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USATECOM PROJECT NO. 8-3-7700-01

FINAL REPORT OF PHASE II

DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS

Alin Gruber
Jack Wm. Dunlap
George DeNittis

DECEMBER 1964

U S ARMY
GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

U. S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
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Prepared Under Contract DA-19-129-QM-2068 (OI 6141)

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

FOREWORD

This report reviews work performed by Dunlap and Associates, Inc., under Contract DA 19-129-QM-2068 (OI 6141) and presents a summary of the results of Phase II of a three-phase research contract. It is the seventh in a series of reports describing research and development work accomplished under this phase of the study by the contractor and the U. S. Army General Equipment Test Activity. (See Appendix B.)

The project is directed toward the development of field measurement methodology for evaluating the effects of military clothing and protective equipment on the combat effectiveness of the individual soldier. Earlier work accomplished under this project indicated that a major constituent of the effectiveness of an individual infantryman in a combat situation is his level of performance in the individual physical tasks which are important to battlefield success. This phase of the study was aimed primarily at the determination of the tasks which make up the most important segment of the infantryman's job and the development of methods and facilities for measuring performance in these tasks. The design and evaluation of field techniques for determining an individual's level of performance in the physical tasks which are most important to success on the battlefield consumed a large portion of the effort in this phase. The detailed results of that work are reported in five individual reports (partial reports two through six) which are jointly authored by representatives of the contractor and GETA. Distribution of this summary report was postponed until those documents were ready for publication.

Throughout Phase II of this study the project team has aimed toward an optimum degree of realism consistent with the requirements for precise and reliable measurements. Generally the primary effort was centered around the establishment of a test situation which contained all of the essential ingredients of a combat task as it is usually performed by infantrymen with the level of effectiveness measured for whatever aspect of performance was amenable with field measurement. The final method usually represented a compromise between the desired realism, the constraints necessary for the task to be included in a field testing program,

and the controls required for reproducible performance measures. Future reporting under this project will be concerned with efforts to combine individual performance tests into an integrated field test situation for the evaluation of personal clothing and equipment.

August 1965

HOWARD W. HEMBREE, Ph. D
Technical Director

U. S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

Final Report of
USATECOM PROJECT NO. 8-3-7700-01, PHASE II
Development of Methodology for Measuring Effects of
Personal Clothing and Equipment on Combat Effectiveness
of Individual Soldiers

December 1964

ABSTRACT

A three-phase research effort is underway to develop field methodology for measuring the effects of experimental clothing and equipment on the combat effectiveness of individual infantrymen. This report covers a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) by Dunlap and Associates, Inc., and is the last of a series of seven reports presenting the results of Phase II of the contract. This report summarizes the work reported in the preceding six reports of this series and also reports on the status of work currently underway.

Six primary research activities were undertaken during the Phase II effort. The first of these activities dealt with the identification of important tasks of combat infantry and the selection of the most important tasks as criterion tasks for which field performance measures were to be developed. This work represented an expansion of work conducted in Phase I and utilized 311 combat veterans of U. S. Army operations in Vietnam, Korea and both the European and Pacific theatres during World War II. Veterans rated the importance of 27 combat tasks to success in combat. The consistency with which qualified veterans judged the relative contribution of various tasks to success in battle justified the use of the ordered list for development of performance measures in the most important criterion tasks.

The remaining five primary activities were concerned with the development of performance measures for five field performance courses. The performance courses developed and tested were: Fire and Reload Weapon Course (M-1 rifle); Maneuver Course (run, jump, climb, crawl, etc.); March/Move Course; and Hasty Fighting Positions Course (digging foxholes). The results of the performance testing on these courses indicate each of the courses is capable of reliably measuring the differential effects of clothing and protective equipment on the performance of individual soldiers.

Progress is reported on the development of two additional performance courses: Reconnaissance, Cover, Concealment and Camouflage Course; and Target Detection Course. Preliminary tests on the relationship of physiological measures to performance measures are also reported.

I. INTRODUCTION

A. General

The purpose of this report is to summarize the results of the research program undertaken by the Contractor during Phase II of Contract No. DA 19-129-QM-2068 (OI6141). Detailed technical information on the research summarized here is contained in a series of six technical reports (referenced below) covering the six major research tasks accomplished during Phase II. Also included in this report are summaries of the status of three research tasks undertaken during Phase II and scheduled for completion during Phase III of the project.

B. Project Objectives

The ultimate goal of the project is a field measurement system that will provide objective data regarding the effects of personal clothing and protective equipment on the combat effectiveness of the individual infantry soldier. The measurement methods and techniques must be sufficiently direct and reliable to permit the routine incorporation of the test program with engineering field evaluations of Quartermaster protective items.

Toward the development of the field measurement system, the project effort has been programmed in three work phases each of which has specified sub-objectives. The phases are as follows:

Phase I: Analysis and evaluation of present methods for evaluating combat effectiveness and development of a research plan.

This phase, which was scheduled as an eight month effort, had the following major sub-objectives.

1. Review of combat effectiveness studies and other related literature;

2. Formulation of a definition of combat effectiveness for the project;

3. Preparation of a research plan to guide the development of the measurement system during Phases II and III.

Phase II: Establishment of criteria of combat effectiveness and research and development of test and measurement situations.

This phase, which is programmed to cover 16 months, has the following major sub-objectives:

1. Refinement of the combat tasks that will constitute the performance criteria;

2. Development and preparation of field test situations for measuring performance in the criterion tasks;

3. Field tryout, evaluation and refinement of the test and measurement situations;

4. Preparation of a Phase III work plan to guide the tryout and validation of an integrated test system and the development and evaluation of the utility of normative data.

Phase III: Evaluations of the measurement system.

This phase, which is scheduled as a 24-month effort, has the following major sub-objectives:

1. Tryout, evaluation and final refinement of an integrated test course;

2. Collection of performance data and evaluation of utility of norms based on these data.

C. Project Reports

The following is a list of technical reports published as documentation of the research accomplished on this project during Phase I and Phase II.

Report of Phase I, USATECOM Project No. 8-3-7700-01E, Development of a Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of the Individual Field Soldier, U. S. Army QM R&E Field Evaluation Agency (now U. S. Army General Equipment Test Activity), February 1964.

Reports of Phase II, USATECOM Project No. 8-3-7700-01E, Development of a Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers, U. S. Army General Equipment Test Activity:

- Identification of Important Tasks of Combat Infantry-Report of Results from a Further Refinement, November 1964.

- Development of a Methodology for Measuring Infantry Performance in Rifle Firing and Reloading. (In Preparation)

- Development of a Methodology for Measuring Infantry Performance in Maneuverability. (In Preparation)

- Development of a Methodology for Measuring Infantry Performance in Marching and Moving. (In Preparation)

- Development of a Methodology for Measuring Infantry Performance in Grenade Throwing. (In Preparation)

- Development of a Methodology for Measuring Infantry Performance in Digging Hasty Fighting Positions. (In Preparation)

- Final Report, Phase II.

D. Organization of Report

The next section of this report summarizes the results and conclusions of the Phase II research. Following this summary is a more detailed review of the work accomplished. Appropriate appendices follow these sections.

II. SUMMARY OF RESULTS

The plans for Phase II indicated that research should be undertaken in two major areas. The first area was the identification of important infantry combat tasks, and the selection of the most important of these tasks as criterion tasks for inclusion in a final integrated test course. This effort was to be a continuation of the preliminary research already completed in Phase I but on a considerably larger scale. The second research area dealt with the devopment and preparation of field test situations for measuring performance in the criterion tasks and to conduct field trials and evaluations of these measurement situations. Plans were to develop six field test situations to measure performance in the criterion tasks. These six field test situations are referred to in this report as performance courses and are listed below.

- Fire and Reload Weapon Course
- Maneuver Course
- March/Move Course
- Grenade Course
- Hasty Fighting Positions Course (digging foxholes)
- Reconnaissance, Cover, Concealment and Camouflage Course

The results of the study on the identification of important infantry combat tasks almost completely verified the preliminary work done in this area during Phase I. Of the ten criterion tasks tentatively selected on the basis of the Phase I work, nine continued to remain as criterion tasks as a result of this more extensive research. Since the data for this research represents the opinions of combat veterans as to what tasks are most important, it is interesting to note the very high coefficients of agreement obtained, especially considering the wide background of experiences in terms of theaters of operations, represented by these men. Further the high degree of agreement among men with experience in different theaters of operation indicates that the criterion tasks should be relatively stable across combat environments.

The efforts to develop and try out the various performance courses listed above were met with a reasonable measure of success. Analysis of the data from the field tests indicate that for the conditions under which subjects performed, each one of the six performance courses developed is sensitive to the effects of clothing and protective equipment on the performance of individual soldiers and that the data are statistically reliable. It is felt that when these courses are combined into an integrated test course and when subjects are tested over an extended period the individual courses will prove more sensitive and more reliable than the present data can support. As a consequence of the encouraging results it is recommended that all of the above mentioned performance courses be included as part of the Phase III Final Integrated Test Course.

III. REVIEW OF PHASE II RESEARCH ACTIVITIES

This section contains a review of the various research tasks undertaken in Phase II. Each task is described in only enough detail to clarify the salient aspects of the individual tasks. No attempt has been made to document the minutiae or the fine technical points regarding the methodologies or analyses employed during the conduct of the research. This information will be found in the detailed technical reports referenced previously, and published as part of the Phase II documentation.

The research tasks to be reviewed are designated below:

- Identification of Important Infantry Combat Tasks
- Fire and Reload Weapon Course
- Maneuver Course
- March/Move Course
- Grenade Course
- Hasty Fighting Positions Course
- Reconnaissance, Cover, Concealment and Camouflage Course
- Target Detection Course
- Physiological Testing

A. Identification of Important Infantry Combat Tasks- A Further Refinement

1. General

This project (USATECOM No. 8-3-7700-01E) has been concerned from its inception with the determination of the criterion combat tasks for which performance measures should be developed. The relevancy of the infantry tasks in which performance is measured underlies the validity and potential utility of the individual field test courses and integrated test program anticipated as the end product of this research effort.

Research on the determination of the criterion combat tasks began in Phase I of this project and the results of that work were reported as part of the Phase I Final Report. The work in Phase I included developing a basic list of 41 tasks which infantry soldiers are called upon to perform in combat. This list was compiled from many sources including Field Manuals, technical publications and interviewing combat veterans. The 41 tasks were then rated for their importance to success in combat by five officers and five enlisted men, assigned to the Ranger Department, U. S. Army Infantry School, Ft. Benning, Georgia, and all of whom had faced the enemy in combat for extended periods of time. The ratings by these combat veterans resulted in a rank ordering of the 41 tasks on the dimension of importance to success in combat. Following an analysis of the rank ordered list, we selected the ten most important tasks in which protective clothing and equipment were likely to affect an individual soldier's performance. It was these ten tasks which served as the focal point for the research on the development of performance measures in Phase II of the project.

Because the Phase I research on the determination of criterion combat tasks is fundamental to the eventual success of the project and because the data are based on such a small number of combat veterans, it was decided to further refine and verify these results as part of the Phase II program.

2. Research Objectives

The primary objective of the Phase II study was to provide an independent check on the results of the Phase I research using a considerably larger sample of combat veterans. A second objective was to obtain information regarding the differential importance of infantry tasks as a function of the theater in which men had obtained their combat experience.

3. Methodology

a. Rating Instrument

The first problem to solve was the selection of a rating instrument with which to collect data. The instrument had to have the following characteristics:

1) Permit subjects to make their judgments independently,

2) Allow for group administration of the instrument,

3) Minimize the amount of time required by subjects to make ratings,

4) Provide an estimate of a man's self consistency.

The triad comparison technique was chosen because it could be adapted to meet these requirements, it is as reliable as the paired-comparison technique, and it requires only one-third the number of comparison cards as a complete paired comparison.

As its name implies, the triad comparison technique presents the items to be judged in sets of three items each. The subject's task is to indicate, for each set, which item of the three is the more important (or greater) and which of the three is the less important (or smaller) with respect to the dimension about which judgments are being made.

In order to permit subjects to work independently and also for group administration, the sets of triads were assembled in booklet form with one triad per page. Each booklet contained 144 stimulus cards, or pages, plus a header card. This header card was used for recording information necessary to identify the respondent.

With regard to the 144 stimulus cards, 117 of the cards constituted the complete triad comparison and 27 cards (representing three cycles from the complete set) were repeat items which were included in order to later estimate a man's self-consistency.

The triads were sequenced in each booklet as follows. The first 27 cards were a random arrangement of those stimulus cards which were to be repeated (as part of the estimate of subject self-consistency).

Then the 90 cards which completed a full triad comparison appeared in random arrangement. Finally, the remaining 27 cards, again randomly arranged, were those cards which were being repeated.

b. Rated Tasks

Regarding the combat tasks to be rated, only 27 of the original 41 tasks were included for this study. This was necessary because the time for a subject to complete a triad comparison for the entire list of tasks would have been prohibitive (and was unnecessary). The number of tasks to be rated were reduced to a manageable figure (27) using the rank ordering of task importance obtained from the Phase I study. The tasks selected were the 27 most important tasks that were appropriate to the ultimate objectives of the Integrated Test Course. All tasks were rated on the dimension of importance to success in combat.

c. Subjects

Data were collected on 311 combat veterans, both officers and enlisted men, selected on the basis of their service records. This number was finally reduced to 208 which represent the final sample. The 103 raters who were dropped from the original 311 were eliminated because of their failure to meet the criteria as to what constitutes combat experience or because of their unreliability and/or lack of sensitivity as raters.

4. Results

The collected data were classified and analyzed according to the theater in which men experienced combat and also according to rank, i. e., officers or enlisted men.

The individual coefficients of agreement were computed between officers and enlisted men within theaters and across theaters as a basis for combining samples. The resulting coefficients of agreement are shown in Table 1.

Based on these results, the data were combined and the over-all agreement among combat beterans from all four theaters was determined by using Kendall's Coefficient of Concordance and then estimating the correlation coefficient from "W." The resulting estimated over-all reliability of the composite ranking was r = .98.

Table 1. Agreement (Inter-Rater Reliability) Among Combat Veterans Within Each Theater[1]

	I Veterans with Combat Experience Only in the Indicated Theater	II Veterans with Combat Experience in the Indicated Theater Plus Other Theaters	III Combined Sample of Veterans from (I) and (II)	Officer Veterans from (I) Compared with Officers from (II)	Enlisted Veterans from (I) Compared with Enlisted Men from (II)
	Officer vs. Enlisted	Officer vs. Enlisted	Officer vs. Enlisted	Officer vs. Officer	Enlisted vs. Enlisted
World War II Europe	.91	.93	.95	.91	.95
World War II Pacific	.77	.86	.92	.84	.87
Korea	.93	.96	.97	.94	.97
Vietnam	.95	.98	.98	.96	.94

[1] All tabled values are correlation coefficients determined using Spearman's Rank-Order Correlation Coefficient (r_s).

The final over-all rank position for each task is shown in Table 2. The rankings for the four individual theaters are also shown.

It is interesting to compare the results of the Phase I research against those of this study. The top ten tasks from both the Phase I and Phase II studies are compared in Table 3.

The following points summarize the more outstanding features of this comparison.

1) The most pronounced feature is the generally close correspondence between the two sets of results. Nine of the first ten tasks selected by the Phase I study appear among the top ten tasks of the Phase II study. While there are shifts in the ordering of the tasks, four of the top five tasks are common to both sets of results; and three of the next five most important tasks are common to both sets of results.

2) The major difference between the two sets of results is the increased importance in the triad results of CLEAR FIELDS OF FIRE and the decreased importance of USE COMPASS. These two tasks appear to have changed positions with each other in comparison with the Phase I results.

5. Conclusions

The following conclusions are tenable on the basis of the foregoing results.

1) The fact that combat veterans can agree so closely about what are the important tasks of combat infantry gives considerable confidence in the relevance of the criterion tasks which will comprise the Integrated Test Courses.

2) The high degree of agreement among veterans from different combat theaters about the importance of infantry tasks implies that the criterion tasks will have considerable stability over time.

Table 2. Ranking of Combat Tasks
All Combat Veterans Combined

Over-all Rank	Task	Europe	Pacific	Korea	Vietnam
1	Fire Weapon	1	1	1	1
2	Observe, Detect, Locate, Identify Hostile Targets	2	2	2	3
3	Load (Reload) Weapon	5	4	3	2
4	Perform Reconnaissance	4	3	5	4
5	Maneuver	3	5	4	5
6	Use Concealment and Camouflage	6	6	9	7
7	Use Cover	8	8	7	6
8	Construct Hasty Fighting Positions	7	7	6	11
9	Clear Fields of Fire	9	12	8	9
10	March/Move	11	11	13	8
11	Use Grenades	10	9	10	15
12	Use Radio/Telephone	13	10	12	12
13	Lay, Detect, Neutralize Mines, Booby Traps, Warning and Illuminating Devices	12	16	14	10
14	Hand to Hand Combat	14	15	11	17
15	Use Compass	17	13	16	13
16	Construct Shelters, Emplacements, Trenches	15	17	15	14
17	Carry Supplies and Ammunition	16	14	17	19
18	Construct Obstacles	20	19	19	16
19	Use Hand Signals	19	18	20	18
20	Lay Communications Wire	18	22	18	22
21	Remove Obstacles	21	20.5	21	20
22	Prepare, Adjust, Arrange Combat Load	22	20.5	22	21
23	Splice Communications Wire	23	24	23	24.5
24	Load/Unload Supplies	24	23	24	24.5
25	Carry, Load, Paddle Assault Boat	25	25	25	23
26	Use CBR Equipment	26	26	26	26
27	Drive Vehicle	27	27	27	27

Table 3. Comparison of Phase I and II Results

Phase I Study

Rank	The Top Ten Tasks Selected for Inclusion in the Triad Comparisons
1.5	Perform Reconnaissance
1.5	Maneuver
3	Observe, Detect, Locate, Identify Hostile Targets
4	Fire and Load Weapons
5	Construct Hasty Fighting Positions
6.5	March/Move
6.5	Use Grenades
8.5	Use Compass
8.5	Use Cover, Concealment & Camouflage
10	Use Radio/Telephone

Phase II Study

Rank	The Ten Most Important Tasks on the Basis of the Phase II Results
1	Fire and Load Weapon
2	Observe, Detect, Locate Identify Hostile Targets
3	Perform Reconnaissance
4	Maneuver
5	Use Cover, Concealment and Camouflage
6	Construct Hasty Fighting Positions
7	Clear Fields of Fire
8	March/Move
9	Use Grenades
10	Use Radio/Telephone

Rank	The Five Tasks Next in Importance
11.5	Clear Fields of Fire
11.5	Use Hand Signals
13.5	Lay, Detect, Neutralize Mines, Booby Traps, Warning and Illuminating Devices
13.5	Carry Supplies and Ammunition
15	Hand to Hand Combat

Rank	The Five Tasks Next in Importance
11	Lay, Detect, Neutralize Mines, Booby Traps, Warning and Illuminating Devices
12	Hand to Hand Combat
13	Use Compass
14	Carry Supplies and Ammunition
15	Construct Obstacles

B. Performance Courses - Philosophy of Development

1. General

Before reviewing the individual performance courses, it would be desirable to understand the general philosophy underlying the development, construction and operation of the courses. The purpose of each course was to develop a field test situation which would yield accurate and reliable data concerning the effects of clothing and protective equipment on the infantryman's ability to perform given criterion tasks.

2. Characteristics of Courses

The desirable characteristics which each field test situation should incorporate included:

- Tasks to be performed should simulate the combat environment to the extent possible and consistent with requirements for experimental controls to assure accurate and reliable data.

- Measures of performance should be objective and not subjective.

- Measures of performance should permit easy and accurate measurement.

- The situation should permit measurement of performance in each task segment (or event).

- The situation should, where desirable, allow for repeated measurement of performance.

3. Operation of Performance Courses

The actual conduct of the tests was done by test personnel assigned to the Methods Engineering Directorate, U. S. Army General Equipment Test Activity, Fort Lee, Virginia. The number of men available to conduct the tests varied but generally averaged 9 or 10 in number. Test subjects were also obtained from the same source and their availability in sufficient numbers for the periods of time required was a constraint on the design and conduct of the tests. In most cases, the number of subjects available for

testing varied between 10-23 men. These numbers are considered minimally adequate for the purposes of the Phase II tests.

The instrumentation utilized to collect data on the several courses varied in level of sophistication depending on the situation. In some cases ordinary stop watches were used, in other cases electric timers were appropriate, and in the case of the Fire and Reload Weapon Course a twenty-channel pen recorder was employed with inputs from a number of electronic sensors located in the test area. In most instances the instrumentation was quite adequate for the precision required and for the small amounts of data that were collected. In Phase III it is anticipated that a considerable increase in the level of sophistication of instrumentation will be required to handle the expected volume of data accurately, quickly, and economically.

C. Fire and Reload Weapon Course

1. General

The primary function of this research was to develop a field performance course which measures the effect of personal clothing and protective equipment on an infantry soldier's ability to fire and reload his rifle, as might be required when under enemy fire. Tests were conducted under two conditions: 1) firing and reloading with and without gloves, and 2) firing and reloading with and without gas masks.

2. Test Situation

The test situation in which subjects were required to perform was similar to that in which the lead scout of an infantry squad might find himself when the unit was attempting to contact the enemy. Briefly, a subject walked along a path visually scanning the terrain for potential targets. At some point in time a silhouette target, located at an unknown range, would appear and simultaneously a "gun fire simulator" located near the target would emit a short burst of machine gun fire to simulate the target having fired on the subject. The firing of the gun fire simulator was the subject's signal to move as quickly as possible to the nearest of several prepared firing positions in his vicinity and commence firing at the target. When the target was hit, it retracted and a second target appeared and "fired" at the subject. When the second target appeared, the subject shifted his fire to it and continued firing until he hit the second target. When hit, the second target retracted and the first reappeared and "fired" at the subject, who again shifted his fire. This process continued until the subject had emptied his weapon.* When his weapon was empty, the subject reloaded (8 round clip) and continued firing at the same pair of alternating targets. When the subject had fired 16 rounds (2 clips), he reloaded again, left the firing position and continued down the path, visually scanning the terrain for new targets. This sequence of activities continued until the subject had fired from 3 firing positions (16 rounds at each position).

As indicated above, performance was measured under two conditions: 1) the performance of subjects firing with gloves was compared to the performance of the same subjects firing without gloves, and 2) the performance of subjects firing with gas masks was compared to the performance of the same subjects firing without gas masks.

*M-1 rifles with 8 round clips were used.

3. Test Measures

Direct time and/or accuracy measures were obtained for the following activities which took place during each test trial:

- Time to take cover or assume firing position (prone or kneeling) after simulated fire.
- Time to fire first round, i.e., the time from having obtained cover to firing the first round (firing response time).
- Time to fire each round.
- Time to fire first effective round, i.e., the time from having obtained cover to when the first target was hit.
- Time to fire first clip, i.e., time from having obtained cover to clip ejection.
- Time to reload, i.e., time from clip eject to bolt closed.
- Time to fire first effective round with second clip, i.e., time from bolt closed to target hit.
- Time to fire second clip, i.e., time from bolt closed to clip eject.
- Number of hits with first clip.
- Number of hits with second clip.
- Total number of hits for both clips.

A number of other measures were derived from those basic measures listed above. These derived measures included:

- Rate of effective fire--first clip.
- Rate of effective fire--second clip.
- Rate of effective fire for both clips.
- Accuracy of fire for both clips. (Number of effective rounds ÷ total number of rounds fired.

- Rate of fire--first clip.
- Rate of fire--second clip.
- Rate of fire--both clips.
- Distribution of firing times for both clips (indicating central tendency and extent of variability).

4. Results

The measures which were analyzed were selected from those listed above as being measures most likely to be affected by the treatment conditions. This was necessary because of the time consuming process required to reduce the raw data, which had been recorded by means of a multi-channel pen recorder.

The Gloves vs. No-Gloves comparison showed that the time required to reload the weapon was longer with gloves than without gloves. These results were statistically significant for near targets but not for far targets, although the results were in the same direction. The accuracy of firing, as reflected by the total number of Hits for Both Clips, resulted in a significant difference only in the case of firing from the Kneeling Position at the Near Targets. A similar tendency was indicated for the Prone Position at Near Targets, but this difference was not significant. Accuracy at the Far Targets was considerably lower and yielded no significant differences.

Comparison of performance between Gas Masks vs. No Gas Masks indicated significant differences on several measures. Firing Response Time (timing from having obtained cover to firing the first round) is significantly longer with the Gas Mask than without the Gas Mask when firing at near targets using the kneeling position. While not significant, this tendency was also present firing against far targets in the kneeling position as well as against near and far targets using the prone position. Significant differences were also found for Total Time to Fire Both Clips against near targets for both kneeling and prone positions. There was no apparent differential effect of Gas Masks on accuracy, although data on Effective Rate of Fire suggest that this might be the case.

5. Conclusions

The magnitudes of the differences detected as significant in the cases of Reload Time -- Gloves vs. No Gloves, Near Targets, and Total Time to Fire

Both Clips -- Gas Masks vs. No Gas Masks, Near Targets, are interpreted to indicate that, in general, the Fire and Reload Course is sensitive to a practically useful extent. As a consequence, the Fire and Reload Course should be included as part of the Final Integrated Test Course.

D. Maneuver Course

1. General

The primary objective of this research was to develop a field performance course which measures the effect of personal clothing and protective equipment on an infantry soldier's ability to maneuver (i. e., to run, jump, crawl and climb) as might be required when under enemy fire. In general, subjects were required to perform on the course while carrying different weighted combat packs. Subjects were also tested under conditions while wearing armored vests and without wearing armored vests.

2. Test Situation

The test course on which the subjects performed was similar to many obstacle courses in common use at many Army training camps. The course consisted of seven events designed to represent a synthesis of the many maneuvering tasks men might be called upon to perform in combat. These seven events included: two 50 yard dashes, an "obstacle course," an overhead ladder, a debarkation net, a running jump, and a crawl event. The nature of most of these events is described by their titles, however, the obstacle course event merits a brief description. The obstacle course was primarily a running event, 100 yards in length. It was designed to simulate the need to run in a "broken field" or zig zag fashion, avoiding obstructions and scaling moderate obstacles. The events on the Maneuver Course were arranged so that subjects began with the two 50 yard dashes, then went to the obstacle course, the overhead ladder, the running jump, the debarkation net and finally the crawl event. The course was designed so that the end point of one event was the starting point of the next event. These starting and ending points for the events were marked by a number of sandbags arranged in the form of a fighting position (i. e., a prone firing position). Thus, subjects began and ended each event in the prone position, behind the sandbags with their rifles in a firing position.

The manner in which subjects performed these events is as follows: 1) at the starting point of the first dash the subject assumed a prone position behind the sandbags with his rifle in a firing position; 2) upon a signal from an Observer/Recorder (O/R) the subject rose to his feet, ran 50 yards and fell to the ground and assumed a firing position behind another set of sandbags; 3) upon a signal from a second O/R the

the subject again rose to his feet and performed the second 50 yard dash in the same manner as the first dash. This procedure was applied to the remaining events on the course with O/R's at the ending and starting points of all events.

Subjects were tested under two basic test conditions. In the first series of tests subjects performed while wearing armored vests and these results were compared to their performance without armored vests, we refer to this test as the vest vs. no vest" test. In the second series of tests subjects carrying three different weighted combat packs. The weights of these different combat packs were 10, 25 and 40 pounds. A third series of tests were conducted with weighted combat packs. This series of tests was scheduled after the results of the original tests on weighted combat packs were available and it was apparent that the dash events were not discriminating. On the assumption that the first two dash events were acting as pre-stressors for other events that proved discriminating, it was decided to add a third and fourth dash to the end of the Maneuver Course thus having the entire course serve as a pre-stressor for these two final dashes. With this in mind the third series of tests were conducted with the objective of determining the effect of pre-stressing on dash performance with weighted combat packs. The pack weights used in this test were 15, 30 and 45 pounds. This change in weights was instituted because a better distribution of weight in the pack and about the harness and belt could be effected if the minimum load condition was 15 pounds. Data were collected in this series of tests only on performance comparisons between the 15 vs. 30 pound packs and the 30 vs. 45 pound packs for reasons of economy of time and availability of subjects.

3. Test Measures

The performance measure utilized for all events on the Maneuver Course, excepting the jump event was the time (in seconds) to complete the event. Performance for the jump event was measured in feet and inches by an O/R. No other performance measures were obtained.

4. Results

With regard to the vest vs. no vest comparisons the statistical analysis of the data yield significant differences in favor of the no vest condition for performance on only the debarkation net event. All other events failed to discriminate between the vest vs. no vest conditions.

The first series of tests on the weighted combat packs (pack weighs 10, 25 and 40 pounds) yielded more encouraging results. The following events discriminated between pack conditions; obstacle course, debarkation net, crawl course and the jump event. More specifically, on the Obstacle Course subjects performed significantly better with the 10 pound pack than with the 40 pound pack. On the debarkation net, the crawl event and the jump event men performed significantly better with the 10 pound pack than with either the 25 or 40 pound packs. No analysis was performed on the overhead ladder event because not enough subjects were able to complete the event to justify statistical treatment of the data. However, for those subjects who completed the event the data indicate performance differences in favor of the light packs over the heavier packs. The dash events yielded no significant differences in performance among the different weighted packs.

The results of the additional testing with the weighted combat packs yielded significant performance differences in favor of the 15 pound pack vs. the 30 pound pack on the second dash and third and fourth dashes when the latter two were performed following performance on the entire Maneuver Course. The comparison of performance with the 30 and 45 pound packs resulted in significant performance differences on the second dash but the third and fourth dashes failed to discriminate as they had with the lighter packs.

5. Conclusions

The magnitudes of the differences detected as significant--primarily in reference to the weighted combat packs--are interpreted to indicate that, in general, the events comprising the Maneuver Course are sensitive to a practically useful extent. As a consequence, this performance course should be included as part of the Final Integrated Test Course.

E. March/Move Course

1. General

The primary objective of this research was to develop a field performance course which measures the effect of personal clothing and protective equipment on an infantry soldier's ability to march under conditions similar to those in a combat area. In general, subjects were required to march for extended periods of time over two prescribed routes representing several types of terrain and carrying packs of varying weights. The effect of the different weighted packs on performance was the issue of interest in this study.

2. Test Situation

The test situation in which the subjects performed was designed to simulate marching under tactical conditions in a combat zone. The major difference, of any consequence, between the test and combat environments was the fact that men marched alone instead of as a unit. Thus, the rate at which the men marched was self-paced. The tests were conducted over two prescribed paths representing different types of terrain. Both paths were continuous, i.e., formed a "closed loop," and were called the "Flat Track" and the "Hilly Terrain" course. The flat track was .489 miles in length, and, as its name implies, was almost flat like a track for foot races. The hilly terrain course was .198 miles in length and consisted of a number of relatively steep grades and generally rough terrain. The flat track was used to simulate march conditions that might be encountered in combat while men were using roads as part of the route. The hilly terrain course was designed to simulate marching conditions across country or on paths.

Test subjects were required to march ten miles around the flat track carrying combat packs of three different weights (pack weights were 15, 30 and 45 pounds). Thus, a subject was required to march on the flat track ten miles with the 15-pound pack, ten miles with the 30-pound pack, and ten miles with the 45-pound pack. Subjects were not required to march more than ten miles on any given day. Regarding the hilly terrain course, only the 15 and 30-pound packs were used. Because of its difficulty, it was doubtful that enough subjects would be able to complete the ten miles, and consequently would result in a sample of data too small for adequate analysis.

The majority of the data collected was obtained under the test conditions described above. However, an additional experiment was undertaken on the flat track which involved pre-stressing subjects on the Maneuver

Course and then having them march only five miles. The purpose of this experiment was to determine if some kind of pre-stressing of subjects would permit a reduction in the number of miles marched by subjects and a consequent reduction in the time required to obtain reliable and sensitive data.

3. Test Measures

The performance measures obtained for all tests were the time each subject required to traverse each lap of the particular course on which he was performing. Thus, on the flat track, measures were obtained on the time each subject took to traverse each .489 miles and on the hilly terrain course time was obtained for each .198 miles. The statistical analyses used only the data obtained for the last three miles of the flat track and the last 3-1/2 miles of the hilly terrain course. Analysis of preliminary data had indicated that it was this portion of the data that differentiated between the various weighted pack conditions. The reason for the use of slightly different segments of performance between the flat track and hilly terrain course was primarily a matter of convenience and was related to the lap lengths of the two prescribed paths.

4. Results

The analyses of the data from both the flat track and hilly terrain course proved very satisfactory. With regard to the 10-mile march on the flat track, the mean times to traverse the last three miles were smallest for the 15-pound pack and largest for the 45-pound pack. The means for both the 15-pound pack and 30-pound pack were statistically significant when tested against the mean of the 45-pound pack. However, the means of the 15-pound and 30-pound packs, when tested against each other, proved not to be significant. The second experiment, dealing with the flat track, where subjects were pre-stressed by the Maneuver Course followed by a five-mile march, yielded essentially the same results as those for the 10-mile march on the flat track, except that comparisons of all combinations of packs proved to be statistically significant and in favor of the lighter packs. Thus, this test proved to be the more sensitive of the two flat track tests. Further, these results indicate that, in the future, five-mile marches, when preceded by performance on the Maneuver Course, will yield more precise and sensitive data than the 10-mile march.

The data from the hilly terrain course, where the 15 and 30-pound packs were compared over a distance of ten miles, produced results similar

to those of the flat track studies. Better performance was obtained with the 15-pound pack than with the 30-pound pack, and the differences in performance were statistically significant.

5. Conclusions

The magnitudes of the differences detected as significant with the weighted combat packs are interpreted to indicate that both the Flat Track and the Hilly Terrain Course are sensitive test situations and will differentiate among clothing and protective equipment to a practically useful extent. As a consequence, this performance course should be included as part of the Final Integrated Test Course.

F. Grenade Course

1. General

The primary objective of this research was to develop a field performance course which measures the effect of personal clothing and protective equipment on an infantry soldier's ability to throw hand grenades under simulated combat conditions. Subjects were required to throw grenades at two general types of targets. The first type of target represented a machine gun emplacement on the ground, while the second target simulated the task of throwing a hand grenade through a window, as is often required during street fighting. For each of these types of targets, performance measures were obtained under two test conditions. In one case, performance was measured when the throwing was done with and without gloves, and in the second case, performance was measured when subjects threw grenades while wearing packs of different weights. The different packs were designated as A, B and C and weighed 15, 30, and 45 pounds respectively.

2. Test Situation

Test subjects were required to perform under several situations which were analogous to general combat situations and, to the extent possible, simulated the combat situations. With regard to the emplacement type target, the subject walked along a prescribed path with his rifle at the ready position. At some point in time, and unknown to the subject, a machine gun simulator would fire a short burst at the subject. This was the signal for the subject to fall to the ground, prepare a hand grenade, and throw the grenade at the emplacement target as quickly and accurately as possible. As soon as the throw was completed, the subject was permitted to move along the path and the sequence of activities was repeated twice more. Actually, two prescribed paths were used; both were circular in nature and thus all points on a given path were equidistant from the emplacement target. The paths themselves are best described as having radii of 20 meters and 35 meters with the target as the center. When a subject performed on the 20-meter path, he threw his grenades from the prone position while, when throwing from the 35-meter path, he threw from the standing position. The target area consisted of the emplacement target in the center with a series of concentric scoring rings and thus resembled a bulls-eye target on the ground. Figure 1 is a schematic diagram of the test setting employed for the emplacement target.

The situation for measuring throwing performance on the window type target was somewhat different than for the emplacement target. In

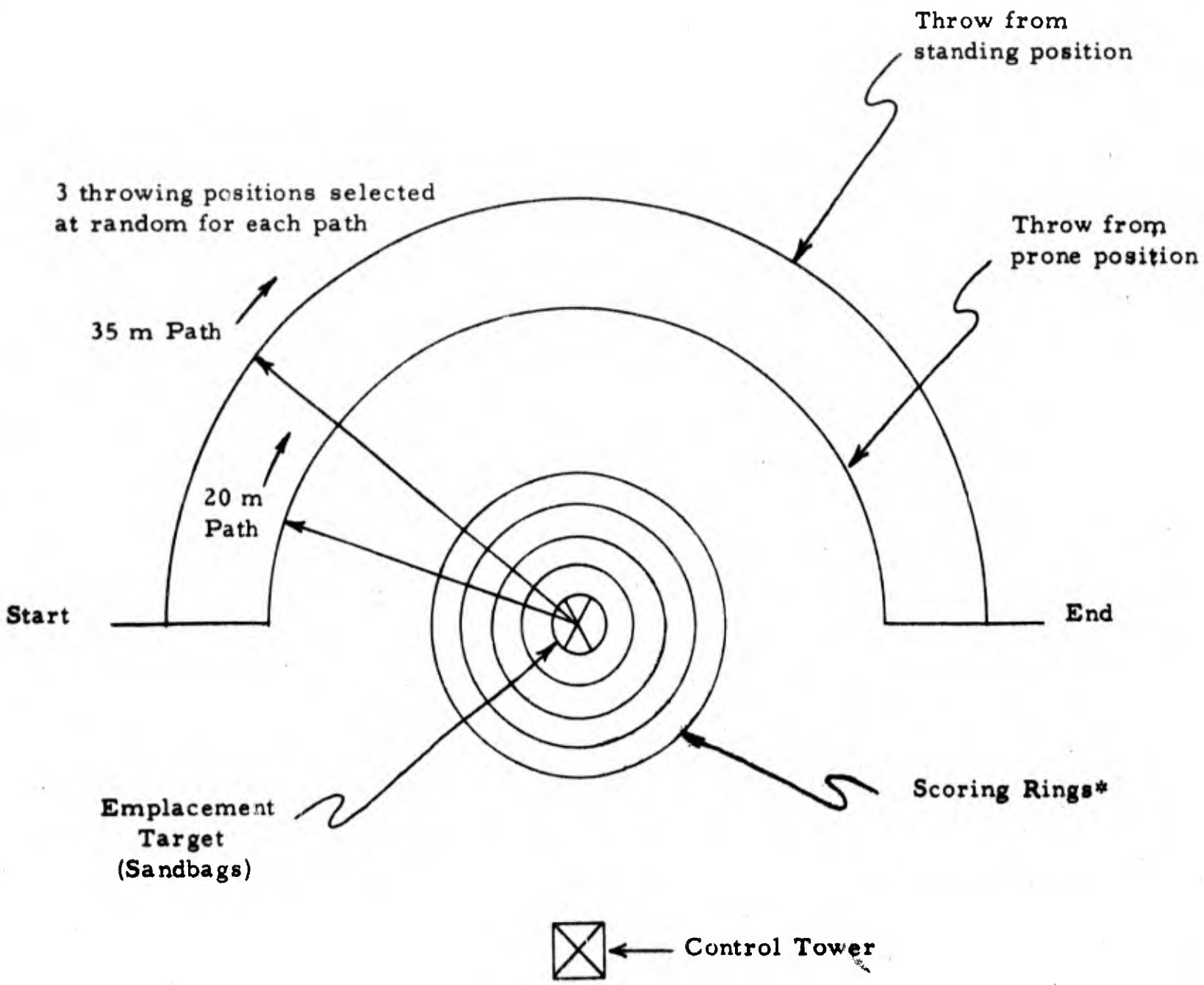

Figure 1. Schematic diagram of test setting for Hand Grenade Emplacement Target.

*Thirteen scoring rings were used, each ring being 5 ft. in width.

this case, a subject started from a prone position behind a low row of sand bags. At the signal to start, the subject jumped up and dashed 30 yards to another sand bag position, took cover in the prone position, prepared his grenade, rose to the kneeling position, threw his grenade and then returned to the prone position. This procedure was repeated until the subject had thrown six grenades for each of the experimental conditions tested. Hits on the target and near misses were scored automatically.

3. Test Measures

The primary measures obtained for both types of targets were time to perform various segments of the activities performed and accuracy of throwing. With regard to the emplacement target, the following measures were obtained:

- Throwing response time for each grenade. (Measured from time of machine gun fire to throwing of grenade.)
- Accuracy of throw. (Measured in terms of the scoring ring in which the grenade detonated.)

The performance measures obtained for the vertical window target were as follows:

- Throwing response time for each grenade. (Measured from the time the subject assumes the prone position, following the dash, to the time the grenade is thrown.)
- Accuracy of throw. (Measured in terms of the automated scoring rings built into the target.)
- Time to run the 30-yard dash. (Measured from the start signal until subject assumes prone position behind sand bags at throwing position.)

4. Results

The statistical analysis of the data collected under the various test conditions provided the following results. With regard to the tests on emplacement targets with different weighted packs, it was found that throwing response time at the 20-meter range is significantly better for the 30-pound pack than for the 45-pound pack. A similar relationship was not found for the tests at

the 35-meter range. No significant relationships regarding accuracy of throwing were found in this series of tests. The series of tests comparing performance with and without gloves on the emplacement target gave similar results. Significant performance differences in throwing response time in favor of the without gloves condition were found at the 20-meter range. No other significant relationships were found for this series of tests.

With regard to the series of tests on the window target, no statistically significant performance differences were observed for either of the experimental treatments (weighted combat packs, and Gloves vs. No Gloves) so far as both throwing response time and accuracy were concerned. However, the 30-yard dashes proved to discriminate among different weighted packs.

5. Conclusions

The magnitude of the differences detected as significant with the weighted combat packs and those detected as significant under the Gloves vs. No Gloves conditions is interpreted to indicate that the Grenade Course will be sensitive to a practically useful extent. Both the emplacement target event and the vertical window target event will yield performance measures which are sensitive to the effects of personal clothing and protective equipment on the throwing of hand grenades. As a consequence, the Grenade Course should be included as a part of the Final Integrated Test Course.

G. Hasty Fighting Positions Course

1. General

The primary objective of this research was to develop a field performance course which measures the effect of personal clothing and protective equipment on an infantry soldier's ability to dig hasty fighting positions (foxholes) under simulated field conditions. Tests were conducted under two conditions: 1) digging while wearing gas masks, and 2) digging without wearing gas masks.

2. Test Situation

The test situation required the subjects to perform the following tasks. First, the subject ran three 100-yard dashes with a short rest between dashes, then he was asked to dig a foxhole. The purpose of the dashes was to pre-stress the subject in order to make the measurement of digging performance more sensitive. The ground in which the men dug had been carefully prepared to assure that its physical condition was the same for all subjects and from day to day.

The method and the associated results reported here represent only one of a number of methodologies attempted during the course of the research. All other methodologies attempted failed to yield reliable data and thus were discarded in favor of the final method reported here. A description of the discarded measurement techniques will be found in a detailed report on this course and referenced in Section I. C. These discarded methodologies, while yielding unreliable data, were more realistic simulations of the combat environment. It was felt that these more realistic situations lacked adequate experimental controls for collection of reliable data. As a consequence, we were forced to make successive concessions in the test situation in favor of control and at the expense of realism in order to obtain the necessary reliability in the data.

The actual environment in which subjects were required to dig is described briefly below. When a subject approached the area where he was to dig, he found marked out on the ground a rough outline of the area in which he was to dig his foxhole. Beside this prepared digging area was a large box suspended from a forklift truck. A portion of the box was below the surface of the ground (a hole was prepared for the box), as shown in Figure 2. Figure 2 also shows a subject wearing a gas mask digging a foxhole and throwing dirt into the box. A load cell was attached to the suspension mechanism and continuously measured the weight of the dirt dug and thrown into the box.

Figure 2. Subject Digging Foxhole in Final Test Situation.

3. Test Measures

The primary performance measures obtained were: 1) the time to dig 700 pounds of dirt, and 2) the time to dig 1400 pounds of dirt. Secondary time measures were obtained on each of the three 100-yard dashes used to pre-stress the primary task.

4. Results

The statistical analysis of the data yielded very satisfactory results. With regard to the primary task of digging, it was found that men performed significantly better without gas masks than when wearing gas masks. This was true for both the first and second 700-pound samples measured; however, the second 700-pound sample appeared to be the more sensitive of the two measures. Regarding the secondary task (the pre-stressing dashes), all of the data collected were in favor of the No Gas Mask condition. Further, the statistical analysis of the data for the first, second and third dashes indicated that performance under the No Gas Mask condition was better than with the Gas Mask, and that these differences in performance were statistically significant.

5. Conclusions

The magnitudes of the differences detected as significant between the Gas Mask vs. No Gas Mask conditions in digging hasty fighting positions are interpreted to indicate that the Hasty Fighting Positions Course is sensitive to a practically useful extent. As a consequence, this performance course should be included as part of the Final Integrated Test Course.

H. Reconnaissance, Cover, Concealment and Camouflage Course

1. General

The primary objective of this research was to develop a field test situation that would yield accurate and reliable data concerning the effects of clothing and protective equipment on the infantryman's ability to move quickly and quietly using concealment, cover, and camouflage, and perform those activities characteristic of a reconnaissance task. A secondary objective was to develop, as part of this test situation, tests to measure the effect of clothing and protective equipment on a soldier's ability to use a compass and a radio/telephone.

Because of difficulties in obtaining suitable real estate on which to construct the course and other difficulties in obtaining adequate instrumentation, the research effort was not completed during Phase II. Therefore, this report presents preliminary findings that are the results of the work accomplished to date.

2. Test Situation

a. Description of Course

The course is shown schematically in Figure 3. The terrain chosen for the course is fairly flat and located at the edge of a wooded area. The wooded area consists of young Georgia Pines and various young deciduous trees with a pine needle floor and a moderate amount of undergrowth. The course is a path traversing the edge of the wooded area, and varies in width from about 30 to about 10 meters. The lateral boundaries are marked with engineer's tape. There are two legs in the course, each about 400 meters long. Leg A begins at the Starting Point of the course (see Figure 3) and ends at Contact Point A. Leg B starts at Contact Point A and ends at Contact Point B, which is also the end of the course.

The performance of subjects was observed from an Observers' Tower located in the open area. Observers in the tower, using binoculars, could see almost to the far boundary markers of each leg of the course.

b. Subjects' Tasks

The subjects were required to start from a prone position and were to proceed along Leg A (staying within the boundaries) to Contact Point A as quickly and as quietly as possible, taking advantage of available

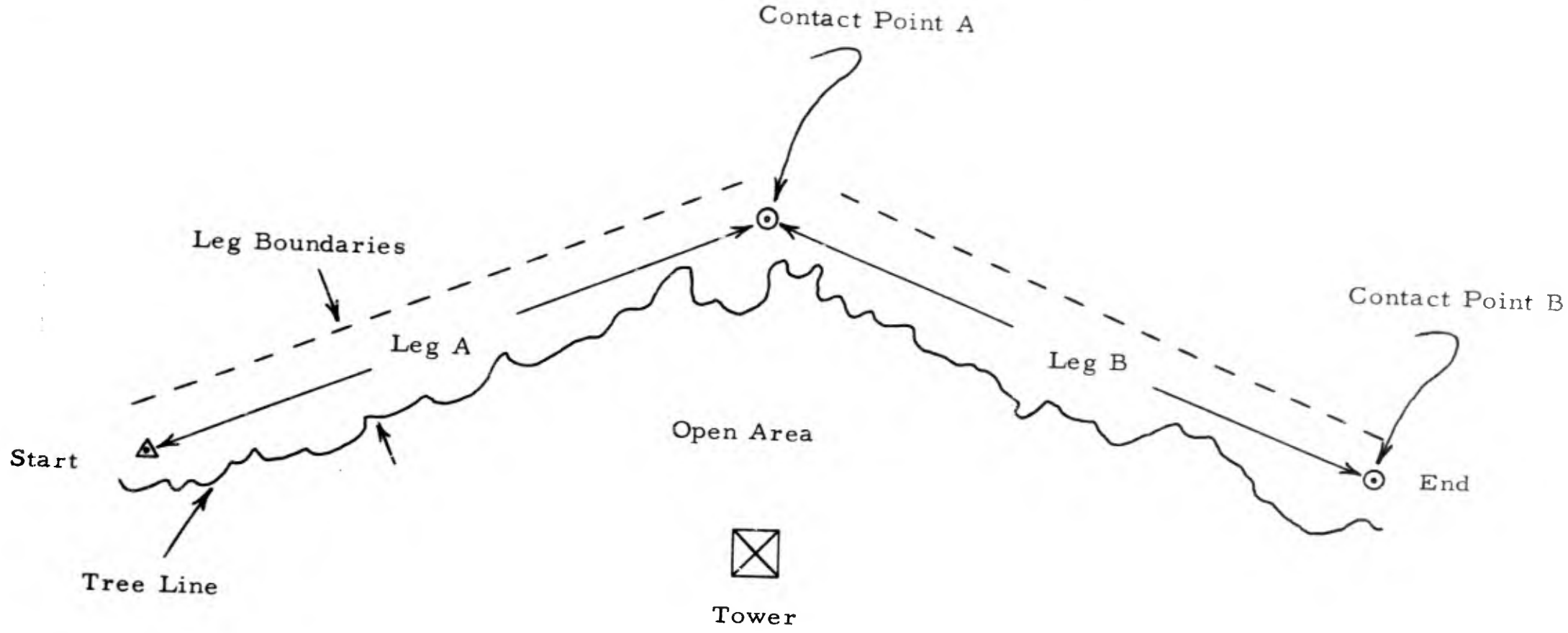

Figure 3. Schematic Diagram of Reconnaissance, Cover, Concealment and Camouflage Course (not to scale)

Note: Length of Legs A and B approximately 400 meters.

cover and concealment. Each subject was aware that observers were located in the Tower and were attempting to observe his movements. Upon arrival at Contact Point A, the subject was required to receive a 20-digit message via telephone and then transmit the same message back to the source. The subject was also asked to take an azimuth reading with a compass on a known mark painted on the Observation Tower. When these tasks were completed, the subject proceeded to "run" Leg B and accomplish similar telephone and compass tasks at Contact Point B.

c. Data Collection Technique

All data were collected by four O/R's stationed in the Observation Tower. All four O/R's in the tower simultaneously observed the movements of one subject as he traversed the several legs of the course. Each O/R was equipped with binoculars for search and observation. Each was also equipped with a pushbutton controlled device that enabled them, individually, to record the number of times that the subject exposed himself as well as the total time the subject was exposed during each leg of the course. The recorder was attached to the binoculars, and when an O/R saw a subject he activated the button, starting a timer and pulsing a counter for one unit. The O/R continued to hold the button in the active position until the subject disappeared from view, at which time he released the button stopping the timer. In this way separate and independent time and frequency scores were obtained from each O/R every time a subject traversed the course.

To assist the O/R's in the Observation Tower, and to assure that they were all looking where the subject could be seen, a Ground Location O/R was assigned to each subject.* His function was to report to the tower, by means of a PRC-6 radio, the location of the subject in terms of sectors into which each leg was divided. These sectors were easily identified from the tower. These elaborate arrangements were necessary to assure the comparability and reliability of the data collected by the four O/R's in the tower. Several other O/R's were required to insure that the tests ran smoothly. Their functions and those of all other test personnel are presented in detail in the Appendix.

d. Instrumentation

The instrumentation required to collect data has already been described in part in the preceding paragraphs. Beyond the binoculars, the special frequency counter-timing device, and the associated clocks the instrumentation required to operate the course consisted of a communications net linking the Observation Tower and all participating O/R's.

*The Ground Location O/R wore "cook's whites" and yellow helmet so that the Tower O/R would not confuse him with the subject who wore fatigues and fatigue hat.

It should be noted here that another instrumentation concept was considered but had to be discarded due to the unreliability of the measures obtained during preliminary tests. This concept involved providing the O/R's in the Tower with M-14 rifle simulators. The simulators are infrared devices which look and operate like the M-14 rifle but emit a narrow infrared beam when fired and can sense a hit when a heat source (a man) is in the emitted beam. The device is currently under development for the U. S. Naval Training Devices Center, Port Washington, New York, by Aircraft Armaments, Cockeysville, Maryland. It was planned to use as performance measures the time it took a subject to traverse each leg of the course, the number of times an O/R fired at the subject, and the number of times the O/R hit the subject. Unfortunately, preliminary tests indicated that there was too much variability among O/R's, both as observers and as marksmen, to yield reliable data, and consequently this instrumentation concept was discarded in favor of the previously described technique.

e. Experimental Conditions

The tests that were conducted on this course attempted to compare the performance of subjects while wearing gas masks vs. their performance without gas masks. Each subject performed once under both conditions. The order of presentation of conditions was counterbalanced to offset the effects of practice and learning.

3. Test Measures

The following direct measures were obtained for each leg of the course:

- Time to complete leg
- Number times observed per leg (frequency of exposure)
- Total time observed per leg (exposure time)
- Number of errors in receiving messages
- Number of errors in transmitting messages
- Accuracy of compass reading
- Time to make compass reading

The following measures were derived from the direct measures listed above:

- Total time to complete both legs
- Frequency of exposure for both legs
- Total exposure time, both legs
- Per cent exposure time of total time, both legs

The Total time observed and the Number of times observed (on each leg) was averaged from records of the four tower O/R's in the following way. The average of the four records was computed; the one record most deviant from the average was discarded, and a new average using the three remaining records was computed. This average of three records was used as the subject's performance measure. Separate measures were computed for each leg of the course and each experimental condition. This procedure was developed from an early sample of data and verified on an independent sample of data before it was applied to the data being reported here.

4. Results

The data collected on the ability of subjects to traverse the two legs of the course were analyzed by an analysis of variance technique. In general, the analysis showed performance differences in favor of the no gas mask condition vs. the gas mask conditions. Specifically, statistically significant differences in favor of the no mask condition were found for the following derived measures: Total time to complete both legs, and Frequency of exposure for both legs. No other measures subjected to analysis yielded significant results. The analysis did indicate that the two legs of the course were not of comparable difficulty.

No useful data were obtained on either the telephone or compass tasks due to the inability of subjects to follow instructions or to their unfamiliarity with the equipment involved or to their failure to retain the skills and knowledges in the use of the equipment taught them in Basic Training.

5. Conclusions

The results so far obtained are indeed encouraging, for they indicate that performance in this very difficult task situation can be measured objectively

and reliably. The results further indicate that the course is sensitive to performance differences resulting from differences in the clothing and protective equipment worn by subjects performing on the course. However, it must be emphasized that these results are preliminary in nature and only suggest, not confirm, that the research is moving in the proper direction.

More research is required during Phase III of the project before this course can become a part of the Final Integrated Test Course. The research in Phase III on the Reconnaissance, Cover, Concealment and Camouflage Course should be directed toward the following objectives:

1) Validation of the present methodology

2) Simplification of the methodology--fewer O/R's to run the course, better instrumentation techniques, etc.

3) Maintenance and improvement of course reliability and sensitivity

4) Development of adequate techniques for measuring performance in the use of the radio/telephone

5) Development of adequate techniques for measuring performance in the use of the compass.

I. Target Detection Course

The purpose of the Target Detection Course is to measure the effect of clothing and protective equipment on a soldier's ability to observe, detect, locate and identify targets. This is one of the special tasks identified in the Phase I report as being affected by only a limited number of clothing items such as headwear.

Work on this course has not progressed beyond the preliminary planning stages primarily because of the requirement for a large amount of real estate that could not be met during Phase II. Current plans for this course would require a subject to observe an area in which is located a number of different targets. The subject's task will be to detect, locate and identify these targets as quickly and accurately as possible. It is planned that the targets will be real equipment positioned to take advantage of the cover and concealment offered by the terrain. Included among the targets will be a variety of tanks and other vehicles. Most of these vehicles have been requisitioned and are now at Camp Pickett, Virginia, where the Phase III work will be conducted. It is now thought to be desirable to take two or more independent measures of each subject's performance, and to conduct the test under various environmental conditions including day and night operation.

Research in Phase III will be directed toward the development of a Target Detection Course that provides a stable and satisfactory performance measure and can thus become part of the Final Integrated Test Course.

J. Physiological Testing

1. Background

The primary objective of this research is and has been the development of a methodology for measuring the effects of personal clothing and protective equipment on the combat effectiveness of the individual field soldier. It was recognized that the test methodology must provide for objective measures of the activities of troops in the field. And, of course, measurement must be in units that are meaningful to success in combat and are reliable and relatively easy to acquire. Initially, two types of objective measures were most likely to refer to combat effectiveness: physiological and task performance. Since measures of a large number of physiological conditions seemed unwieldly to obtain under field conditions the early emphasis of the program was on measuring field performance directly, by employing objective units of speed in performing a task and task accuracy. Even though the decision was made to concentrate on direct performance measures the research staff felt that physiological measures should be investigated for their utility in the over-all program. This feeling was reinforced by the Committee on Field Testing, Advisory Board on Military Personnel Supplies, Division of Engineering and Industrial Research of the National Academy of Sciences--National Research Council. The Committee after reviewing the work done in Phase I urged that research be conducted in an attempt to "relate the overt behavior of the individual to the metabolic cost of physiological degradation that occurs when a man is stressed." Subsequently, during Phase II and in the Spring of 1964, exploratory discussions were held with physiologists from the U. S. Army Research Institute of Environmental Medicine, Natick, Massachusetts. It was suggested that measures such as pulse rate, skin temperature and rectal temperature would be easy to obtain in a field situation and might have some relationship to the performance under study during Phase II. The decision was made to conduct a series of preliminary tests in June 1964 to determine the feasibility of relating physiological measures to performance measures.

2. Test Situation

Three series of tests were actually conducted, one in June 1964 and two in September 1964. Subjects were required to run the Maneuver Course (including four 50 yard dash events--two at the beginning and two at the end) followed by a five mile march on the Flat Track of the March/Move Course. For the treatment conditions, subjects carried

two differently weighted combat packs. Pack A weighed 15 pounds and Pack B weighed 30 pounds. During the first two series of tests subjects performed under both pack conditions and the order of presentation was counterbalanced. The third series of tests utilized two groups of matched subjects, one group using the A pack and the other the B pack.

3. Test Measures

The performance measures obtained on the Maneuver and March/Move Course were identical to those described previously in this report. The physiological measures were pulse rate, skin temperature and rectal temperature. These measures were obtained while subjects were performing on the courses with minimum interference to the activity. Pulse rate was obtained by a trained O/R. Skin and rectal temperatures were obtained with the aid of an instrumentation package. This "package" was designed to permit the sensor units to remain in their proper positions without interfering with the subject's activities. Electrical leads extended from the sensors to a "plug-in" type connector located on the subject's belt. In order to obtain temperature data an O/R, equipped with a special readout unit, simply plugged to the connector on the subject's belt and recorded the measures.

4. Situational Factors

During the course of the tests, a number of situations arose that tended to degrade the quality and reliability of the data and hence the results. The nature of these unexpected situations is illustrated by the example that occurred during the first series of tests when some of the readout units for the temperature data were not compatible with the connector units worn by the subjects. As a consequence, some of the data on skin temperature were lost (no difficulty was experienced regarding rectal temperature). In another example, during the second series of tests, all subjects failed to complete their second five mile march because of medical problems, e. g., blisters and other discomforts. During the third series of tests (in September 1964) there was a rash of minor incidents that resulted in the loss of data on different events, for example, an O/R reading a timer incorrectly, or a subject falling down and suffering a minor injury.

The most important factor affecting the results of the physiological tests, was the small number of subjects available to perform the tests. The size of the groups of subjects in each of the test series was therefore too small for confident statistical treatment of performance data. Some of the data were, however, subjected to statistical manipulation in order to explore possible directions and meanings in the information collected during the physiological tests.

5. Results

The data for each series of tests were subjected to a graphic analyses. Summaries of these analyses are presented in Tables 4, 5 and 6. Each table summarizes a complete test series, including the number of subjects, experimental treatments, test conditions, experimental controls, the performance measures obtained, the type of analyses applied and a qualitative interpretation of the analyses. These tables aid in comparing the results across the three series of tests.

Briefly, the analyses of the performance course data tend to confirm the results of the previously reported studies on both the Maneuver and March/Move courses. However, the physiological data, viewed across the several series of tests, indicate no clear patterns of trends and seem confusing and apparently contradictory. The exploratory information does not appear to relate consistently to either the independent test variables (clothing and equipment condition) or to the task performance measures. We also feel that testable, meaningful hypotheses about human performance are not easily developed on the basis of this physiological information.

6. Conclusions

We conclude, from work completed to date, that there is insufficient information on which to judge the usefulness of physiological information within the framework of this research program. Additional study is required to resolve this question, i. e., to assure that physiological information could be considered relevant to the goals of the program. We expect to probe this matter during the Phase III effort.

Table 4. Summary of Physiological Test
(First Series)

Dates of Test:	June 23, 24, 25, 26, 1964
Number of Subjects:	N = 8
Treatments:	Packs, A(15 lbs) vs. B (30 lbs)
Conditions:	Maneuver Course - with 4 dashes March/Move Course - Flat Track (5 miles)
Controls:	Repeated Measures Counterbalanced trials
Measures:	Performance Maneuver Course - Time to complete each lap March/Move - Time to complete each lap Physiological Pulse Rate Skin Temperature Rectal Temperature
Analysis:	t-test

Results:

Performance Measures (Differentiated between Packs in Favor of A pack) | Physiological Measures

	Event	Favored Pack	t-test	Pulse	Skin Temp.	Rectal Temp.
M/M Maneuver Course	1st Dash	A	N.S.	No t-test-too many reversals No trends	t-tests N.S. B pack consistently lower temp.	t-tests N.S. B pack consistently lower temp.
	2nd Dash	A	Sign.			
	Obstacle	A	N.S.			
	Ladder	B	N.S.			
	Jump	A	Sign.			
	Net	A	Sign.			
	Crawl	A	Sign.			
	3rd Dash	A	Sign.			
	4th Dash	A	Sign.			
	Laps 2-10	A	Sign.		No t-test N too small*	**

* Due to wrong read out instruments

** Lower B pack temperature approaching significance $p < .10$

Table 5. Summary of Physiological Test
(Second Series)

Dates of Test: September 14, 15, 1964

Number of Subjects: N = 5

Treatments: Packs, A(15 lbs) vs. B (30 lbs)

Conditions: Maneuver Course - with 4 dashes
March/Move Course- Flat Track (5 miles)

Controls: Repeated Measures
Counterbalanced trials

Measures: Performance
Maneuver Course - Time to complete event, feet jumped
March/Move - Time to complete each lap
Physiological
Pulse Rate
Skin Temperature
Rectal Temperature

Analysis: Graphic (N too small for statistical analysis)
(Incomplete replication on March/Move)

Results:

Performance Measures — Physiological Measures
Trends in favor of A Pack

	Event	Favored Pack	Pulse	Skin Temp.	Rectal Temp.
Maneuver Course	1st Dash	A	No trends - Many reversals "Generally lower during March/Move"	No trends-Many reversals	Slight increase in temp. for both packs over time. No other trends
	2nd Dash	A			
	Obstacle	A			
	Ladder	A			
	Jump	A			
	Net	A			
	Crawl	A			
	3rd Dash	A			
	4th Dash	A			
March/Move	Laps 2-10	Incomplete data - No subject completed both marches.			

Table 6. Summary of Physiological Test
(Third Series)

Dates of Test: September 16, 17, 1964

Number of Subjects: Total N = 11 (Divided into two groups)

Treatments: Packs, A (15 lbs) N = 6; B (30 lbs), N = 5

Conditions: Maneuver Course - with 4 dashes
March/Move - Flat Track (5 miles)

Controls: Matched Groups (matched on weight)
One trial per subject

Measures: Performance
Maneuver Course - Time to complete event, feet jumped
March/Move - Time to complete each lap
Physiological
Pulse Rate
Skin Temperature
Rectal Temperature

Analysis: Graphic (Group N's too small for statistical analysis)
(Incomplete data in some cells)

Results:

Performance Measures
Generally favor A pack

Physiological Measures

	Event	Favored Pack	Pulse	Skin Temp.	Rectal Temp.
Maneuver Course	1st Dash	B	No trends - Many reversals	No trends	Lower for A pack
	2nd Dash	A			
	Obstacle	A			
	Ladder	B			
	Jump	A			
	Net	A			
	Crawl	A			
	3rd Dash	A			
	4th Dash	A			
March/Move	Laps 2-10	A*		Lower for B pack	No trends

* Performance favored B pack on one lap.

IV. PHASE III - PLANS

This phase has two primary objectives:

1. Tryout, evaluation and final refinement of an integrated test course.

2. Collection of performance data and evaluation of the utility of norms based on these data.

The testing to be accomplished during this phase will take place at Camp Pickett, Virginia. Adequate real estate has been procured and work on improving the land and making it suitable for testing has already commenced.

In order to attain the above objectives, a number of tasks must be completed. The most immediate of these tasks is the construction of an integrated test facility consisting of an integration of the five performance courses developed and tested during Phase II. While this is basically a mechanical task, no further testing or experimental work can proceed without this physical facility. As a result, the land at Camp Pickett, Virginia, must be surveyed, the various individual performance courses must be laid out on the ground and instrumentation must be installed. With regard to the instrumentation, preliminary plans and requirements have already been developed and are in the process of being finalized. It is planned that sufficient instrumentation will be employed to permit automatic data recording.

Another task to be accomplished is the technical planning of the tests. This work is being done concurrently with the construction of the physical facility. This work consists of developing the experimental designs for the tests and determining the statistical analyses to be employed. Consideration is also being given to the problem of computer processing of data.

Finally, it is planned to continue the research started in Phase II on the Reconnaissance, Cover, Concealment and Camouflage Course, the Target Detection Course and the Physiological Testing.

APPENDIX A

INSTRUCTIONS FOR RECONNAISSANCE, COVER, CONCEALMENT AND CAMOUFLAGE COURSE

RECONNAISSANCE COURSE

O/R Briefing(s)

1. Purpose of the Course

The purpose of the Reconnaissance Course is to study the effects of quartermaster clothing and equipment on the Infantryman's ability to perform reconnaissance type activities. This course is one of a series of courses being developed to measure performance in the tasks that are most important in combat.

2. Course Description and Procedure

The course is composed of two legs--Leg A and Leg B--which are run in consecutive order by test participants. Participants are instructed to traverse each leg using maximum cover and concealment techniques in order to minimize the amount of time they can be seen by observer-recorders located on the tower in the center of the test area. Four observer-recorders equipped with binoculars are stationed on the tower. The task of these O/R's is to continuously scan the area and record the number of times the test participant is seen as well as the total amount of time he is seen. Recording is accomplished by the use of microswitches connected to the binoculars which are closed by the O/R when the participant is seen and released when he can no longer be seen. A Ground Location O/R clad in cook's whites and a yellow helmet accompanies each participant through the course and radios his location (using reference signs placed on the outskirts of each leg) to the O/R's on the tower. The Tower O/R's will be told when the man starts, when he crosses each phase line and when he reaches each contact point. When the participant reaches the Contact Point, he will be given additional instructions by the Contact Point O/R. These instructions will include receiving and transmitting a 20-digit message utilizing the handset located at the Contact Point and completing a timed compass reading of the center of the X located on the side of the tower. After completing these two tasks, the participant will be instructed to complete Leg B of the course.

Participants will complete both legs of the course, accomplishing compass readings and receipt/transmission of messages at the end of each leg. At the end of Leg B the participants will have completed the course.

3. Checklist

Starter/NCOIC: Prior to starting participants through the course, insure that:

a. Participants are run according to the predetermined schedule provided by the OIC.

b. Participants are in proper basic uniform (fatigue jacket and trousers, combat boots, and fatigue hat).

c. Participants are properly wearing and/or using the special clothing and/or equipment required by the schedule.

d. Ground Location O/R is properly clad and equipped and has established radio contact with the Tower O/R's.

e. Communication is established with Tower Commo O/R and he is ready to time the trial.

f. Contact Point O/R is ready to time Leg A.

As each participant completes the course (both Legs A and B), the Starter/NCOIC will collect the data cards utilized by the participant at Contact Points A and B.

Tower O/R's (located on top floor of tower)

a. Insure that counters and clock timers are reset prior to each trial.

b. Continuously scan between appropriate phase lines as radioed by the Ground Location O/R and record the number of times and total time each participant is seen.

c. Recording will start when the Ground Location O/R radios that the participant is starting and will cease when the Ground Location O/R radios that the participant has reached the contact point.

d. Record the number of times seen and the total time seen on the data sheet furnished.

e. Maintain position within the tower throughout all trials, i.e., right-front; left-front; left-rear, or right-rear position as appropriate.

Tower Commo O/R (located in bottom of tower)

a. Insure that commo is working to:

(1) Starter/NCOIC
(2) Contact Point A
(3) Contact Point B

b. Insure that data sheets containing instructions to participants are available.

Ground Location O/R's

a. Uniform will be cook's whites and yellow helmet.

b. Insure that radio contact is made with Tower O/R's prior to participant running the course.

c. Inform tower (by means of radio) when:

(1) Participant starts leg.
(2) Participant crosses each phase line.
(3) Participant completes leg.

Contact Point O/R

a. Insure stop watch is reset prior to running course.

b. Insure data sheets and instruction sheets are available.

c. Insure that data cards are prelocated at the contact points.

RECONNAISSANCE COURSE INSTRUCTIONS

Contact Point O/R

1. General

Contact Point O/R's will be responsible for all test participants' performance at Contact Points A and B of the Reconnaissance Course. He will be dressed in the standard fatigue uniform and will carry a clipboard containing a split second hand stop watch and applicable data sheets.

2. Specific Duties

a. Contact Point O/R's will measure (to nearest 1000th of a minute) and record the participant's total time to complete each individual leg. Time will be measured from the command "START" until the participant reaches the Contact Point (moves into area marked with tape).

b. After participant reaches the Contact Point, the Contact Point O/R will instruct the participant as follows:

"USE THE HANDSET LOCATED IN THE BOX TO YOUR FRONT AND INFORM THE TOWER THAT participant's name HAS REACHED CONTACT POINT ("A" or "B" as applicable)."

(Contact Point O/R will monitor (by use of handset provided) all conversation between Tower Commo O/R and test participant to insure that test participant takes appropriate actions - DO NOT AID PARTICIPANT)

c. After test participant has received and re-transmitted the message format to the Tower O/R, the Contact Point O/R will instruct the participant as follows:

"WHEN I TELL YOU TO START, REMOVE THE COMPASS FROM THE BOX IN FRONT OF YOU; STAND AT THE CENTER OF THE X CONSTRUCTED OF TAPE ON THE GROUND, AND TAKE AN ACCURATE COMPASS READING OF THE CENTER OF THE X

LOCATED ON THE SIDE OF THE TOWER. AS SOON AS YOU HAVE THE READING, TELL IT TO ME. WE ARE INTERESTED IN HOW QUICKLY AND ACCURATELY YOU CAN COMPLETE THIS READING -- ARE THERE ANY QUESTIONS?

READY -- START."

(Contact Point O/R will measure and record the time (to nearest 1000/sec) taken by the participant to complete the reading (from "START" until participant states his reading).)

d. After compass reading phase is complete, the Contact Point O/R will instruct the participant as follows:

(1) When located at Contact Point "A"

"YOU HAVE COMPLETED THE REQUIRED TASKS AT THIS CONTACT POINT. WHEN TOLD TO START YOU ARE TO MOVE TO CONTACT POINT "B," USING MAXIMUM COVER AND CONCEALMENT TECHNIQUES, SO AS TO REDUCE THE AMOUNT OF TIME YOU WILL BE SEEN BY OBSERVERS LOCATED AT THE TOWER. YOU WILL BE GIVEN ADDITIONAL INSTRUCTIONS WHEN YOU REACH CONTACT POINT "B" -- ARE THERE ANY QUESTIONS? READY -- START."

(Contact Point O/R will measure and record time taken by participant to complete Leg "B" -- When participant reaches Contact Point "B," repeat previous instructions given at Contact Point "A.")

(2) When located at Contact Point "B"

"YOU HAVE NOW COMPLETED ALL REQUIRED TASKS OF THIS COURSE. RETURN TO THE ASSEMBLY AREA AND REPORT TO THE STARTER/NCOIC."

(Contact Point O/R will collect both data cards and will turn them in, along with his completed data sheet to the Starter/NCOIC).

RECONNAISSANCE COURSE INSTRUCTIONS

Ground Location O/R

1. General

Ground Location O/R's will be assigned a test participant by the Starter/ NCOIC and will accompany that participant in all phases of his Reconnaissance Course trials. The Ground Location O/R will be dressed in Cook's Whites (shirt and trousers) and a yellow helmet liner. He will carry a PRC-6 radio.

2. Specific Duties During Participant's Traversal of Legs A and B

(1) Ground Location O/R's will maintain continuous contact (PRC-6) with Tower O/R's and will provide location information of the participant, i.e.,:

(a) When participant starts each leg
(b) When participant crosses each phase line (1 thru 16)
(c) When participant completes each leg

(2) Ground O/R's will insure that participants stay within established ground limits (edge of woods on the right and tape boundary on the left).

3. Specific Duties at Contact Points A and B

(1) Ground Location O/R will immediately notify Tower O/R's (by radio) when the participant reaches the contact point (crosses into tape area).

(2) Ground Location O/R's will notify Tower O/R's when participant is prepared to start the Leg B position of the course. After insuring that the Tower O/R's are ready, the Ground Location O/R will start the participant through Leg B while simultaneously informing the Tower O/R's that the man is starting.

RECONNAISSANCE COURSE INSTRUCTIONS

Tower Commo O/R

1. General

The Tower Commo O/R will be located in the bottom of the tower and will monitor all wire communications on the course. Prior to starting the course, the Tower Commo O/R will insure that commo is established between his station and:

(1) Tower OIC
(2) Starter/NCOIC
(3) Contact Point "A"
(4) Contact Point "B"

2. Specific Duties

When test participants arrive at Contact Point (A - B) they will be instructed by the Ground O/R to call the tower and state "(Participant's name) has reached Contact Point (A or B)." At this time the Tower Commo O/R will instruct the participant as follows:

"USE THE DATA CARD AND PENCIL LOCATED IN THE BOX TO YOUR FRONT TO COPY THE FOLLOWING MESSAGE - COPY THE MESSAGE EXACTLY AS I READ IT TO YOU - I WILL NOT REPEAT ANY PART OF THE MESSAGE - YOU WILL BE REQUIRED TO READ THE MESSAGE BACK TO ME - ARE YOU READY TO COPY? - MESSAGE FOLLOWS: (Use format designated by OIC) END OF MESSAGE."

After completing the transmission of the message, the Tower Commo O/R will instruct the participant as follows:

"CONTACT POINT 'A' - READ BACK THE MESSAGE"

Tower Commo O/R will copy on the data sheet provided the message read back by the participant. Upon completion of the read-back he will instruct the participant as follows:

"CONTACT POINT 'A' - YOU HAVE COMPLETED THIS PHASE OF THE COURSE. PLACE THE PENCIL AND HANDSET BACK IN THE BOX IN FRONT OF YOU -- GIVE YOUR COMPLETED DATA CARD TO THE O/R ACCOMPANYING YOU AND AWAIT FURTHER INSTRUCTIONS FROM THAT O/R TOWER OUT."

RECONNAISSANCE COURSE

TROOP BRIEFING

1. Purpose of the Course

You are serving in research experiments that will eventually lead to a standard course on which to evaluate the effects of Quartermaster clothing and equipment on a soldier's ability to perform important combat tasks. This is a serious and expensive undertaking. Everyone wants the American soldier to have the best clothing and equipment. The best clothing and equipment may save lives.

Today you will be helping us evaluate our preliminary concepts for a course designed to reveal the effects of Quartermaster clothing and equipment on the infantry soldier's ability to perform reconnaissance type activities.

2. Course Procedures

The course is divided into two legs which for identification purposes are termed Leg A and Leg B. You will traverse each leg of the course one time and one time only. The course is run as follows.

Your preliminary instructions will be provided by the starter while you are in the assembly area. The uniform will be fatigue trousers and jacket, combat boots and fatigue hat. You will carry the M1 rifle. You may be issued additional clothing and/or equipment by the Starter/NCOIC prior to running the course. You will continue to wear or carry, as appropriate, all clothing and equipment throughout the course. Do not remove any of these articles until told to do so by the Starter/NCOIC.

The course will actually be run in two phases. Phase I is termed Leg A. When told to START by the Starter/NCOIC you are to move from the START Point to Contact Point A, using maximum cover and concealment in order to reduce the chances of your being seen by enemy observers located in the tower. You are free to move in the area between the edge of the woods and the engineer tape located on the ground to your left. Upon reaching Contact Point A, you are to immediately call into the tower using the handset provided and state that "This is _____, I have reached Contact Point A." At this time you will be given additional instructions by the O/R located in the tower. After you have finished all tasks at Contact Point A, you will be

directed by the Tower O/R to move from Contact Point A to Contact Point B using maximum cover and concealment. Upon reaching Contact Point B, use the handset to call the tower stating " This is _____, I have reached Contact Point B." You will then be given additional instructions.

Remember that we are interested in your ability to conceal yourself from view of the observers on the tower while moving to the contact points.

ARE THERE ANY QUESTIONS?

APPENDIX B

Project Reports

PROJECT REPORTS

I. Report of Phase I, USATECOM Project No. 8-3-7700-01, Development of a Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of the Individual Field Soldier, U.S. Army QM R&E Field Evaluation Agency (now U.S. Army General Equipment Test Activity), February 1964.

II. Reports of Phase II, USATECOM Project No. 8-3-7700-01, Development of Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers, U.S. Army General Equipment Test Activity:

1. Identification of Important Tasks of Combat Infantry - Report of Results from a Further Refinement, November 1964.

2. Development of a Methodology for Measuring Infantry Performance in Rifle Firing and Reloading, June 1965.

3. Development of a Methodology for Measuring Infantry Performance in Maneuverability, June 1965.

4. Development of a Methodology for Measuring Infantry Performance in Marching and Moving, June 1965.

5. Development of a Methodology for Measuring Infantry Performance in Grenade Throwing, June 1965.

6. Development of a Methodology for Measuring Infantry Performance in Digging Hasty Fighting Positions, June 1965.

7. Final Report, Phase II, December 1964.