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COMBAT LOAD REQUIREMENTS FOR A DISMOUNTED INFANTRY RIFLEMAN

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SUBJECT: Combat Load Requirements for a Dismounted Infantry Rifleman

1. PROBLEM: To determine the minimum essential basic load which a dismounted infantry rifleman should be expected to initially carry into combat in order to fight and sustain himself without exhausting himself carrying it.

2. ASSUMPTIONS:

a. The role, mission and TOE/CTA equipment for the dismounted infantry rifleman will remain unchanged in the near future.

b. The dismounted infantry rifleman's basic combat equipment load will continue to be comprised of the fighting, mission and existence loads in the near future.

c. The minimum essential basic combat load for the dismounted infantry rifleman will continue to be based on the immediate tactical mission.

d. All soldiers assigned as dismounted infantry riflemen will continue to differ greatly in mass and body weight.

e. The criterion for determining the maximum load weight to be carried by an individual dismounted infantry rifleman will continue to be computed as a third of the total body weight.

3. FACTS BEARING ON THE PROBLEM:

a. Field Manual FM 100-5 concludes that the focus for winning campaigns and battles means that the US Army must meet several challenges. It must be prepared to fight world-wide against varied threats. It must be prepared to fight battles of greater scope, range and intensity than ever experienced before. It must prepare soldiers and units for such battles. (6:1-1)

b. The authors of two studies: "Study to Reduce the Load of the Combat Infantryman" (1962), and "Study to Conserve the Energy of the Combat Infantryman" (1964), both called for a major effort to reduce the weight of everything the soldier wore or carried under a program identified as LINCLOE -- Lightweight Individual Clothing and Equipment. The result of these two studies was the birth of the present day fighting and existence loads for the individual combat soldier. (2) (3)

c. Field Manual FM 21-15 defines both the fighting and existence load concepts. The field manual establishes both load configurations and total weights. It states, "The important point in the fighting and existence loads concept is that you should carry only the items necessary to complete your immediate mission. The load you carry should not include any other item that can be carried another way." (4:85, Annex A)

d. The authors of "The Carrying Loads Within an Infantry Company" establish the fighting and existence load configurations for the infantry rifleman. It further outlines individual physical load carrying abilities (a third of total body weight) to include dimensions and weights for various equipment loads based on climate and geographic areas. The authors conclude, "The present load of the soldier, including his basic fighting load, plus the special clothing and equipment required for cold climates, and the additional special equipment carried by many MOS' in the infantry, exceeds tolerable limits, if the loads are to be carried significant distances. The price to be paid in expenditure of energy may reduce the combat efficiency of the soldier beyond acceptable limits." (7:69, Annex B)

e. "Combat Developments Draft Study Plan for Reducing the Soldier Load" states, "The infantryman has accepted an ever increasing load/burden caused by technological advances in the equipment field. This study is to determine the type of items the soldier must carry into battle to include weapons, ammunition, night sights and other equipment. At present, it is accepted that he cannot fight and survive with his total equipment load. A failure to solve this problem will cause the infantryman to remain overloaded, will reduce his mobility, will result in an inability to successfully complete his mission and survive on the modern battlefield." (1:1-2 Annex C)

4. DISCUSSION:

a. In order for the infantry rifleman to enter combat and function effectively on the immediately assigned tactical mission as well as on any follow-on operations, it will be necessary that he is equipped with a variety of functional support equipment that will sustain him in his primary role.

b. Over the years advancement in technology has certainly reduced, in both weight and dimensions, the current combat loads for the infantry riflemen. Through scientific analysis and evaluation the US Army has determined the physical work, load weight, tactical mobility and environmental extremes as each impacts on the capabilities of the infantry rifleman to function in his role. Currently, the US Army has established its fighting and existence loads in FM 21-15.. These load configurations at present provide the best minimum equipment necessary to allow the infantry rifleman to fight and sustain himself in combat.

c. The US Army, while continuing to research and study the effects on and the capability of the infantry rifleman to carry the current combat load configurations, has recognized that the present load weights and dimensions exceed tolerable limits.

d. Weight totals of various mission essential equipment for the infantry rifleman are usually not included as part of the minimum fighting and existence load. After adding these weights to the total, the tolerable limits would be further exceeded.

e. Load configurations must be based on the distances that an infantry rifleman is required to travel by foot with a particular load. Depending on the terrain associated with different world-wide scenarios, it would be conceivable that the infantry rifleman will have to carry his total load without assistance from any other organic or inorganic support.

f. A current ongoing study to test the minimum load carrying capabilities of the infantry soldier stipulates that fighting and mission loads should not exceed thirty percent of the total body weight. A combination of the fighting, mission and existence loads should not exceed forty-five percent of the total body weight. The need for more conclusive tests has been decided on and are currently being conducted.

5. CONCLUSIONS:

a. The infantry rifleman's basic load will remain as currently configured in the near future. He will be required to carry all elements of the fighting load and only those items of existence and mission loads that will fulfill the immediate tactical mission. The total load carrying criterion must be based between thirty and forty-five percent of the total body weight so that he will not exhaust himself carrying it.

b. Any excess loads beyond the tolerable limits that the infantry rifleman will need to accomplish his immediate tactical mission will have to be carried by some other organic or inorganic means supported by his unit, until US Army technology can reduce the total load to the tolerable limits.

c. If forced to overload the infantry rifleman to accomplish the immediate tactical mission, all leaders must thoroughly plan to avoid strenuous movement over any terrain that will cause exhaustion and thus reduce the infantry rifleman's ability to function upon reaching the objective.

6. ACTIONS RECOMMENDED:

a. Completion of a study defining the exact load carrying capacity of an infantry rifleman based on different physical abilities, load configurations, climates and missions.

b. Supervision by all leaders to assure tolerable limits are not exceeded by weighing the infantry rifleman's total load prior to deployment. Excess equipment can be reduced by using the buddy system in which two men teams can avoid carrying unnecessary like items.

c. Completion of the combat development study at Annex C.

d. Implementation and completion of a state-of-the-art equipment program by Natick Laboratories which reduces the load weights to a level whereby the infantry rifleman can effectively carry his fighting, mission and existence loads without exhausting himself carrying it.

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ANNEXES: A -- Extract from FM 21-15, "Care and Use of Individual Clothing and Equipment"

B -- Extract from Technical Report 73-51CE, "The Carrying of Loads Within an Infantry Company"

C -- "Combat Development Draft Study Plan for Reducing Soldier Load

D -- Bibliography

CONCURRENCES: ____________________

NONCONCURRENCES: ________________

CONSIDERATION OF NONCONCURRENCES:

ANNEXES ADDED:

ACTION BY APPROVING AUTHORITY:

DATE:

Approved (disapproved), including (excluding) exceptions.

____

Signature

LOAD-CARRYING

RULES

If you follow the rules listed below, you'll be able to carry loads with much more ease and comfort.

■ *If you don't follow the rules, you'll make a hard job that much harder.*

Here are the simple rules....

- Keep your load as light as possible.
- Know your equipment.
- Assemble the equipment properly.
- Keep every item in its proper place.

AND REMEMBER — —
IT'S YOUR BACK!

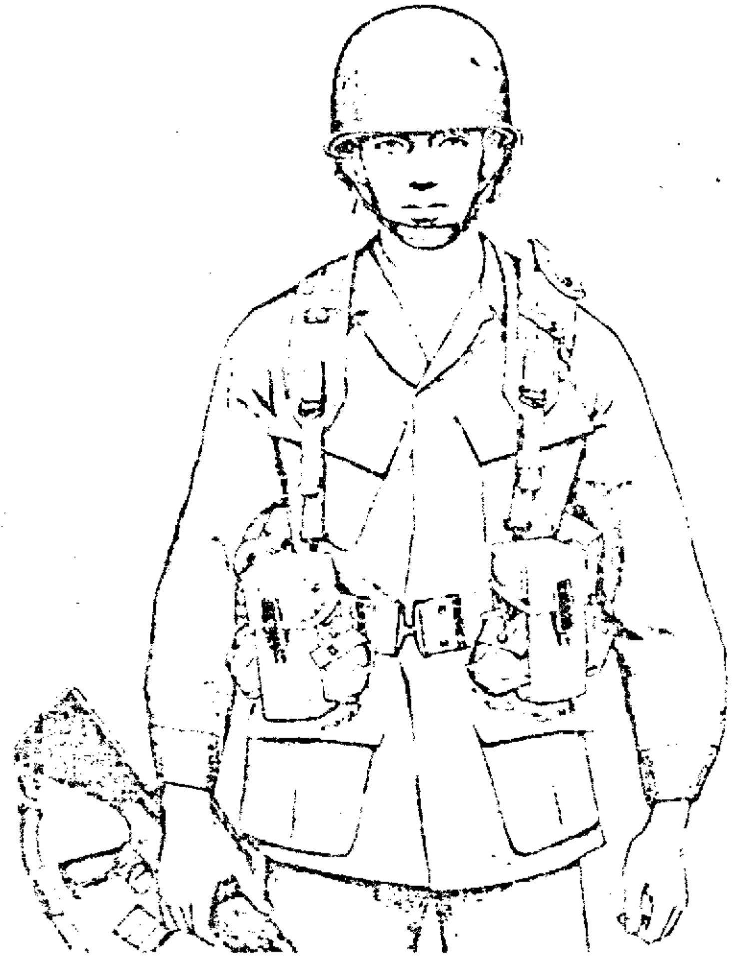
Fighting and Existence Loads Concept

The important point in the fighting and existence loads concept is that you should carry only the items necessary to complete your immediate mission. **The load you carry should not include any other item that can be carried another way.** Because the type of mission, terrain, and environmental conditions will influence your clothing and equipment requirements, your unit commander may prescribe to you the essential items. Remember—*the prime purpose of the fighting and existence loads concept is to lighten your load.*

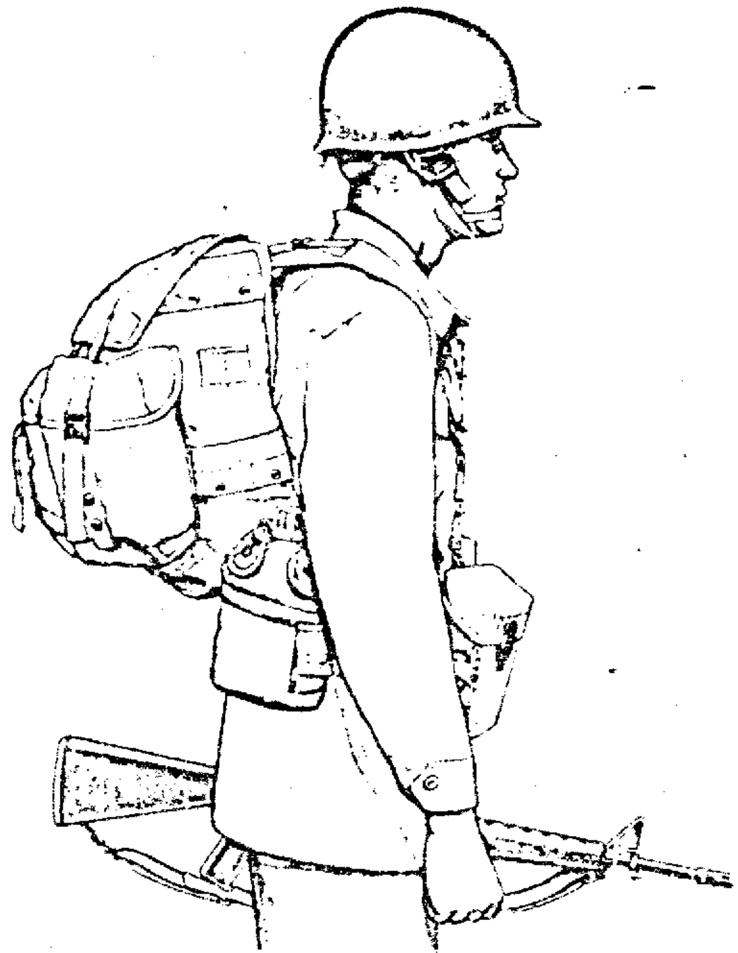
Fighting Load. The typical fighting load is made up of essential items of individual clothing, equipment, weapons, and ammunition that are carried by you to complete the immediate mission of your unit. See *appendix C* for a list of typical items included in the fighting load, using the all-purpose lightweight individual carrying equipment (ALICE).

Existence Load. The typical existence load consists of items other than those in the fighting load which are required to sustain or protect you, which may be necessary for your increased personal and environmental protection, and which you normally would not carry. *When possible, the existence load items are transported by means other than man-carry.* Otherwise, both the fighting and existence loads are carried by you—the soldier. See *appendix C* for a list of typical items included in the existence load, using the all-purpose lightweight individual carrying equipment (ALICE).

Annex E



Fighting Load



Existence Load

ANNEX A

APPENDIX C

13 TEMPERATE ZONE (HOT WEATHER) FIGHTING AND EXISTENCE LOAD ITEMS (TYPICAL)

1. Fighting Load Items*

a. Clothing:	Approximate weight (pounds)
(1) Helmet w/ cover	3.44
(2) Trousers and jacket, utility	2.26
(3) Underwear (summer) and socks	.60
(4) Boots, leather (DMS)	3.36
(5) Poncho (lightweight)	1.70
(6) Belt, waist, web w/ buckle	.20
Total	11.56

b. Equipment:	
(1) Rifle, M16, w/ sling and 1 magazine (30 rounds)	7.91
(2) Ammunition (180 rounds) and magazines (6 each)	6.21
(3) Ammunition cases (2 each)	.86
(4) Handgrenades (2 each)	2.00
(5) Smoke grenades (2 each)	3.00
(6) Canteen (filled) w/ cup and cover	3.60
(7) Water purification tablets	.06
(8) Individual equipment belt, first aid packet w/ case, and suspenders	1.59
(9) Intrenching tool w/ carrier	2.52
(10) Bayonet-knife, M7, and scabbard, M8A1	1.30
Total	29.[illegible]

c. Rations:	
(1) Meal w/ spoon	1.75
Total weight (fighting load)	[illegible]

*Items included in the fighting load will be determined by mission and environmental conditions.

Annex A

FIGHTING AND EXISTENCE LOAD ITEMS (TYPICAL)

*2. Existence Load Items**

a. Armor, vest	9.50
b. Mask, CBR, protective, 17 M (carrier)	2.97
c. Suit, chemical protective, w/ gloves and hood	3.78
d. Liner, poncho	1.60
e. Cap, utility	.22
f. Frame, pack, including cargo bag, shoulder and waist straps	3.10
g. Pack, medium, combat, field	2.46
h. Pack, large, combat, field	2.86
i. Cover, field pack, camouflage	.82
j. Shelf, cargo support	.41
k. Shelter half, with 5 pins, aluminum poles, and rope	1.45

l. Strap, cargo tiedown (2 each)	.40
m. Sleeping bag, intermediate cold	7.50
n. Sleeping bag, extreme cold	9.50
o. Mattress, pneumatic, insulated	3.50
p. Hood, sleeping	.40
q. Shirt, sleeping	.65
r. Bag, waterproof	.75
Total weight (existence load)	[illegible]

*Items included in existence loads will be determined by the mission, terrain, and environmental conditions.

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THE CARRYING OF LOADS WITHIN AN INFANTRY COMPANY

Stephen J. Kennedy, et al

Army Natick Laboratories
Natick, Massachusetts

May 1973

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TECHNICAL REPORT

73-51-CE

THE CARRYING OF LOADS WITHIN AN INFANTRY COMPANY

by

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May 1973

Clothing & Personal Life Support Equipment Laboratory

C&PLSEL-100

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CONTENTS

C. THE INFANTRY RIFLEMAN'S LOAD

The basic problem with respect to reducing the weight of the soldier's load has been adequately covered in such studies as the 1964 Study to Conserve the Energy of the Combat Infantryman, conducted by the Combat Developments Command Infantry Agency. Numerous studies, conducted in support of the AMC Natick Laboratories' development programs by the U.S. Army Research Institute of Environmental Medicine (ARIEM), a Class II Agency of The Surgeon General, located at Natick Laboratories, have demonstrated the necessity and potential benefits of such weight reductions. The scope of this problem, however, can be clarified as follows:

The basic load of an infantry rifleman, generally taken as the representative soldier, for temperate hot weather areas, is a fighting load, without personnel armor, of 37.72 lbs. With personnel armor the weight totals 49.66 lbs. Adding CW protection and basic existence load items, the total weight is 61.12 lbs. as shown in Table I.

Figure 15 — Infantry Rifleman

Basic Fighting Load (w/armor)	49.66 Wt. (lbs.)
Existence Load	11.46
TOTAL	61.12

TABLE 1

The Load of the Infantry Rifleman*

(Warm Weather)

	Weight in pounds	
Weapon	8.89	
(M-16 Rifle, with one magazine and 20 rounds; plus bayonet)		
Ammunition	10.52	
(8 magazines, 20 rounds in each, in ammunition pouches; 2 hand grenades; 2 smoke grenades)		
Personal Equipment	10.19	
(Load Carrying Equipment, plus attached items: 1 full canteen, entrenching tool, first aid pouch + 1/3 ration)		
Clothing, Environmental Protective	8.12	
(Including boots and poncho)		
Fighting Load w/o Body Armor		37.72
Personnel Armor	11.94	
(Helmet w/liner; body armor vest)		
Fighting Load w/Body Armor		49.66
CW Protection	6.75	
(Mask and Protective Overgarment)		
Existence Load, other items	4.71	
(Poncho liner; 1/3 ration; toilet articles, etc.)		
TOTAL LOAD		61.12 lbs.

OTE: Magazines carrying 30 rounds are now replacing the 20 round magazines. The weight the 30-round magazine, loaded, will be 1.01 pounds instead of 0.70 lbs for the 20-round agazine. However, the soldier will now carry 7 magazines of 30 rounds instead of 9 magazines 20 rounds. This will result in a net addition to his load of 0.67 pounds.

*Source: FM 21-15, "Care and Use of Individual Equipment," August 1972.

It will be obvious that the weight of some components of this load will be constant for all climatic zones. The weight of the weapon, of the basic load of ammunition, and of the personnel armor and CW protective items will remain the same in all climatic zones. However, in hot weather, more than one canteen is usually carried. Also, the substitution of cold climate clothing, and the addition of special gear for cold climates will both increase the weight of the load, and also create an encumbrance to movement. The added weight for cold climates, as shown in Table II, is 11.63 lbs. for cold-wet clothing (Table IIA), and another 8.21 lbs. added for extreme cold weather clothing (Table IIB), for a total additional clothing weight of 19.84 lbs. Adding the 23.19 lbs. for individual existence items for cold weather (Table IIC), the total added weight for extreme cold protection is 43.03 lbs. before adding the 9.75 lbs. for skiis or 4.6 lbs. for snowshoes as shown in Table IID.

Adding together the 61.12 pounds for the load of the infantry soldier in warm weather areas (shown in Table I), taking the figure for clothing for cold-wet areas (Table IIA) and eliminating from the equipment list (Table IIC) items for extreme cold, such as the inner sleeping bag and the snow camouflage cover for the rucksack, etc, gives a total weight of 90.59 pounds for a cold-wet area; if we use the total added clothing weight (Table IIB) plus the entire equipment list shown in Table IIC of 43.03 pounds for extreme cold weather areas, we arrive at a total load for the infantry rifleman (Figure 16) of 104.15 pounds, not counting the weight of oversnow equipment, if required.

While all of the items listed may not need to be carried by all soldiers all of the time, the items included in these Tables are those shown in current Field Manuals, as referenced. For purposes of this study, they should be considered to provide an approximate basic weight of what is considered "the soldier's load."

In summary, depending on the climatic zone being considered, this load as shown in the Field Manuals is as follows:

Basic Load of the Soldier

		Weight (lbs)
Hot weather clothing and equipment		61.12
Added for cold-wet areas		28.41
	Total cold-wet	89.53
Added for extreme cold		14.62
	Total extreme cold-	104.15
Oversnow equipment:	skiis or snowshoes	9.75 or 4.60

TABLE II

Added Weight of the Load in Cold Climate Operations

...m	Weight of Cold Climate Item (in pounds)	Weight of Hot Climate Item (in pounds)	Added Weight (in pounds)
...d-Wet Clothing			
Underwear and socks	1.90	.60	1.30
Suspenders	.25	—	.25
Shirt, wool/nylon, OG	1.50	—	1.50
Trousers, wool serge	1.68	—	1.68
Trousers, cotton/nylon, wind resistant	2.10)	2.26)	3.04
Coat, cotton/nylon, wind resistant	3.20)	)	
Liner, coat, nylon quilted	.73	—	.73
Cap, cold weather	.26	—	.26
Muffler, wool	.38	—	.38
Glove-shells, leather	.22	—	.22
Glove-inserts, wool/nylon	.13	—	.13
Poncho, lightweight	1.70	1.70	—
Boots, Insulated	5.50	3.35	2.14
Total Added Weight for Cold Wet Areas:			11.63
...treme Cold Clothing (Cold-Dry)			
...ood, winter	.96	—	.96
Parka, cotton/nylon	1.98	—	1.98
Liner, parka, nylon quilted	.95	—	.95
Overwhite set:			
Parka	1.94	—	1.94
Trousers	1.00	—	1.00
Liner, trousers, nylon quilted	.64	—	.64
Mitten-inserts, trigger finger or	.22	(replaces glove inserts)	.09
Mitten-shells, trigger finger	.43	(replaces glove shells)	(-.21)
Mitten Set, Arctic	1.08	(replaces mitten shells)	.65
Total Additional Weight for Extreme Cold:			8.21
Total Weight for Extreme Cold Areas:			19.84
...dividual Equipment			
Bag, Sleeping (Inner)Mountain	7.06)	—	
Bag, Sleeping (Outer)	5.41)	1.60	10.87
Mattress, pneumatic	3.00	—	3.00
Case, water repellent	2.25	—	2.25
Rucksack, lightweight	3.00	1.00 (pack)	2.00
Rucksack, snow camouflage cover	.75	—	.75
Canteen, cold climate (2/3 filled)	3.85	3.60 (full)	.25
Chapstick	.04	—	.04

TABLE II (cont.)

Item	Weight of Cold Climate Item (in pounds)	Weight of Hot Climate Item (in pounds)	Added Weight (in pounds)
Individual Equipment (Cont.)			
Thong, emergency	.12	—	.12
Glasses, sun, w/case	.30	—	.30
Sunburn preventive cream	.19	—	.19
Camouflage face paint, white/loam	.08	—	.08
Box, match, waterproof, w/matches	.15	—	.15
Starter, fire	.15	—	.15
Knife, pocket	.40	—	.40
Toilet articles and towel	2.64	—	2.64
Total Added Weight for Individual Equipment :			23.19
Total Added Weight - clothing and personal equipment for extreme cold			43.03

Weight of Oversnow Equipment
(Added where occasion requires) :

Skis, all terrain, w/bindings & poles	9.50)	= 9.75
Ski wax (per box)	.25)	
or		or
Snowshoes, Magnesium, w/bindings	4.60	4.60

* - To be added to the cold-wet clothing system for extreme cold climate conditions.

Source:
FM 31-70, "Basic Cold Weather Manual," April 1968.

In these listings, separation of the load into fighting and existence loads has not been attempted, except as shown in Table I for hot weather areas. The situation could vary greatly in cold weather areas because of diurnal and day-to-day variations in temperature, as to what would be needed under a particular situation since environmental survival is absolutely essential, and no firm figure can be readily arrived at.

It is evident that we are dealing with very heavy loads for any soldier to carry. Despite the continually increasing awareness of the impact of heavy loads on the soldier's mobility in any climate, and his susceptibility to heat exhaustion collapse in jungle or desert operations, current loads have reached very high levels. Therefore, the emphasis upon a continuing program that focuses on reducing the weight of the soldier's load is obviously fully justified.

Several aspects of the impact of heavy loads are addressed in the following sections.

D. PHYSICAL WORK, LOAD WEIGHT AND TACTICAL MOBILITY

Typical military work demand levels range from about 100 kcal/hour for sentry duty, 150 kcal/hour for driving, and 175 kcal/hour for mine-clearing to perhaps 250 to 300 kcal/hour while patrolling, as a function of the terrain covered. An assault will require 425 kcal/hour ± 10% (at least in peacetime when the men are not under actual enemy fire), but infantrymen will seldom approach the maximum of a 600 kcal/hr (10 kcal/min) level which only allows an average soldier one hour of sustained work, or a 15 to 20 kcal/min level, which results in his exhaustion within 6 minutes.

Such energy cost levels are, of course, conditioned by the weight of load carried. A typical peacetime load table might show a combat rifleman carrying 44 lb. (20 kg), a machine gunner 70 lbs. (32 kg) and radio/telephone operators, mortar men or recoilless riflemen carrying loads greater than 77 lbs. (35 kg). Since it was recommended by a British Royal Commission in 1867, that a 45 lb. (20 kg) load is the maximum desirable for an approach march, with lower loads suggested for combat, even these peacetime loads are excessive. However, almost always throughout history, loads have increased during wartime operations, frequently doubling as shown in Figure 17. Reductions in weight in one part of the load tend to be offset by the addition of extra amounts of ammunition, grenades, flares, mines, etc. As shown in Figure 17, there appears to be a cycle in the load carried. Significant reductions in the load, achieved when a significant disadvantage is incurred to the greater mobility of the less-loaded enemy, may be replaced later by increases in the load carried to meet the real or imagined requirements of war.

Load carriage systems and load placement are important since hand-carried loads require almost twice as much energy as the equivalent weight carried on the corso, while the weight of heavy boots requires six times as much energy as the equivalent weight on the torso. In addition, bulkier clothing increases energy cost, with multiple-layer winter uniforms requiring 1.15 times as much energy as they should based on weight alone. Of course, varying terrain also alters energy costs; taking a black-top road at a fixed speed as a basis for comparison, with an efficiency factor *(m)* equal to 1.0, then, at the same speed, a dirt road would require 1.1, light brush 1.2, heavy brush or forest 1.5, and swamp 1.8 times as much work, with snow ranging from 1.6 for hard-packed snow to perhaps as much as a multiplier of 5 as a function of snow depth.

Combining all these factors, it is possible to predict the work demand as:

Energy cost = $m\ (W + L)\ [2.3 + 0.32\ (V - 2.5)^{1.65}]$ - where V is speed in km/hr, and weight (W) and load (L) are in kg. For example, at 5.6 km/hr (3.5 mph) on a level, black-top road, each kilogram of load increases energy cost by 4.4 kcal/hr (i.e., 2 kcal/hr per pound of load). While it is thus possible to predict the physical work required as a function of body weight plus load and terrain *(m)* at any given speed, in the actual event what is important is not what the energy cost will be for a given speed, but rather what work rate the man will actually adopt.

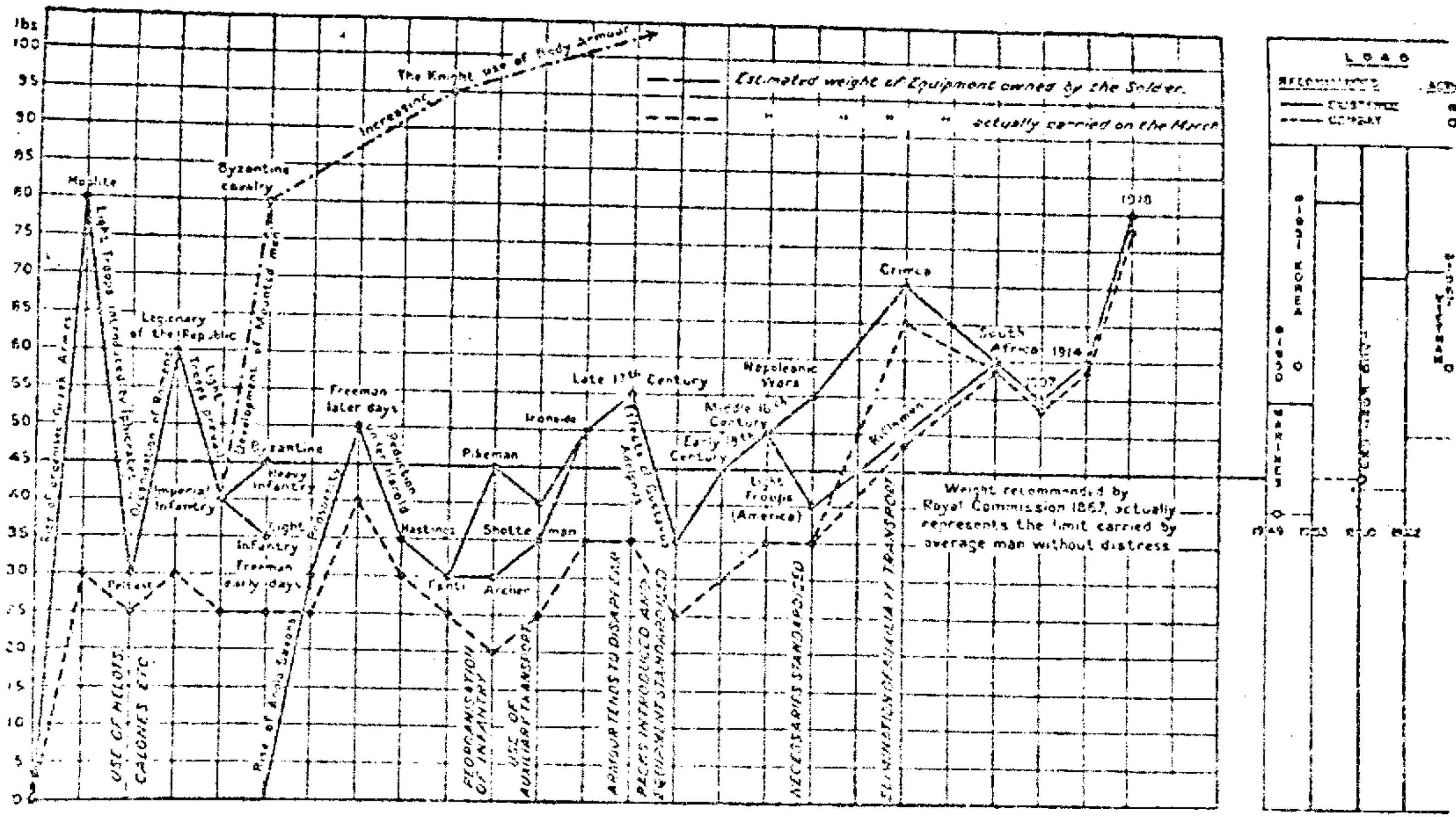


Figure 17

History of the Soldier's Load

Extensive review of limited combat studies and many laboratory studies has clearly suggested that reasonably fit, 18 to 30 year old, 70 kg, 172 cm soldiers, when working as hard as they are willing to, will work at a rate of 425 kcal/hr ± 10%, unconsciously adjusting their march rate as a function of load, terrain, etc. to achieve this level. This 425 kcal/hr level is relatively unaltered by sleep loss or temperature effects, and holds with minor adjustments even for loads up to 70 kg (154 lbs.), but is, of course, highly dependent upon motivation.

The adoption of this 425 kcal/hr self-paced work level is so reliable that substituting 425 for the energy cost in the above equation allows prediction of speed as a function of load and terrain. The validity of the speeds predicted by this approach has been demonstrated and, with an available adjustment for uphill instead of level terrains, summarises what needs to be said now and in future about the impact of load on the soldier, and on his mobility over a variety of terrains. The equation also serves to indicate endurance time, since he is not apt to exceed one hour of continuous work, when pressed to the 10 kcal/min level, or 6 minutes at 15 to 20 kcal/min. Whether elite troops will be appreciably better than other units in this regard is debatable, although their motivation to reach and sustain the 425 kcal/hr level will certainly be helpful.

These energy cost relationships will be unchanged with increasing age, but since maximum work capacity decreases from perhaps 17.5 kcal/min at age 20 to 12.5 kcal/min at age 60, the older soldier will be working at a greater percentage of his maximum and the same work will seem harder. The impact of these generally unalterable physiological limits on present military operations is well-known.

With increasing use of armored personnel carriers and helicopters to deliver the combat infantryman into contact with the enemy, he may do less approach marching in the 1980-1990 time-frame and thereby lose the opportunity to learn, by necessity, to limit his load and discard nice but not really necessary items. Thus he may be brought into actual combat carrying the extra food, magazines, souvenirs, and the like which in older days he would have discarded during the approach march.

A 1980-1990 time-frame projected combat scenario will require greater mobility and endurance. Thus greater emphasis on load reduction, on auxiliary load transport, on improved re-supply and load rotation will be essential; these tactical alterations are required by human physiology since little can be done to increase the man's capacities. One load item whose weight will be a continuing problem, particularly in the heat, is water. Since the soldier can not

...thout it, a supply must be carried and resupply on the order of 25 lbs. (13 qts.) per man ...y may be necessary.

Another factor that has not been addressed but that is significant now, and in the foreseeable ..., is the interaction between fear, which draws on the man's physical resources, and physi... work which draws on the same resources. Since this interaction with fear is almost always ... in training and in peacetime maneuvers, loads can be carried (with little impact on the ...ires or observers estimation of mission accomplishment) which could be extremely damaging ... actual combat. As a result, it is easy to plan combat operations with loads and pace which can ... be maintained under fear where the effects of heavy loads will be magnified. In actual combat the soldier's morale and the ability to sustain an engagement may be seriously degraded by failure to recognize the limits imposed by the interaction between fear and physical work. Training the ...idual with heavier loads than anticipated in combat is desirable to help offset the additional demands on physical resources imposed by fear during combat.

Selection of individuals with outstanding fitness can be accomplished, but it is unlikely that this can be done for other than elite units in the future. Individual variability in a given unit is generally not too great, but significant differences exist between elite units and others, with every man in an elite unit frequently able to run 3.2 km in 15 minutes or less. This is usually a result both of superb leadership, in which the officers also train to achieve this level, as well as of selection of individuals for these elite units, and these factors too are among the many that dictate the effects of loads on the soldier.

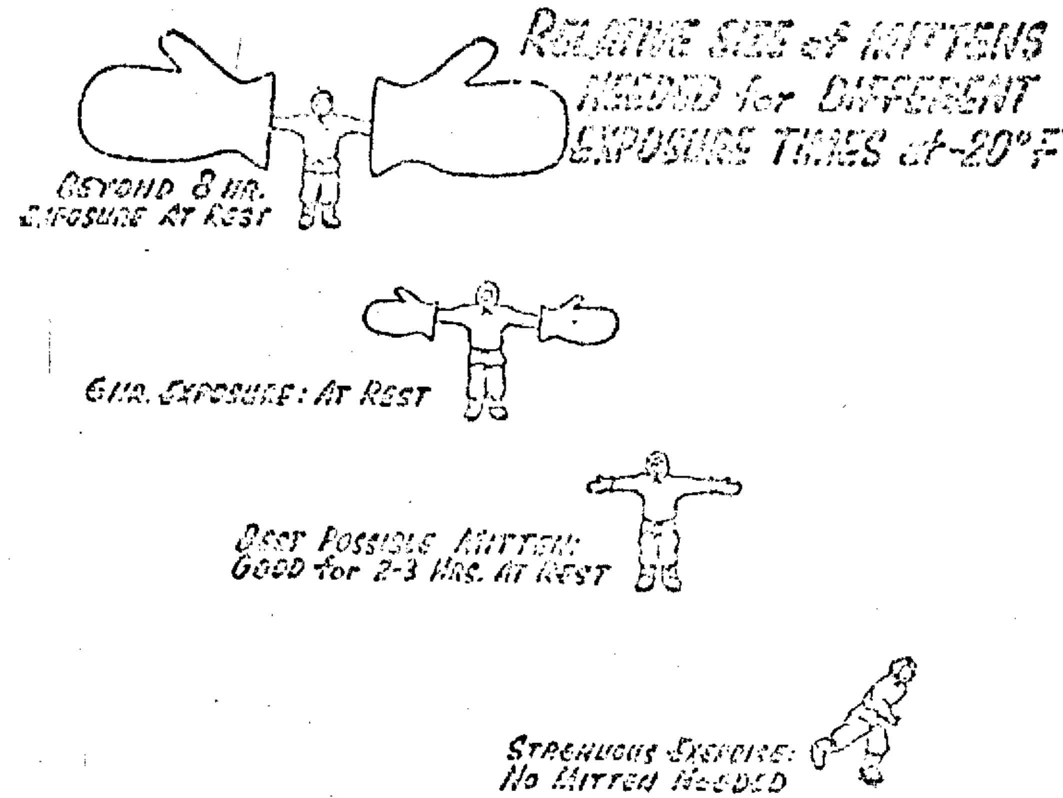
E. LOAD WEIGHT, PHYSICAL WORK AND ENVIRONMENTAL EXTREMES

The impact of a heavy load becomes most serious at the two climatic extremes of hot climates and very cold climates. In the heat, the extra heat production demanded by the extra work load compounds the risk of heat exhaustion collapse. In the cold, the increased clothing weight (Table III) increases heat production, as predicted by the heat production equation given above, while adding the additional 15% increase associated with the difficulty of moving in such bulky, multi-layered clothing systems. As indicated above, these problems of heavy loads tend to be overlooked since most load carriage studies are conducted in comfortable environments. Thus, the physiological impact of a heavy load is underestimated when the soldier is committed to combat in extreme environments.

The extra heat production demanded by a heavy load increases the body's requirement for heat loss and results in increased sweat production. In jungle climates, or when armor or chemical/biological protective clothing is worn, the extra sweat frequently cannot be evaporated. The soldier gains no benefit from this wasted sweat production and his risk of heat exhaustion collapse, increased by the extra heat production, is further increased by the dehydration of the body by this excess sweat production. Furthermore, the increased sweat may drip into his eyes and soak his skin and make it more vulnerable to abrasion; increased skin infections and foot blisters are a common occurence under such conditions.

In the cold, it is essential to get rid of excess body heat without having excess perspiration absorbed into the clothing system, which would thereby reduce its insulating efficiency, leave the soldier exposed to the discomfort of after-exercise chill and increase his risk of cold injury. Through the front opening of the cold weather clothing system, which the man can open up when he is active in order to cool himself off, the use of vents at the wrists and neck, and the use of suspenders so that his trousers are not constricted at the waist, every available means is taken to assist the man to avoid over-heating. The relationship between body activity and the requirement for effective insulation for keeping warm is well shown in the classic illustration of the mittens. (Figure 18)

Figure 18



The amount of insulation required when the man is very active and generating up to 425 kcal/hr is quite small, as compared with what he requires when he is at rest or sleeping and generating no more than 60 kcal/hr. Thus the weight and bulk of protective clothing, added to the soldier's load, creates a problem that is quite different from that in a temperate area, and conclusions based upon the usual load carriage studies require substantial modification when the soldier is engaged in combat in cold climate areas.

F. LOAD IN RELATION TO BODY SIZE

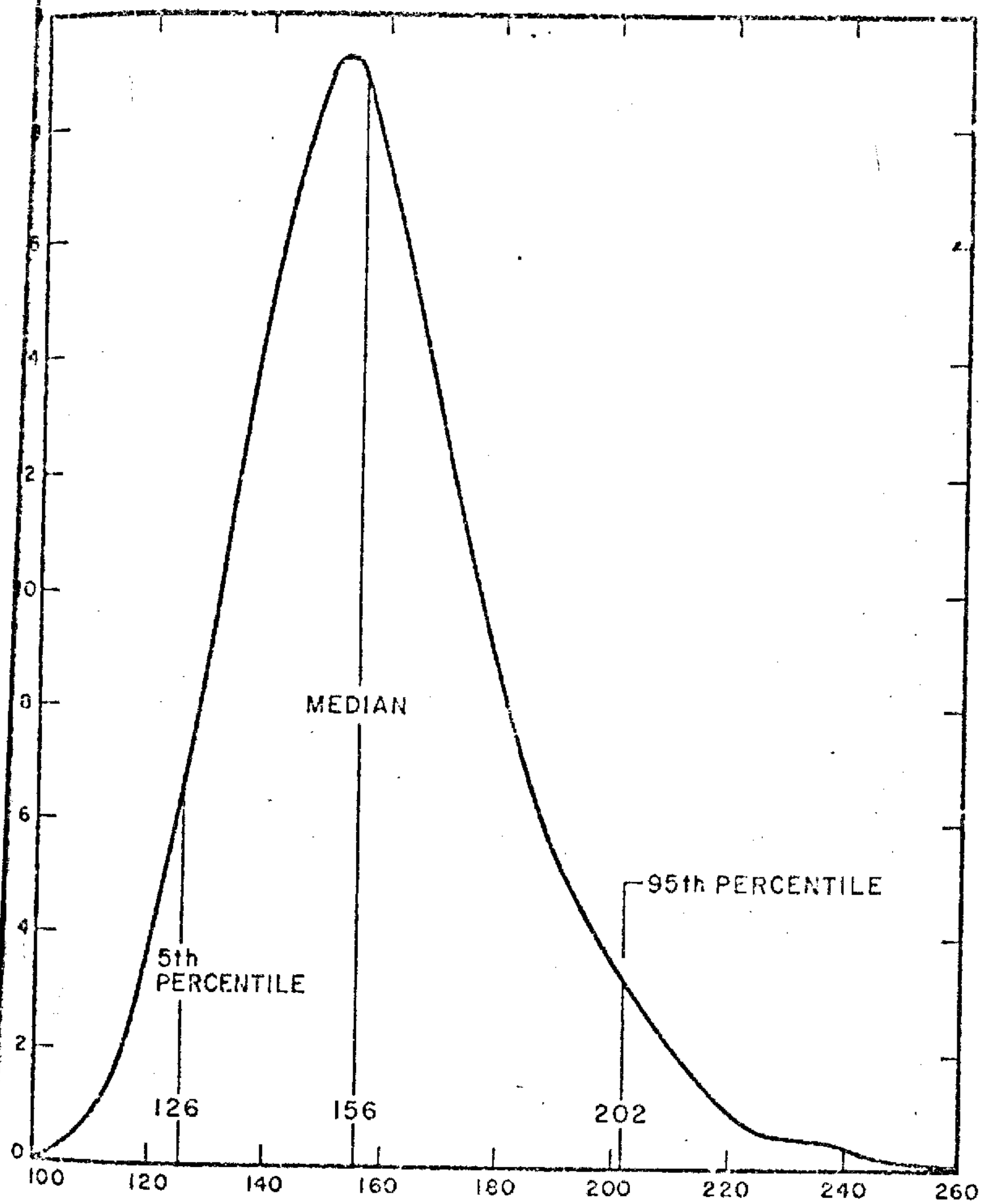
Another point which is significant from a physiological standpoint is the variation in the size of men in the total population. Discussions of the load carrying problem have referred to "the load of the soldier" as though it were sufficient to consider only the average man.

The need for considering the range of body dimensions in the total population has been taken for granted with respect to clothing, footwear and other items worn by our troops, as being necessary for proper fit and comfort, as well as for achieving a suitable and uniform military appearance.

This concept of sizing for different sizes of men has been applied to only a very limited extent, if at all, in items of personal equipment and man-portable equipment made available to the infantry company. Except for the belt and suspenders of the load carrying system, which are designed to be adjustable for different size men, all other items of the load carrying system are of a single dimension and weight.

The physical work capacity of an individual soldier is largely established by his body size, with each added centimeter of height increasing maximum work production capacity by 0.2 kilocalorie/minute (kcal/min), and each kilogram (kg) increase in body-weight increasing maximum work capacity by 0.3 kcal/min. During a short (six minute or less) heavy assault, the maximum work capacity of the individual is relatively unimportant, but weight is important, and body weight becomes very important during sustained work, since it must be moved by the man. Thus a load which is appropriate for an average 70 kg (154 lb), 173 cm (5 ft 8 in.) man, could be increased by perhaps 50% for a 100 kg (220 lb.), 182 cm (6 foot) soldier and should be decreased by about 50% for a 50 kg (110 lb.), 162 cm (5 ft 4 in.) man. Failure to make such allowance means that the small man is working relatively much harder than the average, and the bigger man less, although it is a frequent observation that the smallest men may wind up carrying the heaviest items. In such a case, it would be unlikely that physiological and the usual work performance measures would show significant differences between a small and a large soldier, since the work would be identical if the weights of man plus load are identical. However, the smaller man will feel that the work is more difficult, and to the extent that it represents a greater percentage of his total work capacity, it will be harder for him and he will tire faster, and, in fact, lose his combat efficiency faster than a larger man. The extent of this problem will become apparent when one considers the range in size of the men in military service. The four accompanying charts, which are based upon, The Body Size of Soldiers — U.S. Army Anthropometry-1966 by Robert M. White and Edmund Churchill, show the range in size of our soldiers in four dimensions which are critical with respect to load carrying.

Figure 19



WEIGHT DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 19 shows the range in weight of soldiers. The average size man (median) weighs 156.3 pounds, and is generally the man who is thought of as "the soldier" when his capability in carrying a load is considered.

A practicable or desirable upper limit to the load for a man to carry, which will not unduly burden him, has been set by rule of thumb for many years at around a third of body weight; other studies merely recommend that the marching load not exceed 45 lbs. (cf. Fig. 17).

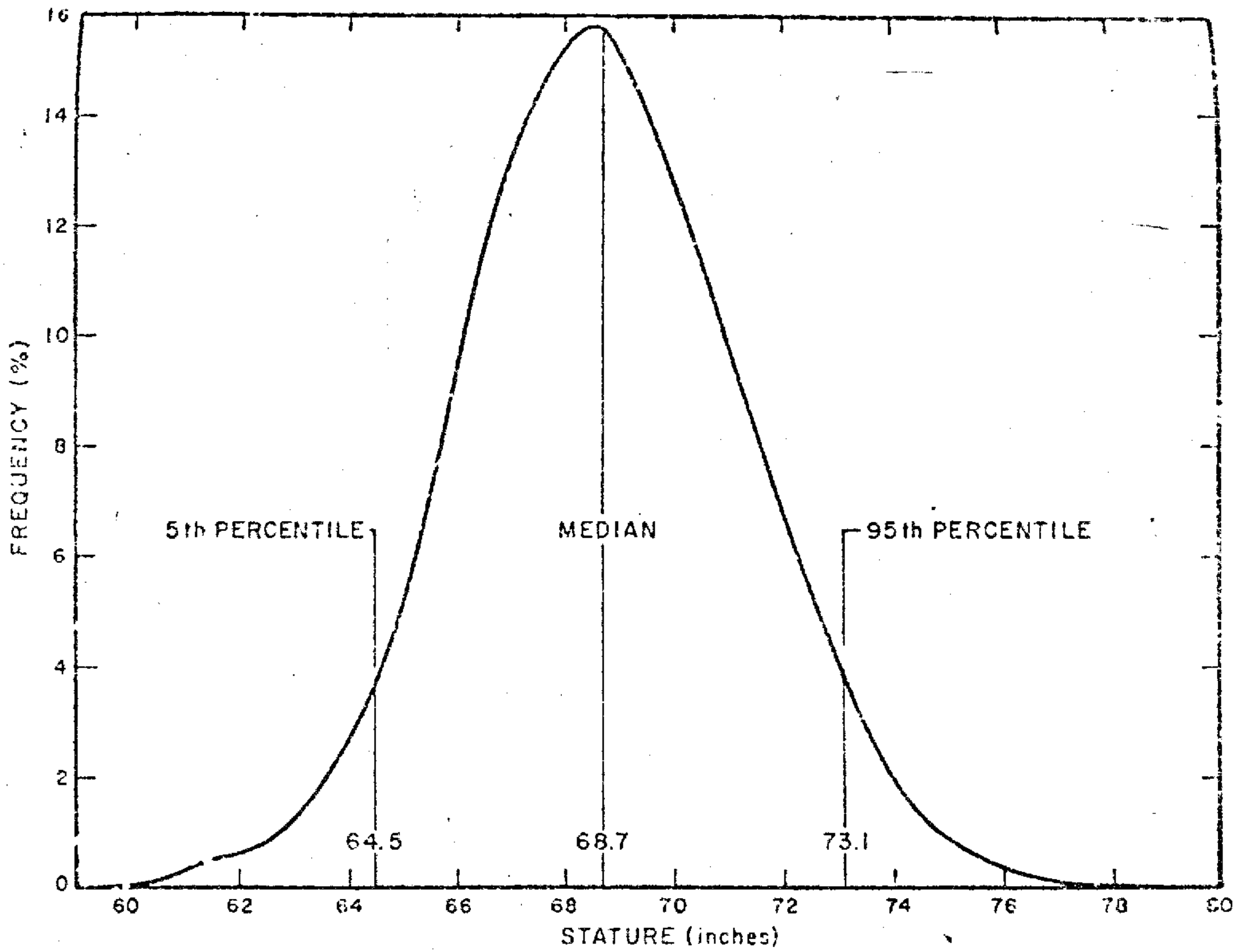
In short, the fifty percent of the infantry company who are smaller than the average are at a proportionately and significantly greater disadvantage in respect to their efficiency as load carriers to the extent that they come closer to the fifth (126.3 lbs.) or first (116.0 lbs.) percentile of men according to weight. On the basis of a third of body weight, the fifth percentile man, weighing thirty pounds less than the median, should carry a load ten pounds lighter than the median man; on the basis of relative maximum work capacities, the reduction in load should be about 23% for such an individual, on the basis of a 45 lb. load, again about 10 lbs. The above conclusion is to be tempered somewhat in respect to a balanced proportion between weight and height, i.e., that his weight is essentially muscle mass and not just fatty tissue. To the extent that this balance exists, height could be equally used as a criterion of the proportion of the smaller soldier's work capacity expended in carrying the same size load as a larger soldier, as discussed above. (Figure 20).

A further disadvantage of the small man is reflected in his waist circumference. While the dimensions shown in Figure 21 are for the nude man, by adding about 1½ inches, one can get the actual dimensions over the waist belt on fatigue trousers. The equipment which occupies space on the belt is of fixed dimension: the canteen, the entrenching tool, the bayonet, the ammunition pouches, and the space occupied by the pack in the back.

For the fifth percentile man, with a waist girth of only 27.4 inches (plus about 2 inches for his clothing), these items are crowded together on his belt, whereas for men in the upper half of the size range, there is ample space, and the ammunition pouches may be moved off to the side and away from the center of the body where they will be less cumbersome.

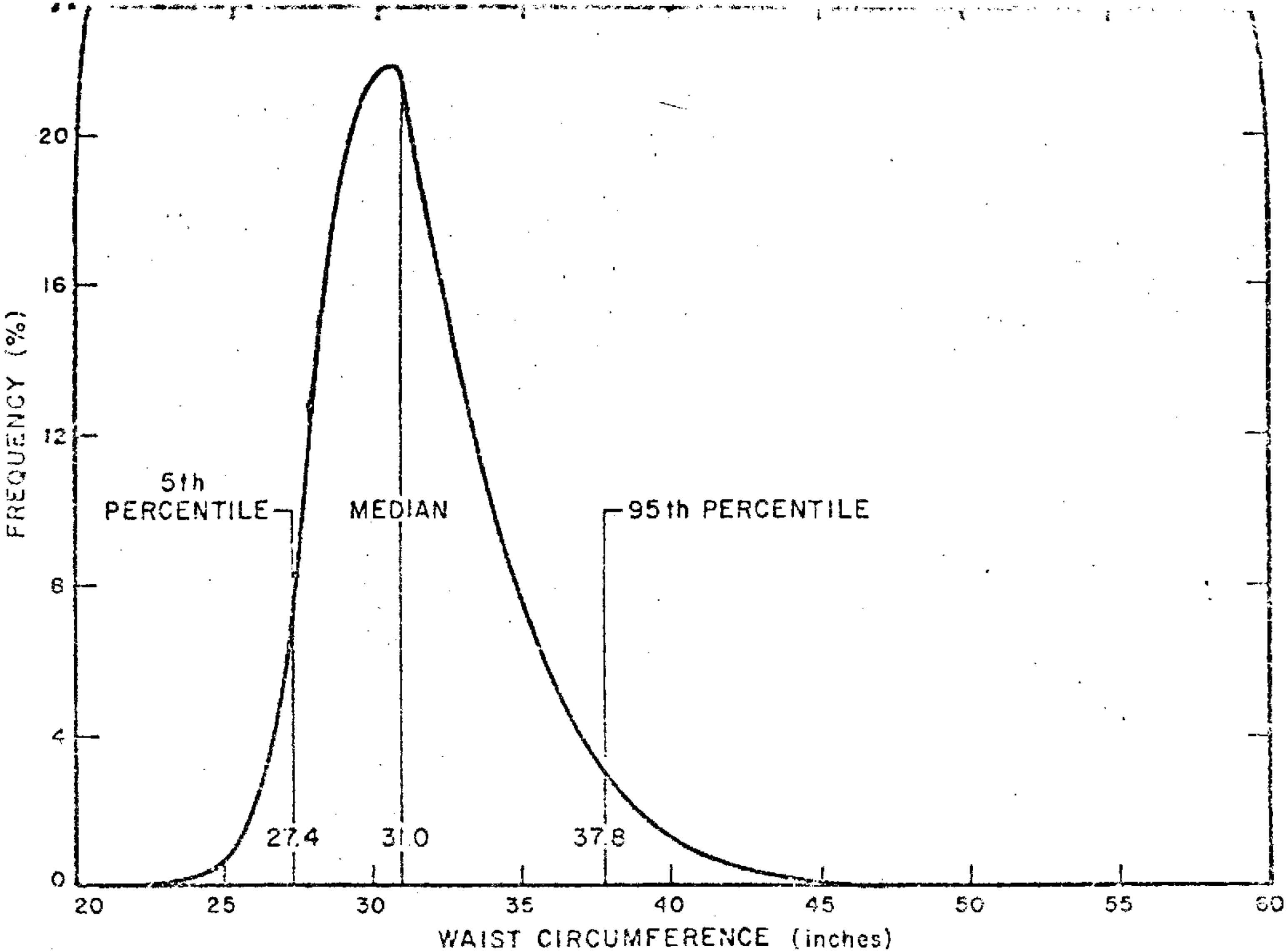
The same kind of problem exists for the man with a short back waist length (Figure 22). The correlation between stature and back waist length is not high, only .43, so we are not talking here necessarily about the difference between tall and short men. What matters in this respect to good load carrying is the space on the back above the buttocks for the positioning of a large load, whether a large pack or special items of man-portable equipment. It is also critical for a two-component load, such as a pack and sleeping bag attached separately to the load carrying harness, and to a packboard frame.

In short, the problem of load carrying cannot be reduced just to consideration of the average size man. While it is recognized that some items of equipment cannot be made in different sizes, the determination as to their effective man-portability should be weighed against the limitations of smaller sized man in the military service who may be called upon to carry them. This will apply both to weight and to the configuration of the equipment to be carried.



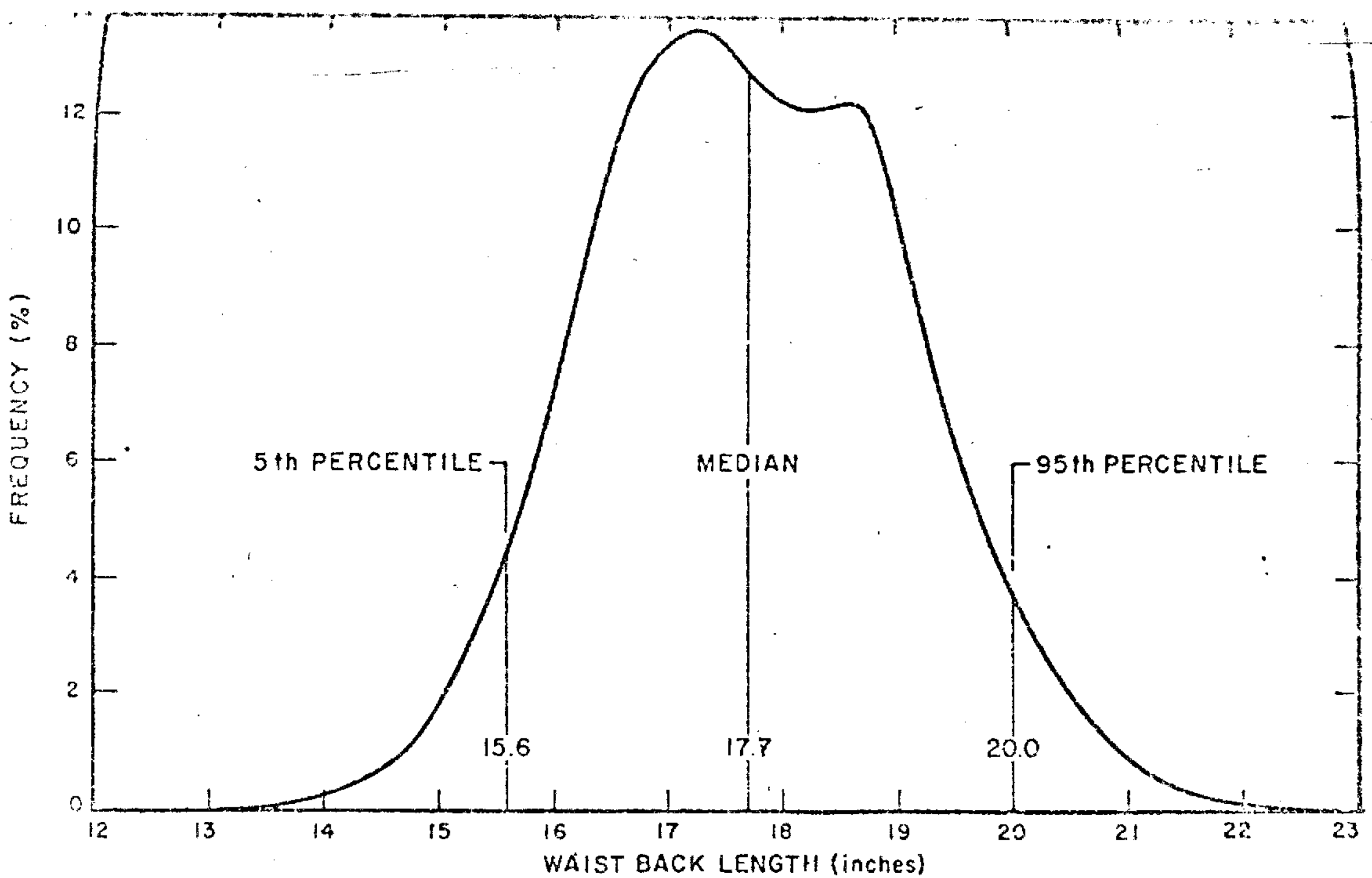
STATURE DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 20



WAIST CIRCUMFERENCE DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 21



WAIST BACK LENGTH DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 22

COMBAT DEVELOPMENTS STUDY PLAN
REDUCING THE SOLDIER LOAD (DRAFT)

1. Purpose. To conduct a comprehensive review program directed toward providing recommendations on how the infantryman's load can be lightened without degrading his ability to complete his mission and survive. The weight reduction of the individual infantryman's fighting, mission, and existence loads will be viewed from the aspect of improving the design, doctrinal employment, and tailoring of mission essential items in the hot-dry, hot-wet, temperate, cold-wet, and cold-dry environmental zones.

2. References. Annex A

3. Terms of Reference.

a. Problem. The infantryman has accepted an ever increasing load/burden caused by technological advances in the equipment field. This study is to determine the type of items the soldier must carry into battle, to include weapons, ammunition, night sights and other equipment. At present, it is accepted that he cannot fight and survive with his total equipment load.

b. Definitions.

(1) Fighting Load. In addition to weapons and ammunition, the typical fighting load is made up of those essential items of individual clothing and equipment that are carried to accomplish the immediate mission of a given unit.

(2) Existence Load. The existence load consists of those items other than the fighting load which are required to sustain or protect the soldier, and normally would not be carried by the individual for extended period, but would [illegible] by [illegible].

(3) Mission Load. Consists of those items not found in either the

fighting or the existence loads but which are required to successfully engage and defeat specific targets.

c. Impact of Problem. A failure to solve this problem will cause the infantryman to remain overloaded, will reduce his mobility, will result in an inability to successfully complete his mission and survive on the modern battlefield.

d. Objectives.

(1) Conduct a literature search to collect information from previous tests to evaluate the soldier load.

(2) Conduct a series of company level field evaluations to determine what equipment is required for the fighting load, mission load, and existence load.

(3) Conduct a series of field evaluations to determine how and where the soldier's load can best be carried in view of the current storage and transportation capabilities.

(4) Conduct a series of field evaluations to compare Standard A items with commercial off-the-shelf equipment.

e. Scope.

(1) Determine if current and future technology will permit the dismounted soldier to fight and survive in an Air Land Battle for a minimum of 72 hours with little or no external logistics support.

(2) The study will address the soldier's ability to succeed in both European and Southwest Asian environments.

ability to transport his loads will be addressed.

f. Limitations.

(1) The study will be limited to a series of 72-hour battlefield time-frames during which there will be little or no external logistical support.

(2) The study will be limited to those scenarios in which dismounted infantry will most likely be employed.

g. Assumptions.

(1) The basic mission of the infantryman to close with and destroy the enemy's capability to fight will not alter.

(2) Scenarios will not demand super-human efforts from the soldier.

(3) Portaging equipment and aids are allowed and should be evaluated for beneficial utility.

(4) Current tactics and doctrine will remain valid during the study time-frame.

(5) The battlefield will include the use of nuclear, chemical, electronic warfare, and directed energy weapons.

(6) TOE and force structures are fixed as currently exist or projected.

(7) Technology will continue to become increasingly more sophisticated and will provide lighter weight, off-the-shelf items of equipment superior to those which are currently available.

(8) As the state-of-the-art changes, currently available equipment will become obsolete.

h. Essential Elements of Analysis (EEA).

(1) What are the critical tasks associated with the soldier's ability

to transport his loads and continue to fight successfully?

(2) What external support does he require to complete his mission with regard to contingency scenarios?

(3) What are the deficiencies associated with current equipment?

(4) What new equipment must be procured or developed to correct current deficiencies?

(5) What corrective action in the area of force structure is required to resolve the deficiencies?

(6) What costs are associated with the changes to the soldier load as recommended?

(7) What is the impact of improved threat capability upon the soldier's ability to fight and survive?

(8) What are the required physical and mental criteria to sustain the soldier on the battlefield?

(9) Is carried weight the constraining issue?

(10) What are the upper limit load carrying bounds for the 5th - 95th percentile soldier?

(11) Is the 72-hour time limit realistic given the finite carrying ability of the soldier?

(12) What portaging aids are available?

(13) Are mechanical aids required?

enable the soldier to succeed in battle?

i. Constraints. None. (if troops and monies are available)

j. Alternatives.

(1) Standard A, experimental items, off-the-shelf items and items in development are to be considered for evaluation. These will include foreign items.

(2) Other alternatives, as identified during the course of the study, will be evaluated.

k. Operational and Organizational Concept. TBD.

l. Mission Profile. TBD.

m. Measures of Effectiveness (MOE). The following MOE are representative of those to be used. Additional MOE may be added during the course of the study.

(1) Load carrying ability based on percentage of naked body weight (i.e., 30% for fighting and mission loads and 45% for fighting, mission, and existence loads).

(2) Degradation of performance over a timed close combat assault course by specific squad position (e.g., rifleman vs grenadier vs machinegunner vs Dragon gunner, etc).

(3) Percentage of soldiers not able to physically meet slowest time based on close combat assault course time comparisons.

(4) Semantic differential rating questionnaire based on bipolar adjectival pairs which survey/rank soldier preferences regarding equipment used. This method enables objective data [illegible] from a subjective first hand [illegible].

(5) Weight of different type loads desired for the specific missions.

n. Methodology. The methodology for conduct of the study is a multi-disciplinary approach which incorporates numerous data collection methods. Outlined below is a general three-phase plan for execution which culminates in an evaluation of the tested equipment.

(1) PHASE I: A data base test in FY83 evaluating Standard A issue equipment versus selected off-the-shelf equipment.

(a) Purpose. The phase will provide a data base of Standard A issue equipment against which all other tested equipment will be rated.

(b) Approach. The data base test will use a regimental MTOE company with normal attachments for stability of personnel using a 72-hour Infantry Company ARTEP, (IBP by Scores Branch) using limited logistic support scenario (i.e., only organic vehicles, resupply of ammunition and water) consisting of movement to contact, coordinated attack, defense and a withdrawal. The environments for test will incorporate hot-dry, hot-wet, temperate and intermediate cold (cold-wet) climate testing of the equipment. Chemical-biological (CB) threat simulations will be conducted during all sub-phases. All normal or mission essential weapons will remain standard. These tests will integrate performance indications, human factors and semantic differential questionnaires.

(c) Results. The test will yield data against which all other equipment fighting configurations will be based.

(1) PHASE II: This phase will be a new equipment phase in FY83 stressing the integrated fighting system.

(a) Purpose. The Phase II testing will provide data to evaluate new equipment variations and incorporate lessons learned from Phase I.

(b) Approach. The methods used during Phase II will be as identical as possible to the Phase I approach.

(c) [illegible]

define those items of equipment desired.

(3) PHASE III: A FY81 phase stressing the Integrated Battle Mess system prototype Concept Evaluation Program (CEP) Test.

(a) Purpose. To provide acceptability data for the equipment and concepts tested in previous phases.

(b) Approach. To be determined.

(c) Results. Will provide data for acquisition of preferred items of equipment. It will provide a means to assess the equipment's operational effectiveness to include compatibility, interoperability, reliability, availability, and maintainability; safety; health and human factors as well as the need for any modifications.

o. Models. Not applicable.

p. Related Studies. See references, Annex A.

4. <u>Environmental/Threat Considerations.</u>

a. Study mission scenarios will be adjusted to accommodate the European/Mid-East areas of operations and the hot-dry, hot-wet, cold-dry, cold-wet, and temperate climates.

b. Threat projections will accommodate the 1992 projections.

c. Modifications to scenarios may also be made to accommodate equipment, state-of-the-art technology and at the direction of the Study Advisory Group (SAG).

5. <u>Support and Resource Requirements.</u>

(1) HQ TRADOC:

(a) Provide guidance as required during conduct of the study.

(b) Establish the Study Advisory Group (SAG), develop SAG membership, and provide SAG chairman. (CCLMAA SAG and the IFSP JWG)

(2) TRADOC schools, centers, agencies. Provide study support and SAG representation as required.

b. Data Requirements. As determined by the 9th Infantry Division and the High Technology Test Bed (HTTB) IAW the MOU.

6. <u>Administration.</u>

a. Study Schedule

(1) Presentation of work in progress to be presented to the CC(L)MAA.

(2) Development of further efforts beyond FY82, as required.

b. Study Project Officer, USIAIS: ATSH-CD-MS-C, CPT Graber, AV 835-3087/7514.

7. <u>Correlation.</u> ACN 36870 applies.

ANNEX A

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