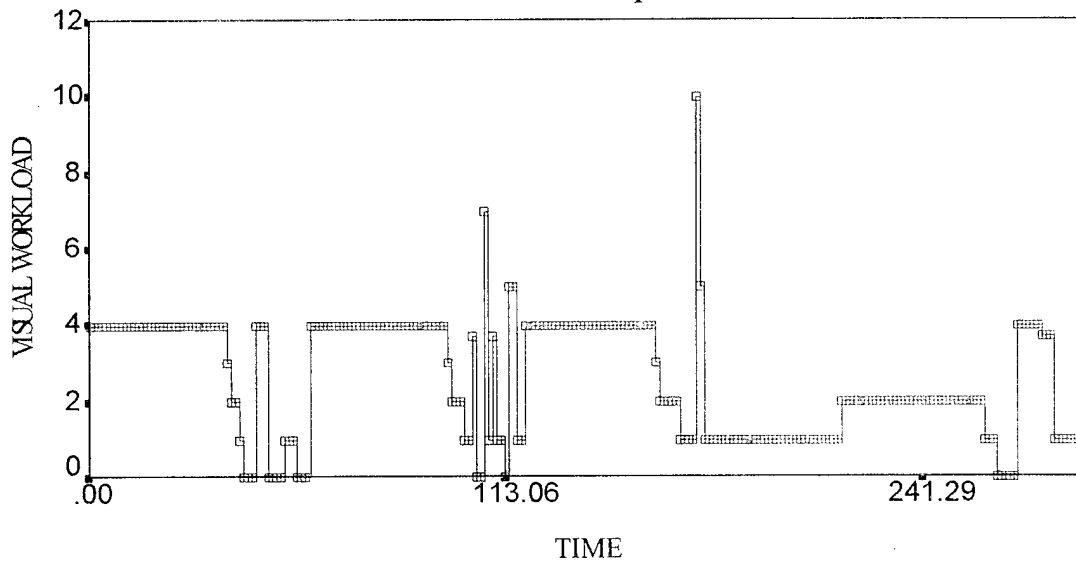
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Current Equipment Squad Member



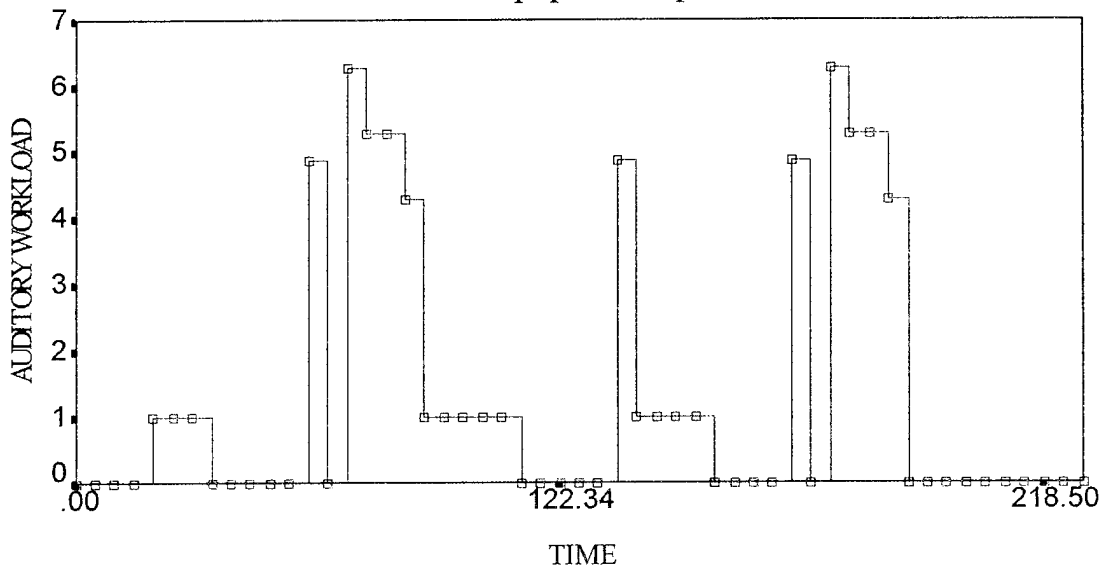
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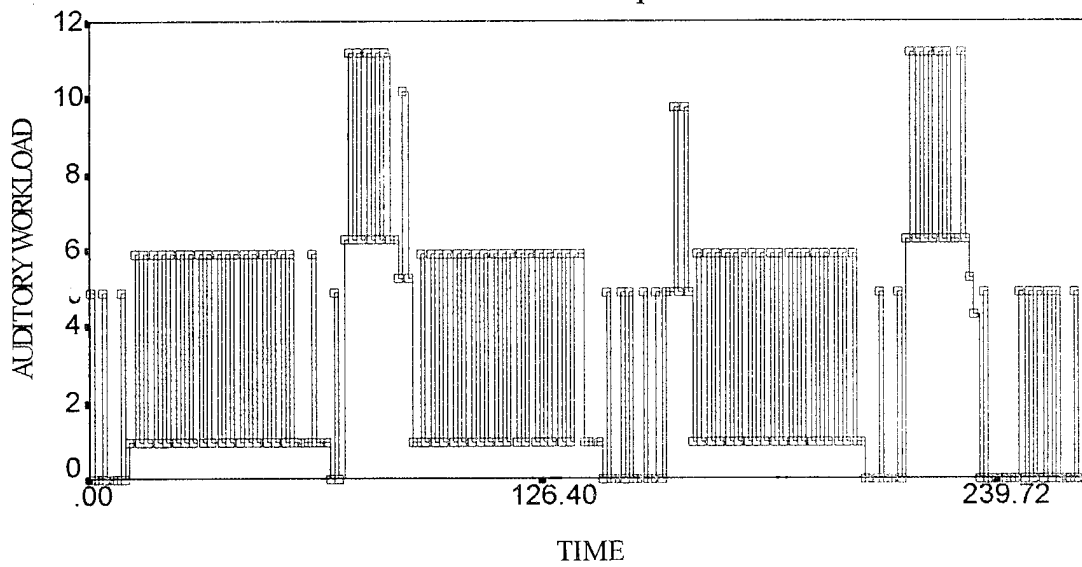
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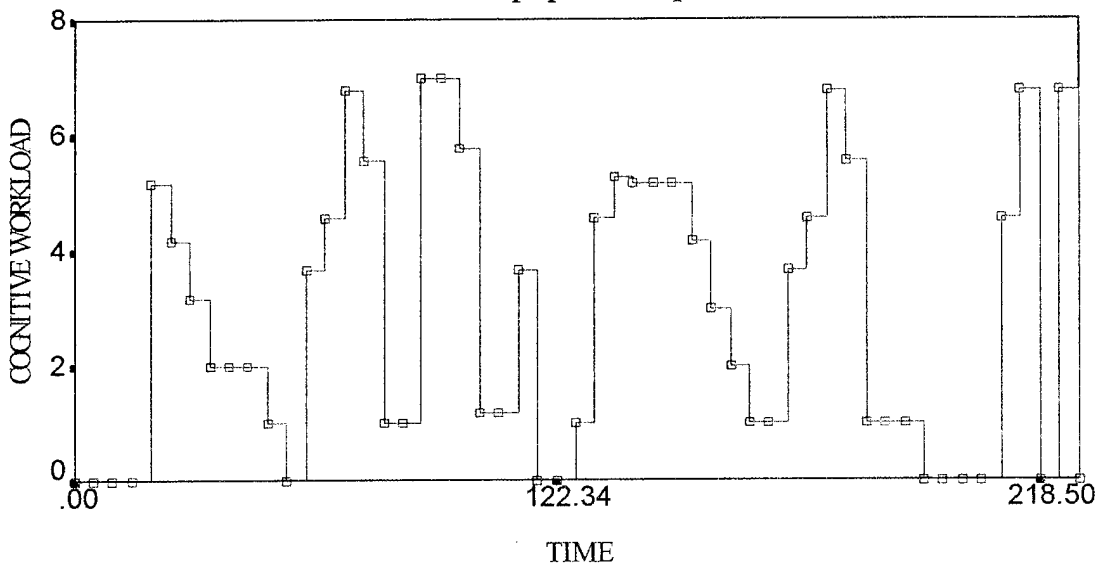
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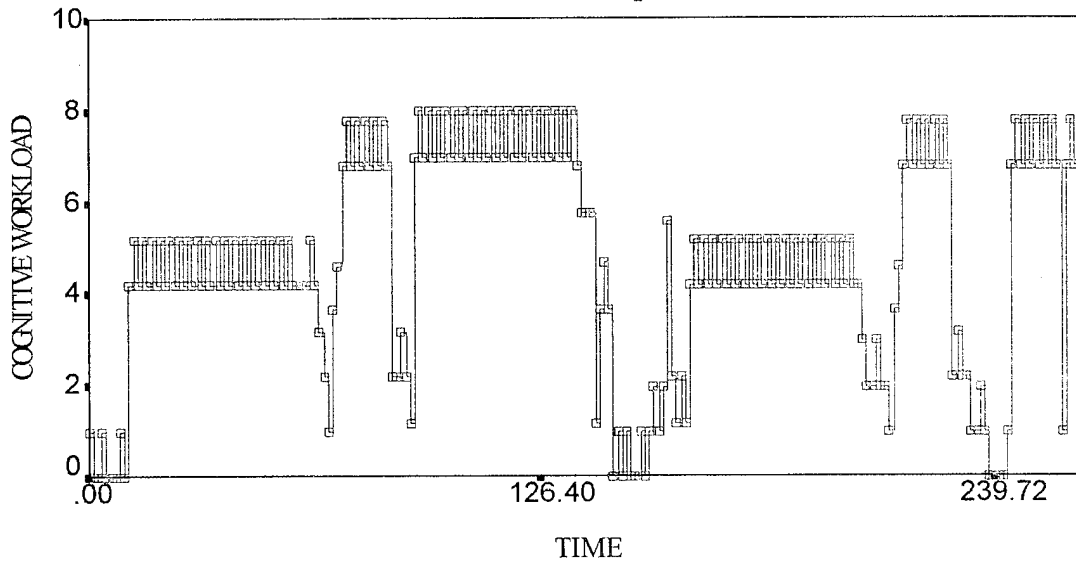
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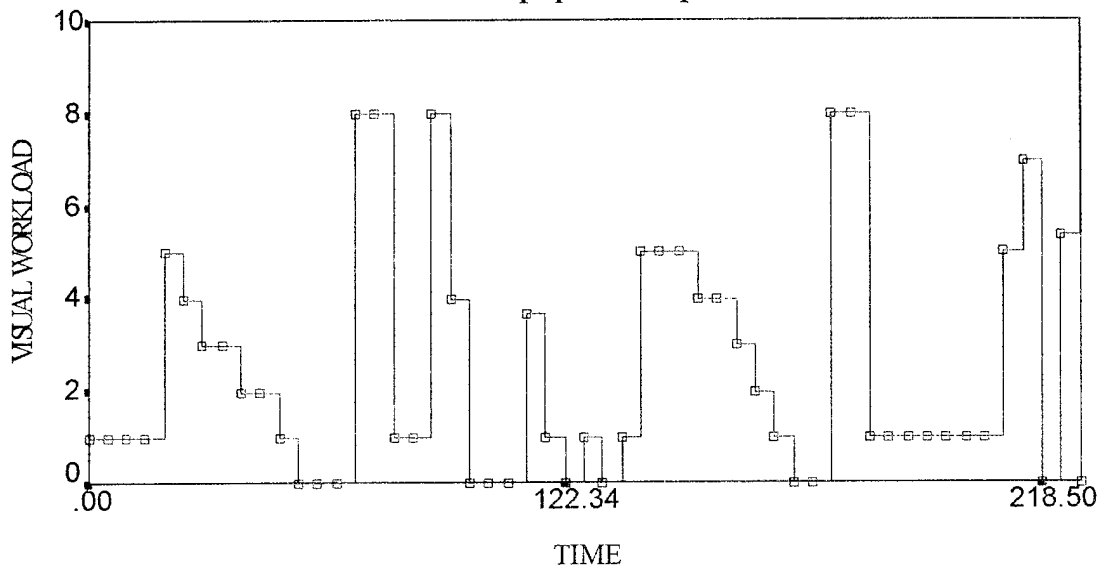
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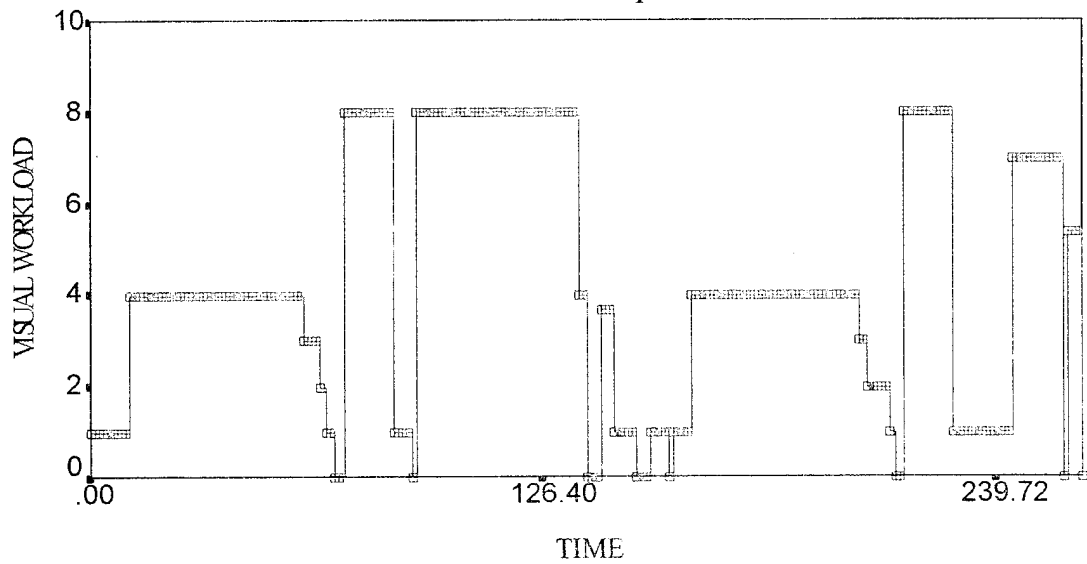
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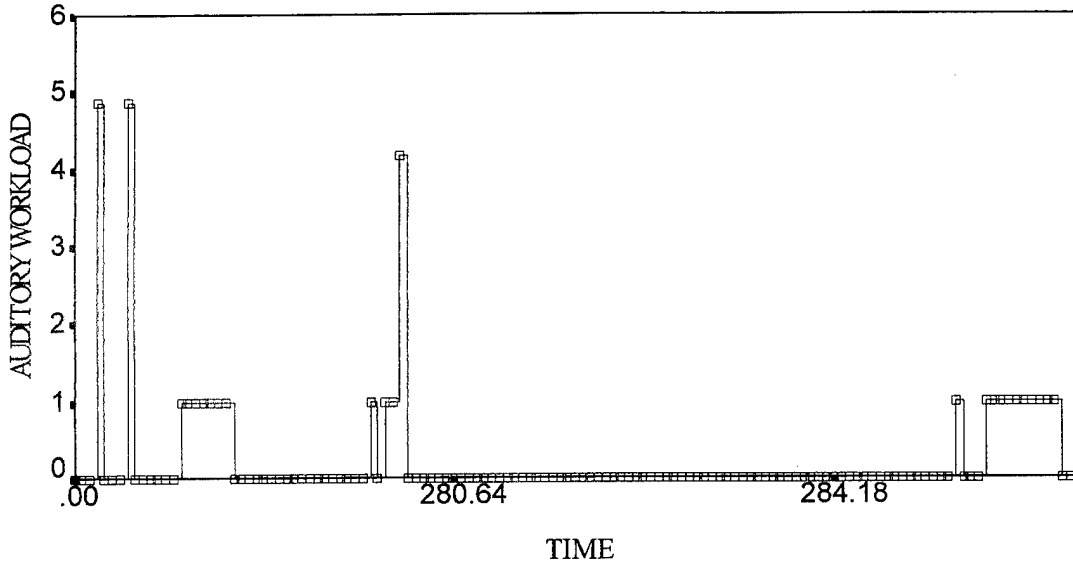
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Current Equipment Squad Member



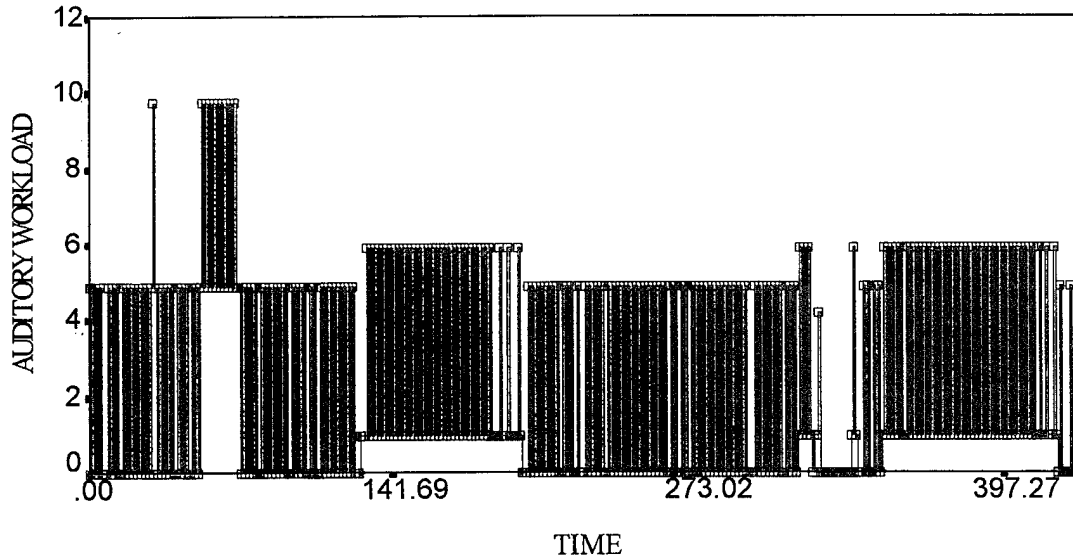
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Land Warrior Squad Member



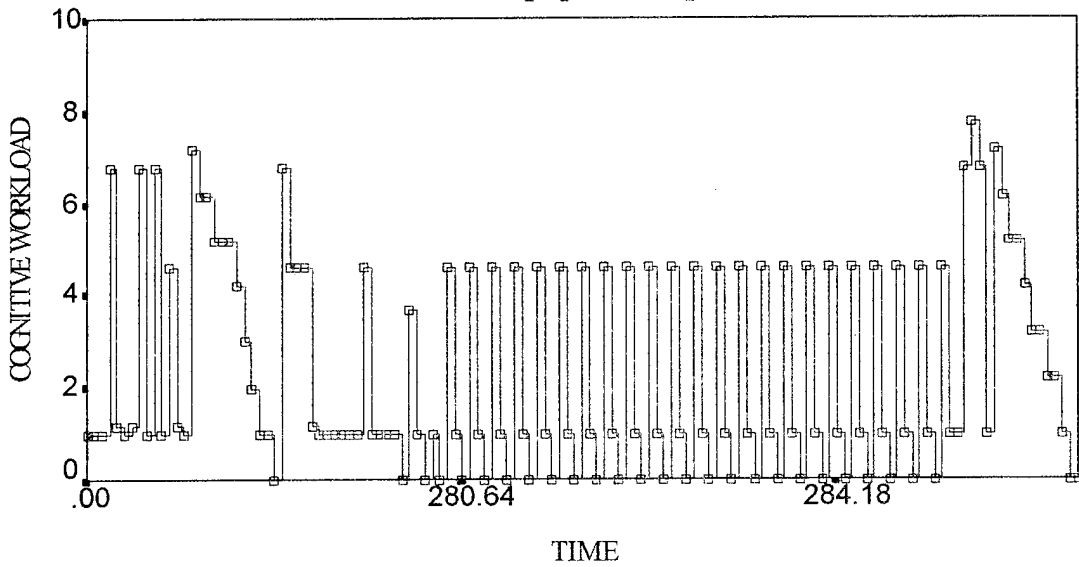
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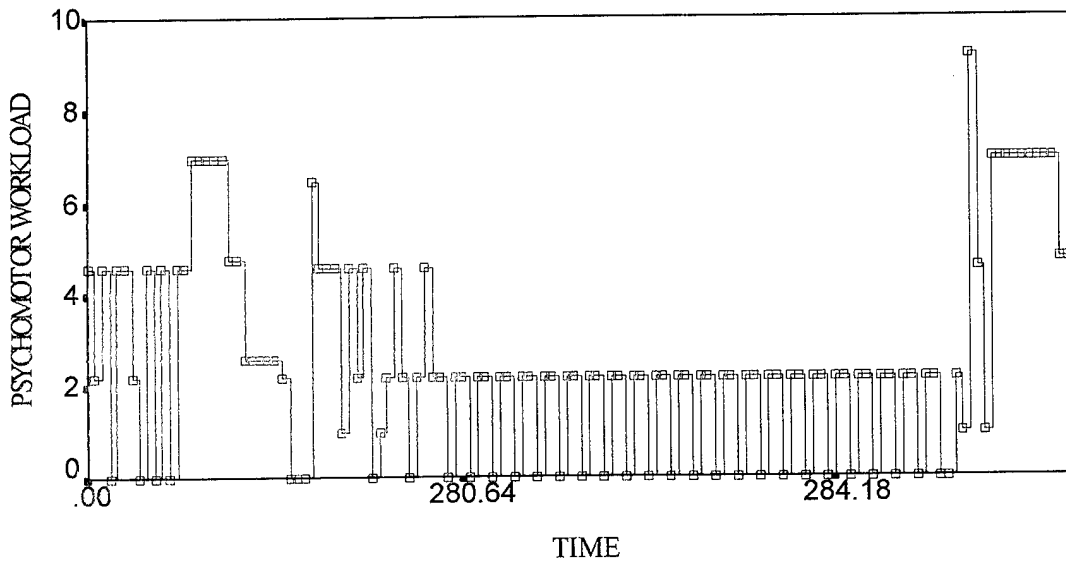
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Land Warrior Squad Leader



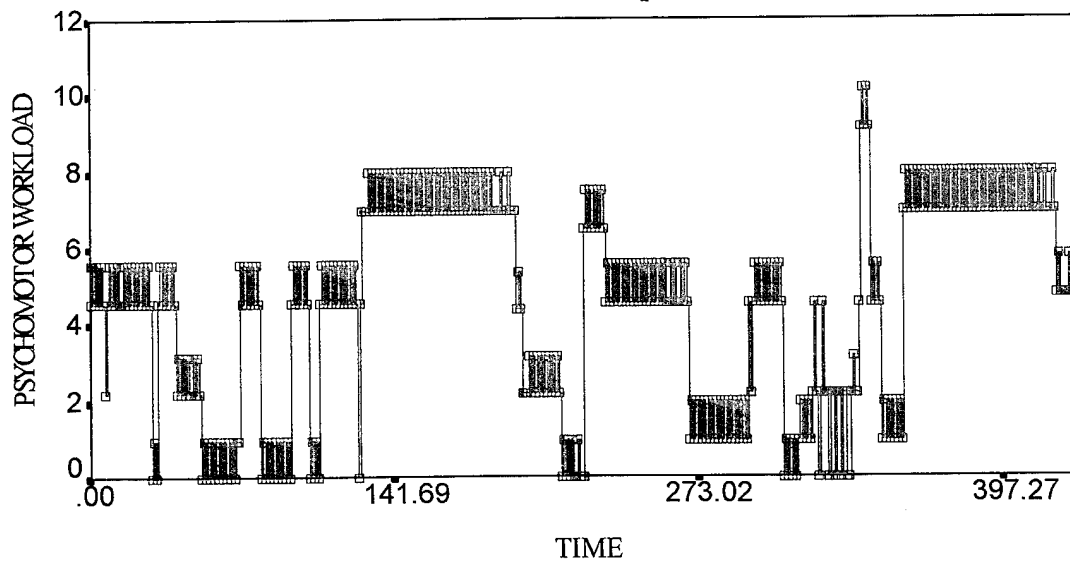
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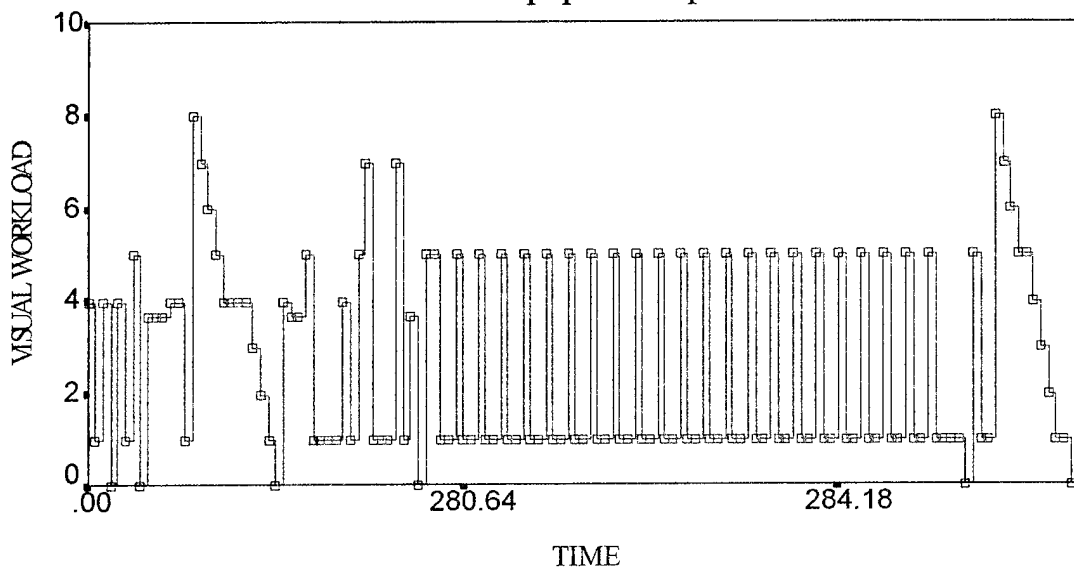
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Current Equipment Squad Leader



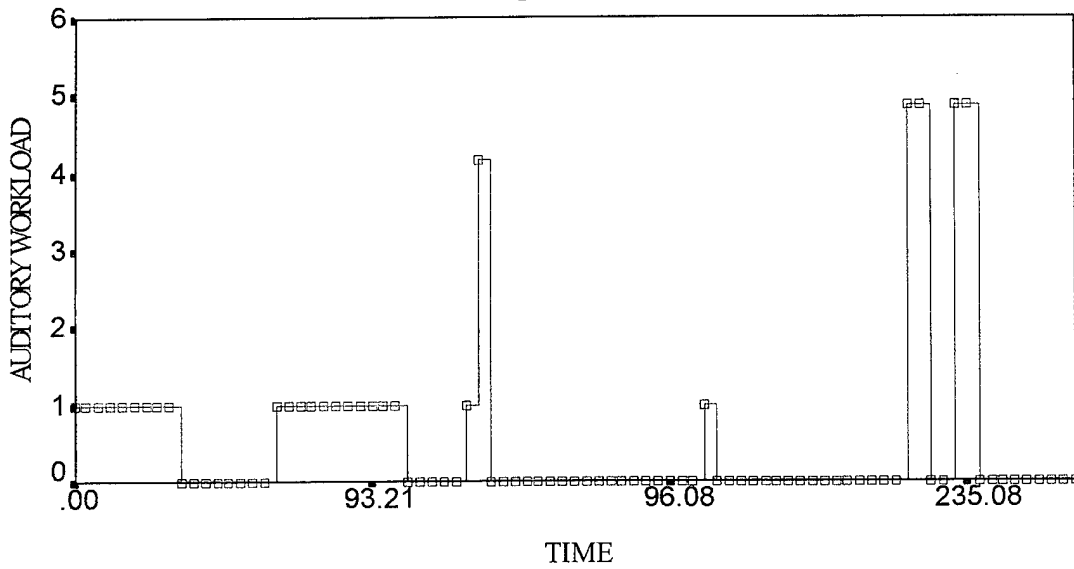
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Land Warrior Squad Leader



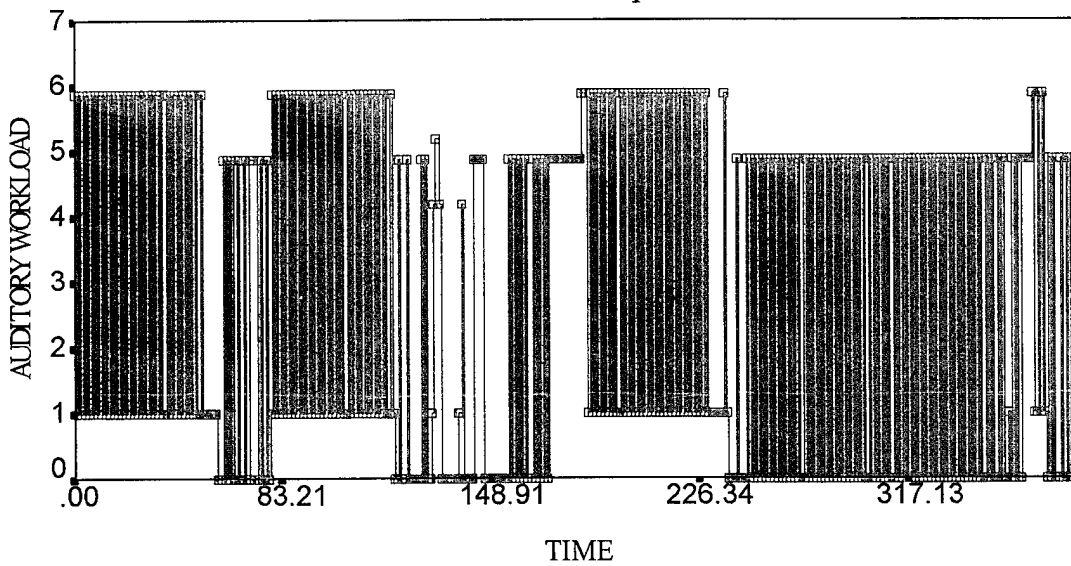
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Current Equipment Squad Leader



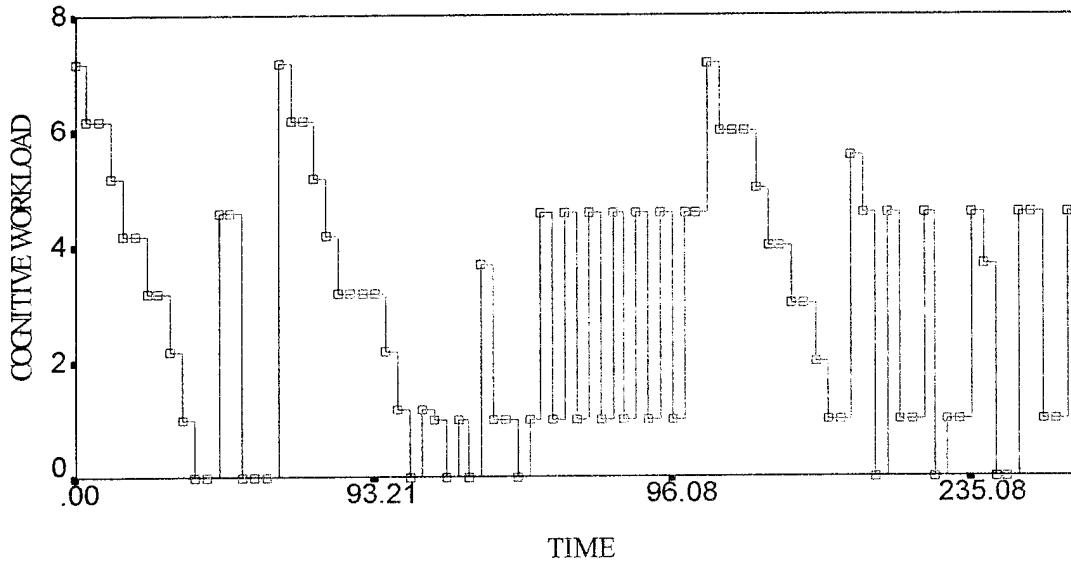
Auditory Workload - Attack Current Equipment Squad Leader



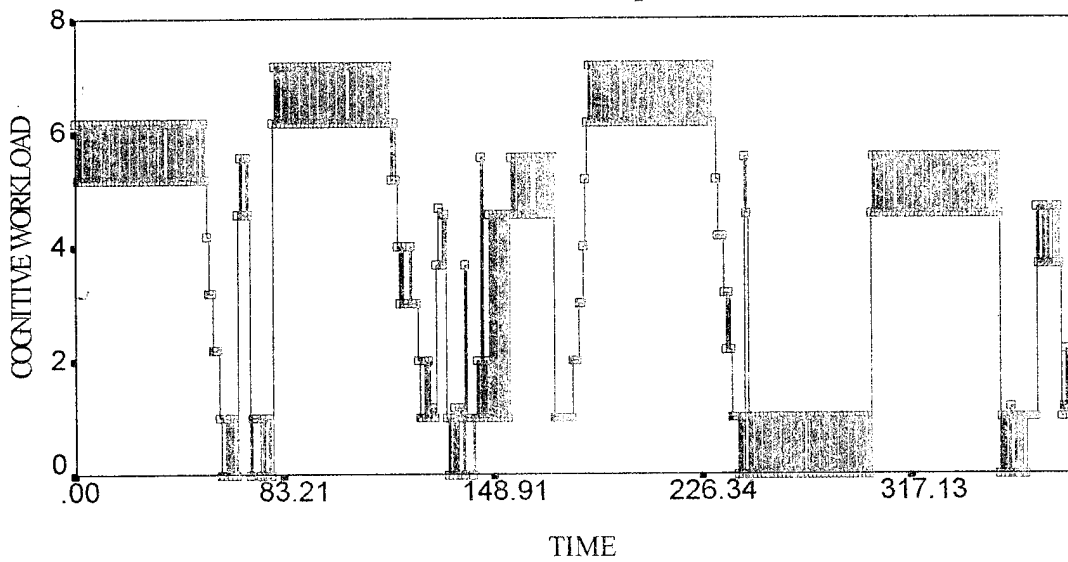
Auditory Workload - Attack Land Warrior Squad Leader



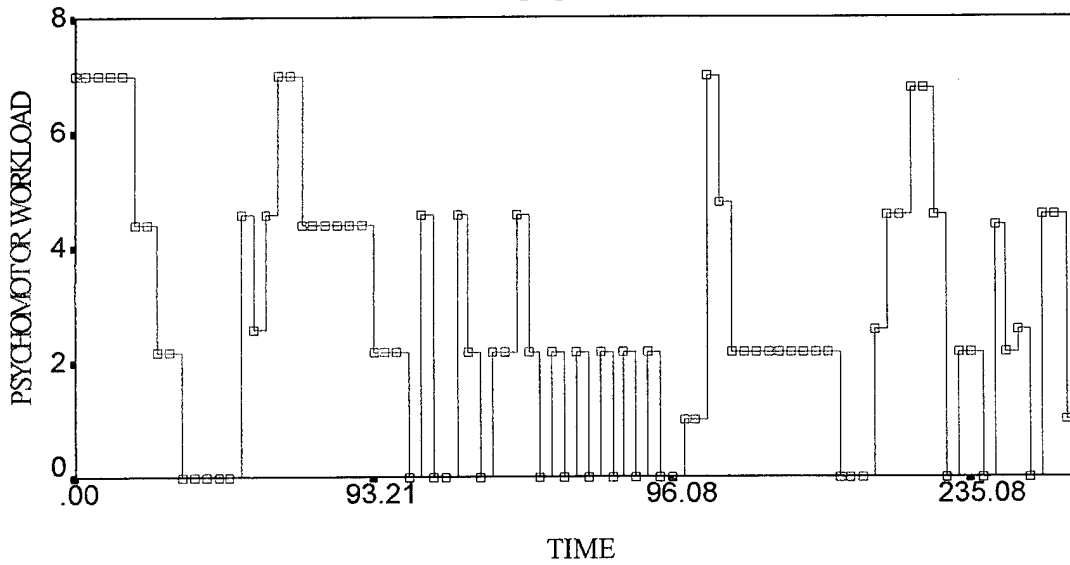
Cognitive Workload - Attack Current Equipment Squad Leader



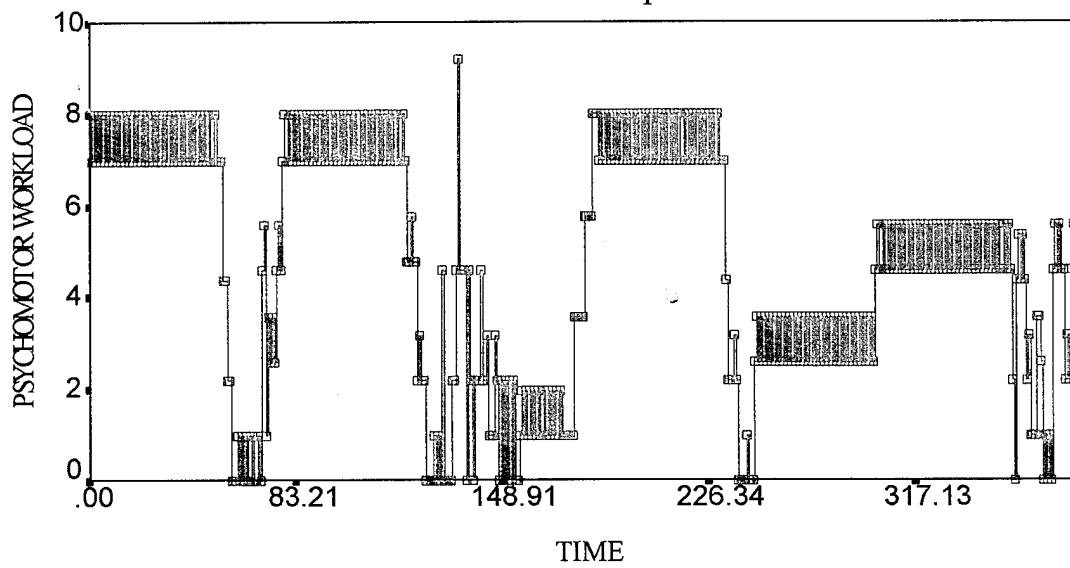
Cognitive Workload - Attack Land Warrior Squad Leader



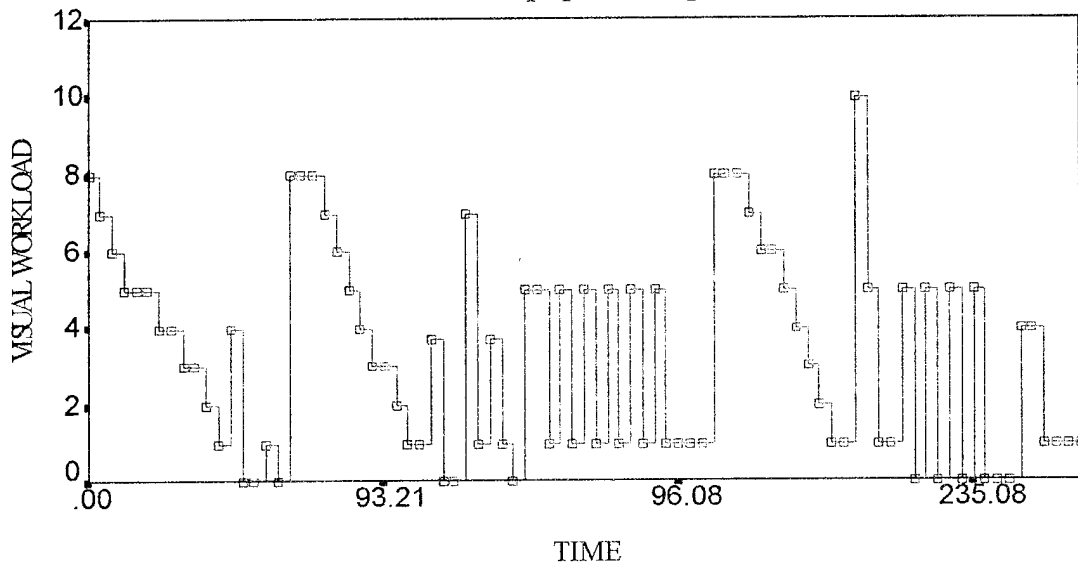
Psychomotor Workload - Attack Current Equipment Squad Leader



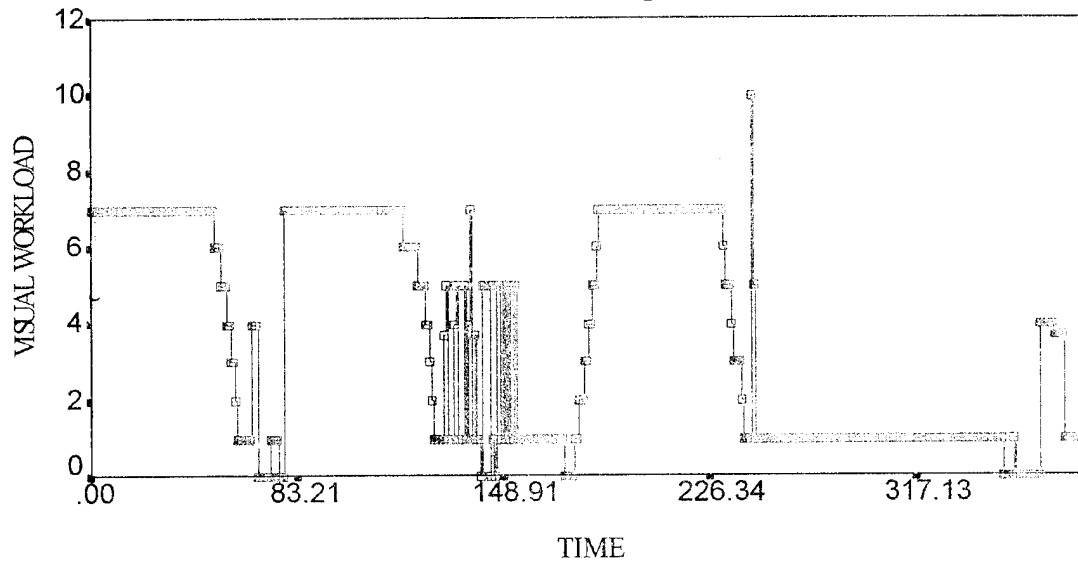
Psychomotor Workload - Attack Land Warrior Squad Leader



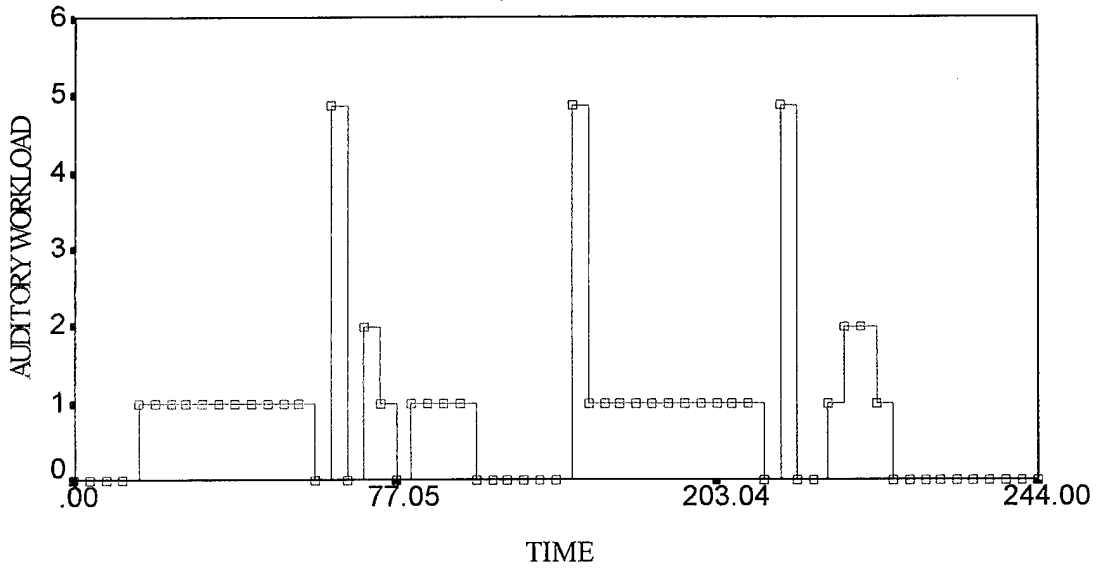
Visual Workload - Attack Current Equipment Squad Leader



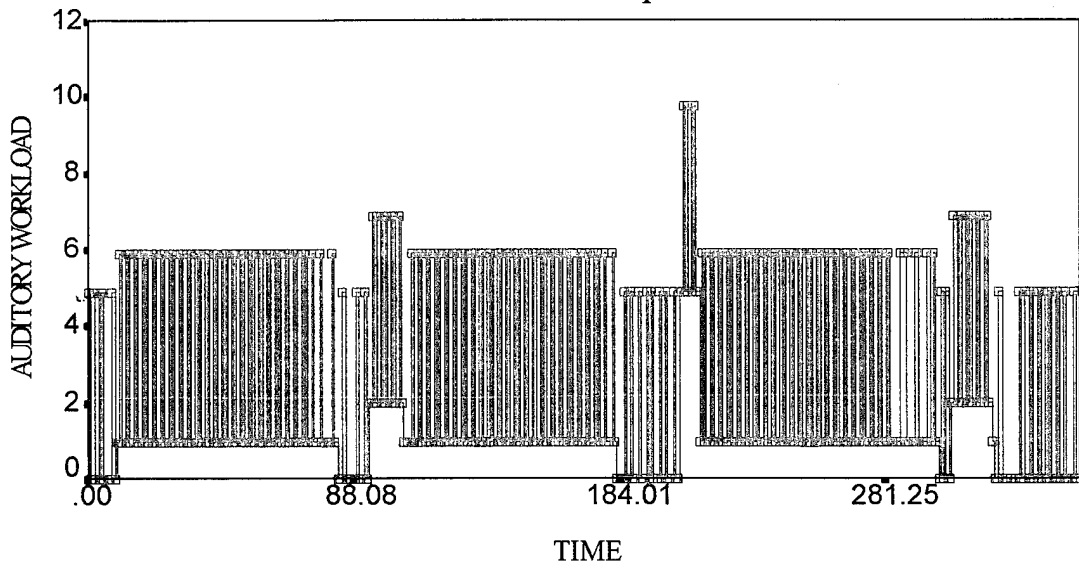
Visual Workload - Attack Land Warrior Squad Leader



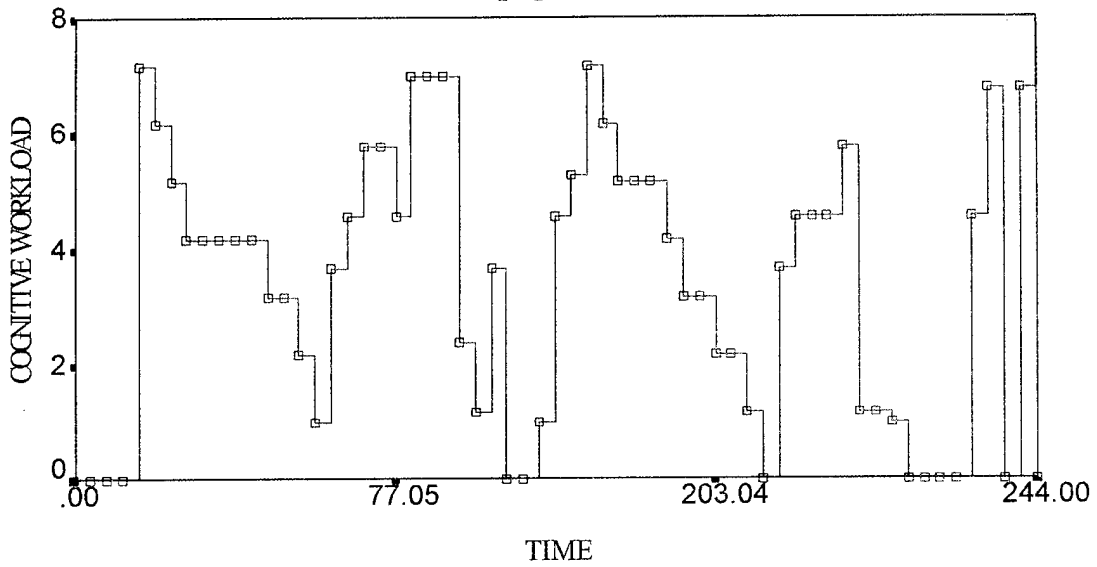
Auditory Workload - Recon Current Equipment Squad Leader



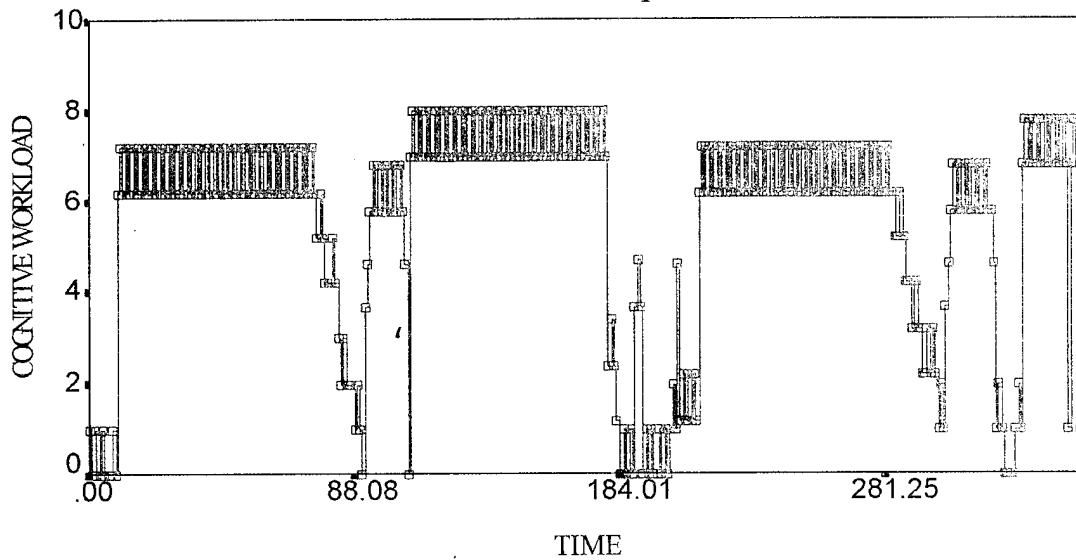
Auditory Workload - Recon Land Warrior Squad Leader



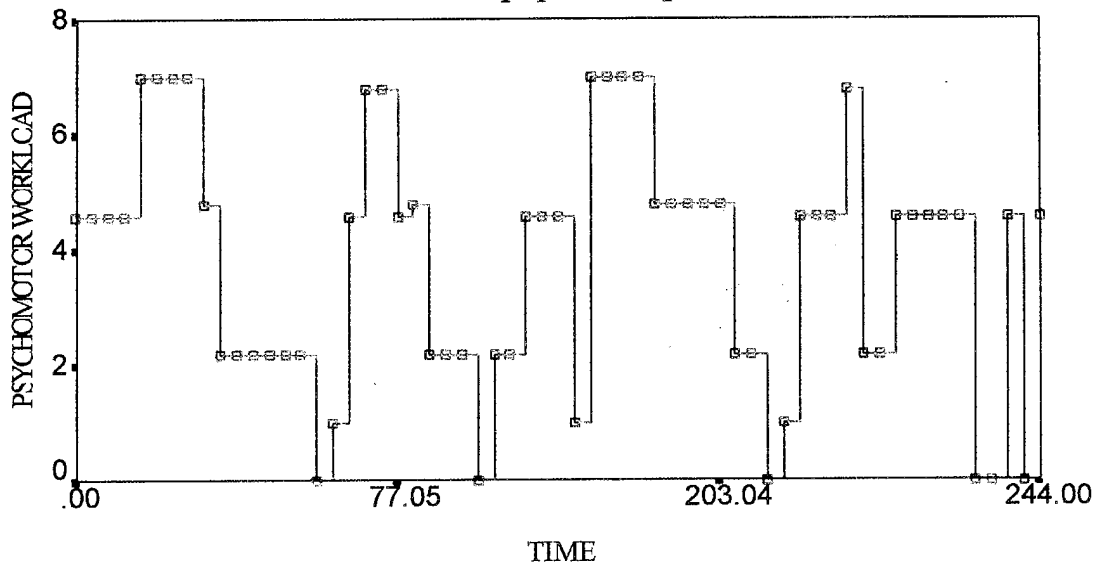
Cognitive Workload - Recon Current Equipment Squad Leader



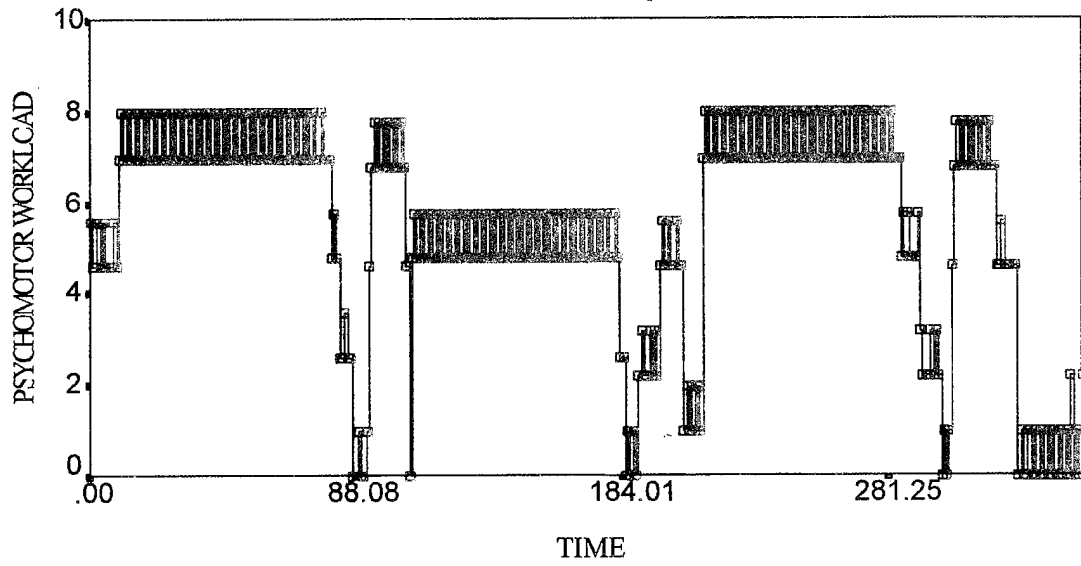
Cognitive Workload - Recon Land Warrior Squad Leader



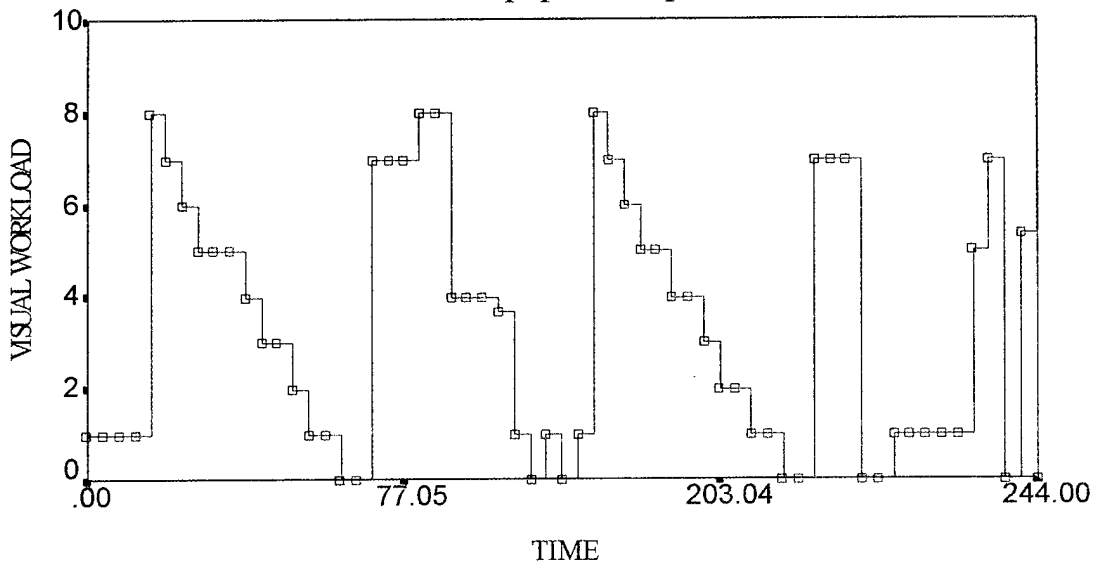
Psychomotor Workload - Recon
Current Equipment Squad Leader



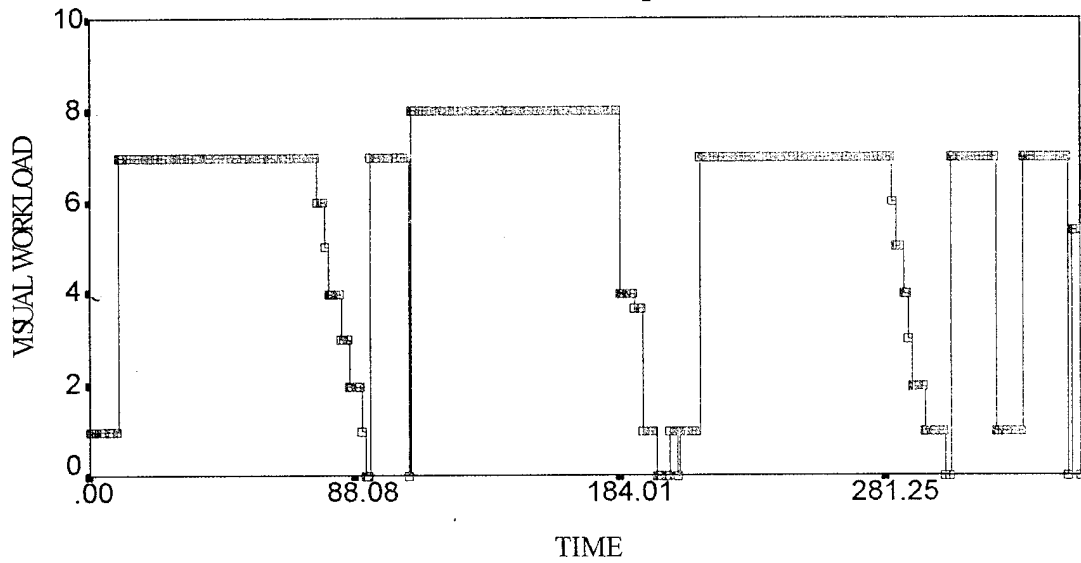
Psychomotor Workload - Recon
Land Warrior Squad Leader



Visual Workload - Recon Current Equipment Squad Leader



Visual Workload - Recon Land Warrior Squad Leader



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