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EVALUATION OF US AIR FORCE SURVIVAL/ARMOR VEST IN US ARMY OH-58 HELICOPTERS

AD-A044842

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UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

Clothing, Equipment and Materials Engineering Laboratory

CEMEL-161

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (19) TR-77-3-CEMEL	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) "Evaluation of US Air Force Survival/Armor Vest in US Army OH-58 Helicopters."		5. TYPE OF REPORT & PERIOD COVERED (9) Final Feb. 1976
		6. PERFORMING ORG. REPORT NUMBER (14) CEMEL-161
7. AUTHOR(s) (10) Thomas H. Judge and Michael B. Kulinski		8. CONTRACT OR GRANT NUMBER(s) MIPR AF FY76157505042
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Natick Researhc and Development Command ATTN: DRXNMA-VCA Natick, Massachusetts 01760		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS (11)
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Natick Research and Development Command ATTN: DRXNM-VCA Natick, Massachusetts 01760		12. REPORT DATE Feb 76
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) N/A (12) 59p.		15. SECURITY CLASS (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

N/A

DDC OCT 11 1977 C

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

ARMOR	SURVIVAL (GENERAL)	BALLISTICS
BODY ARMOR	SURVIVAL EQUIPMENT	PROTECTIVE EQUIPMENT
ARMOR VEST	SURVIVAL VEST	BALLISTIC PROTECTIVE EQUIPMENT
SURVIVAL	PROTECTIVE CLOTHING	FABRICS

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

The USAF developed a Survival/Armor Vest concept. This was coordinated with the DoD Tri Service Committee in Aircrew Body Armor with a complete exchange of development information between the services.

The US Army, during this time, was developing an Individual Survial Vest for Aircrewmembers, "ISVESTA", a concept using standard components. For DoD Tri Service standardization it was decided to evaluate the USAF Vest by the US Army Aviation Test Board at Ft. Rucker, AL.

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The Test Report, (Ref 1), found a number of flight safety hazards with both vests. However, the test report did not identify in detail the deficiencies found with the USAF Vest. This report identifies those conditions found on the OH-58 type Helicopter.

Four evaluations: Static, Flight, Body Load and Pressure, and Sizing were conducted and these revealed a number of minor design deficiencies. The material used in the vest construction does not provide sufficient retention of the armor insert and carrier. Lack of retention caused the armor insert to rest on the pilots legs creating leg discomfort.

The USAF Survival/Armor Vest requires redesigning to correct the deficiencies presented here. The sizing criteria were also evaluated. New sizing criteria are recommended to improve the sizing.

FOREWARD

This evaluation was conducted in coordination with the Tri Service Aircrew Body Armor Working Group. This report covers the work effort accomplished during 1975.

The USA NARADCOM Project Officer, Mr. Thomas H. Judge, was assisted in this evaluation at US Army Natick Research and Development Command and Ft. Devens Air Field by Capt. Paul Severance who served as a test subject and many members of the flight operation staff and maintenance crews at Ft. Devens Air Field. Mr. Fred Meers of USA NARADCOM photographed all the scenes for still and motion picture records.

The outstanding efforts of the above personnel contributed greatly to the success of this evaluation.

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SUMMARY

This evaluation revealed the US Air Force Survival/Armor Vest has a number of deficiencies that could be identified as Human Factor problems, contributing to incompatibilities between the pilot and his effort to satisfactorily operate the OH-58 Helicopter. The material used in the survival vest design does not provide for sufficient retention on the pilot's body of the armor carrier and insert during flight. The length of the armor insert and its side edges limit the pilot's ability to properly operate the controls of the OH-58 Helicopter.

The deficiencies cited are minor design problems. However, they do restrict the pilot's motion during flight and, as such, were listed as flight safety hazards. A modification program, such as a product improvement program, could be undertaken to modify the armor insert, armor carrier, and the survival vest to eliminate these problems. A Human Factors study would be required to determine the dimensional profile of the armor insert. Modification of the insert would then be required to meet a new profile outline. Action should also be taken to redesign the armor carrier to meet the new profile outline for the armor insert. This action would provide the opportunity to review and apply the latest state-of-the-art in ballistic fabric materials.

The survival vest will require redesigning to include weight retention characteristics to support the weight of the armor carrier and insert in a position on the body where it will not restrict the pilot's movements nor create physical discomfort.

A computer evaluation of the sizing criteria used for the USAF armor insert four-size system was conducted and indicated the criteria of using Stature, Waist, and Chest Circumference had a "No-Fit" percentage of 64.71. It was discovered that by using Vertical Trunk measurement in place of Stature, the "No-Fit" percentage drops to 22.23% and distributes the four sizes more evenly over the population. A Human Factors study is further indicated to evaluate the practical application of this change among USAF personnel and possible members of the US Army and US Navy Aviation Communities.

EVALUATION OF US AIR FORCE SURVIVAL/ARMOR VEST

IN US ARMY OH-58 HELICOPTERS

INTRODUCTION

The United States Air Force Survival/Armor Vest Concept, figure 1, which consists of a vest fabricated of nomex raschel knit, and back and front anatomical shaped ceramic inserts contained in carriers of ballistic protective fabric and felt, was introduced into the Development Test II of the US Army Individual Survival Vest for Aircrewmembers as an intra-service standardization item for comparison review in US Army helicopters. The US Army Individual Survival Vest for Aircrewmembers, figure 2, is fabricated of nomex oxford cloth. It has pockets to contain the SRU-21/P Survival Vest component, back and front ceramic armor inserts covered with spall, and fragmentation carriers fabricated from ballistic protective fabric and felt.

Both Survival/Armor Vest concepts were designed to provide pockets to contain the standard survival components presently used in the Individual Survival Vest SRU-21/P and ceramic armor protective inserts to protect the aircrewmember from 30-caliber armor piercing projectiles. The US Army Aviation Test Board at Ft. Rucker, AL., following the completion of the test program, published a final report Development Test II (Service Phase) of the Individual Survival Vest for Aircrewmembers, citing a number of flight safety hazards caused by the US Army Individual Survival Vest for Aircrewmembers and further stated the same deficiences were found associated with the USAF Survival/Armor Vest Concept.[1] The development program for US Army Individual Survival Vest for aircrewmembers was terminated following the Development Test II Program.

The flight safety deficiences cited in the final test report for the USAF Survival/Armor Vest concept were not defined in detail by the US Army Aviation Test Board. Therefore, under the Department of Defense Tri-Service Agreement on Aircrew Body Armor,[2] the US Army Natick Research and Development Command, as the lead laboratory for the refinement, design engineering, and development of aircrew body armor for interface with the USAF and US Navy embarked on an evaluation program to identify these deficiences in detail, using the USAF Survival/Armor Vest in the OH-58 US Army Helicopter. This helicopter was identified through analysis of the final test report (see ref. 1) to have the greatest number of problem areas. The identification of these deficiences permits this Command, in cooperation with the USAF, the opportunity to take corrective redesign actions to eliminate the flight safety hazards cited by the US Army Aviation Test Board against the present design.

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[1]Development Test II (Service Phase) of Individual Survival Vest for Aircrewmembers Oct 1974, Captain Leslie C. Mingus, Project Officer USAAVTED, AL.

[2]Joint Agreement on Consolidation of Functions and Facilities Aircrew Body Armor 29Mar1972

to achieve the objectives of this evaluation, four studies were undertaken to define and identify the pilot's areas and actions that lead to the safety of flight citations by the US Army Aviation Test Board. These studies include:

(1) Static Ground Evaluation where the pilot was observed by the evaluator following through flight envelope motions while stationary on the ground.

(2) Flight Vibration Study where the retention of the armor insert was evaluated during the actual flight conditions.

(3) Body Load and Pressure Evaluation to study the unseen loads and pressure exerted of the pilot's body by the survival/armor vest and the aircraft shoulder/lap belt restraint system.

(4) A sizing study was conducted to develop criteria that could be used to expand the range of body sizes a vest would fit and reduce the number of no-fits.

FIGURE 1

[illegible] CONCEPT

DISCUSSION OF TESTS PERFORMED

1. STATIC GROUND EVALUATION

A. OBJECTIVE:

To identify those areas contributing to the incompatibilities of the USAF Survival/Armor Vest with the pilot of an OH-58 Helicopter during his flight performance envelope.

B. METHOD OF EVALUATION:

The Survival/Armor Vest was worn by the pilot. The pilot that was chosen for these evaluations was selected at random. His body measurements are: Stature 62 in. (147.08 cm), chest circumference 44 in. (111.76 cm), and waist circumference 37 in. (93.98 cm). A large-regular size vest was issued to him for these evaluations. Only one pilot was chosen for this detailed follow-through on all evaluations of this OH-58 Helicopter. The pilot was observed by the evaluator and provided subjective reports that together formed the results of this evaluation. The front door of the OH-58 Helicopter was removed to facilitate photographing the pilot's actions. The pilot went through the following flight motions.

Releasing cyclic friction.
Reaching starter switch with right hand.
Reaching radio controls.
Adjusting restraint system.
Bringing cyclic to the rear.
Retrieving check list from floor.
Egressing from helicopter.

C. EQUIPMENT:

OH-58 Helicopter Serial Number 20632
USAF Survival Vest Concept
US Army Flight Suit
16-mm Motion Picture Camera

D. EVALUATION RESULTS:

In releasing the cyclic friction, figures 3 & 4, the left top edge of the armor insert and carrier hit the pilot's chin. In bending forward and twisting to the right, the left bottom edge of the armor insert and carrier pressed into the waist area and the survival first aid kit pressed into the left leg. As the pilot reached for the starter switch and radio controls, figure 5, the armor insert and carrier restricted the right arm movement, rode up outside the chin; the shoulder harness then pressed into the neck, and the lap belt pressed the armor into the legs.

When the cyclic control was brought fully to the rear, the survival component, along with the right side edge of the armor insert, forced the right arm of the pilot outside the helicopter. During flight operations, the door is closed and the pilot is forced to use a wrist action or a twisting of the body to move the arm to go between the armor panel on the seat and his body.

The helicopter check list was on the floor of the fuselage and the pilot found it difficult to retrieve it. This check list is used for preflight check and landing check of instruments and controls. These problems were similar to those identified when he adjusted the Cyclic Friction in figure 3.

When egressing from the helicopter the pilot found himself restricted in the neck area and on the left leg, figure 6. The armor insert and carrier bottom edge dug into the left leg, figure 7, and restricted the leg from further movement in egress. The upward movement of the armor plate from the leg binds the chin when the head is bent forward to clear the top edge of the door exit, figure 8.

E. CONCLUSION:

The USAF Survival/Armor Vest with the armor insert will require redesign action to eliminate the binding caused by the armor insert on the arms, legs, and under the chin.

The aircraft cockpit design is limited. Its development did not consider the military pilot, his combat life support equipment, and the requirements of a military flight mission when designing the seats and pilot co-pilot mission envelopes.

FIGURE 3

RELEASING CYCLIC MOTION

FIGURE [illegible]
STARTING HELICOPTER ENGINE
AND REACHING RADIO CONTROL

FIGURE 6

EGRESS FROM OH-58

[illegible] 7

[illegible] ICTION

2. FLIGHT VIBRATION EVALUATION

A. OBJECTIVE:

To determine if the vest material and the design used in the fabrication of the vest can retain the armor carrier and insert in a safe position on the bodies of the pilot and co-pilot during helicopter flight. A safe position is considered to be one that does not restrict pilot or co-pilot motion or cause discomfort to the pilot or co-pilot during the flight operational envelope.

B. METHOD:

The Survival/Armor Vest was worn by the same pilot used in the static ground evaluation. The co-pilot flew the helicopter due to the flight safety hazards cited by the USA Aviation Test Board. (The pilot followed through on the controls.) The equipment was flown in the CH-58, since this helicopter was identified as having the worst human factor conditions cited in the US Army Aviation Test Board Report (see page 2) that contributed to flight safety hazards. The flight was a round robin type with normal routine flight procedures.

The vest was worn one inch off the legs of the pilot with the top edge of the carrier lined up with the upper edge of the breast bone. This position was checks for movement every ten minutes during flight. Due to the lack of control over the plate movement, flight was terminated after two hours.

C. TEST RESULTS:

The armor insert and carrier dropped an average of 3/8 in. to 5/8 in. every five minutes. At the end of ten minutes, the armor insert and carrier were resting on the legs with no where else to go. Every ten minutes, the armor insert and carrier were returned to the initial position and the pilot readjusted the shoulder harness and lap belt in an attempt to control the armor insert. The vest material and design did not provide adequate retention characteristics to keep the armor insert and carrier off the pilot's legs.

D. CONCLUSION:

The USAF Survival/Armor Vest requires redesigning of the vest to provide built-in support and retention for the armor insert to keep it up off the legs during flight operations.

3. BODY LOAD AND PRESSURE EVALUATION

A. OBJECTIVE:

To determine if the vest, armor insert, and carrier, when worn as a complete assembly, contribute to unseen load and pressure on the body of the pilot as he follows through on his flight envelope motion.

B. EQUIPMENT:

OH-58 Helicopter at Ft. Devens, MA.
USAF Survival/Armor Vest
US Army Flight Suit
US Army NDC Load Profile Analyzer
16-mm Camera and Miscellaneous Equipment for recording evaluation.

EQUIPMENT NOTE:

The Load Profile Analyzer, figure 9, consists of four basic units: Load Sensing garment, front and rear display consoles representing the upper torso, power supply, and remote control unit.

The load sensing garment is a front closure vest containing 248 pressure sensors. The sensors, figure 10, are arranged in a matrix similar to the display console and mounted on vertical strips of mylar tape. The tape is configures to follow the lines of the torso. Each tape is connected to the bottom to a wiring harness. The harness transmits the signal to the display units by means of an umbilical line.

Each pressure sensor on the garment is represented on the torso model by a tri-colored lamp which is energized by the sensor output. The yellow filament is energized to indicate that o.5 lb of pressure is being placed on the sensor; the green filament indicates 1.0 lb and the red is 1.5 lb or more. The displays can be held in four action modes; accumulate, continuous, hold, and clear. In this evaluation the continuous mode was used to show continuity of a pilot's actions and their results on the display consoles.

A 16-mm Motion Picture Camera recorded the evaluation at 24 FPS. The results of this evaluation were arrived at through the use of a 16-mm Motion Picture Projector Analyzer and the stop action on the projector.

C. METHOD:

The sensor vest was worn under the USAF Survival/Armor Vest, the pilot then entered the helicopter in the pilot position. The umbilical line was connected between the sensor vest and the display console. The pilot proceeded to follow the same flight envelope motions that were used during the Statis Ground Evaluation. The pressure of the body load was transmitted to the display console. This information was recorded by 16-mm color film for future use by an analyzer projector.

D. TEST RESULTS:

Pressure loads developed in the right chest area when the pilot bent over to release the cyclic friction, figure 11, or reached over with his right hand to activate the starter switch and radio controls.

Right Chest pressure, figure 12, was caused by the shoulder harness which pressed down on the shoulder and the armor insert which pressed in on the body. As the pilot continued to bend forward, the lap belt buckle caused pressure on the waist and forced the armor insert and carrier into the lower abdomen.

In retrieving the helicopter flight check list from the floor, pressure was exerted on the abdomen. The top right edge of the armor insert was forced into the body by the right shoulder harness, figure 13.

Exiting the helicopter caused pressure on the center chest and just below the center of the rib cage, as shown in figure 4. The armor insert also exerted pressure in the waist as the pilot lifted his body to exit the helicopter.

E. CONCLUSION:

This evaluation details the loads on the body and affirms the problem areas found in the static ground evaluation. It also points to the sensitivity of the sensor vest and its possible value in substantiating a given problem on the body of an individual when wearing clothing and/or other equipment.

NOTE:

All test results are based on the number and location of 1-1/2-lb pressure loads imposed on the body as displayed on the console unit. Only the pressure loads on the front console unit were recorded for this evaluation.

FIGURE 1

LOAD PROFILE ANALYZER

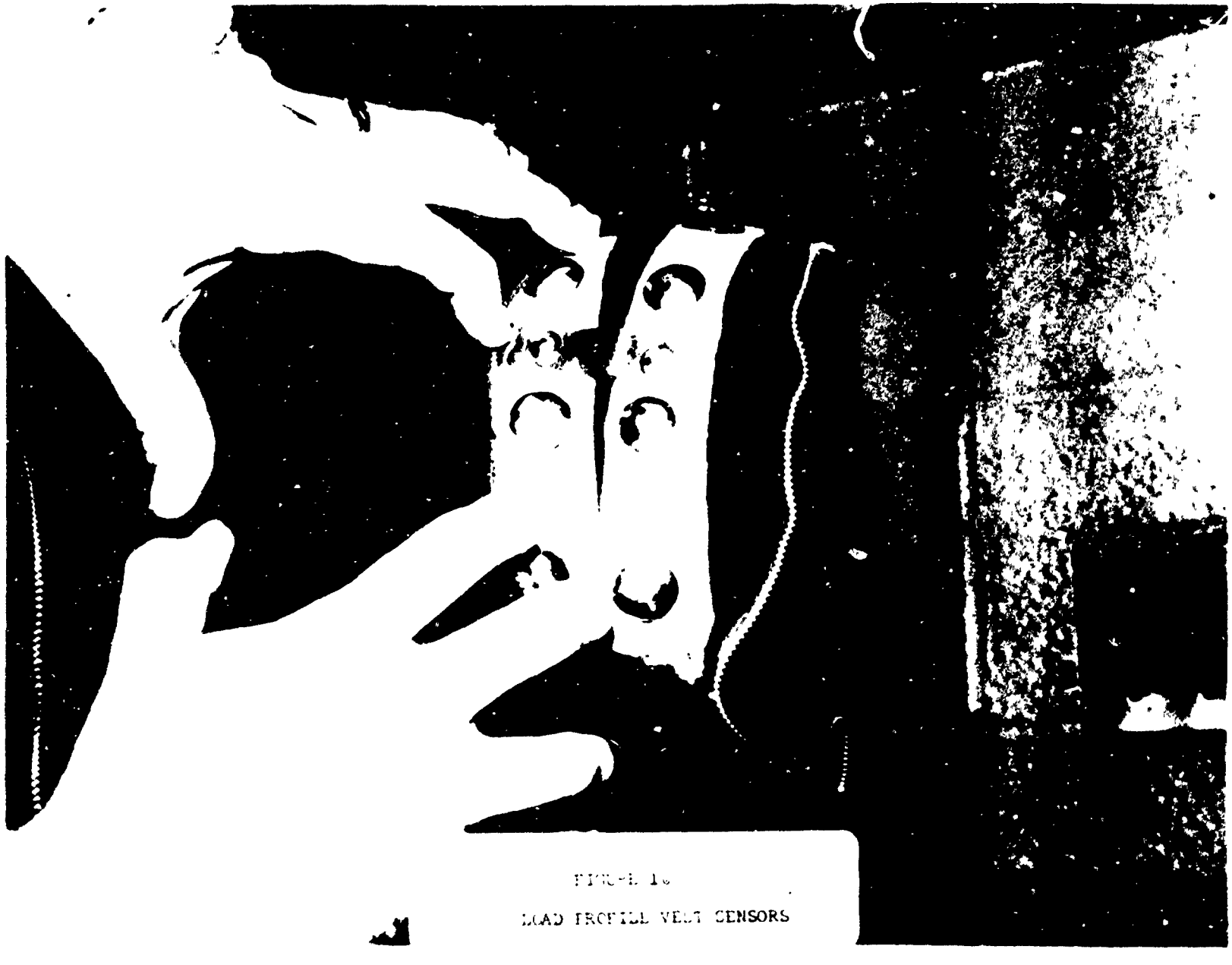

FIGURE 16

LOAD PROFILE VELT SENSORS

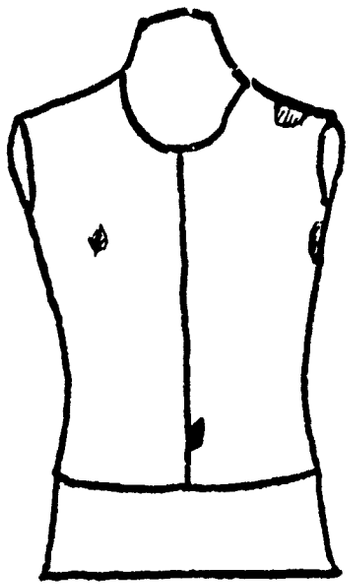

FIGURE 11

Reaching Cyclic Friction

FIGURE 12

Bending Forward

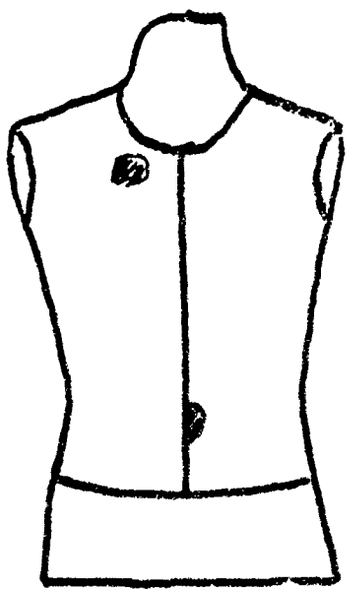

FIGURE 13

Retrieving Helicopter Check List

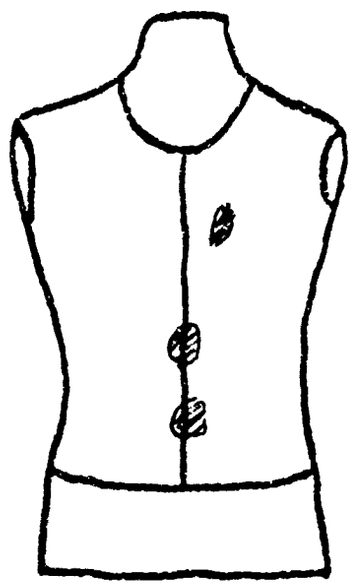

FIGURE 14

Exiting Helicopter

Load Profile Display Read Out

Areas of Pressure
on the body
1 1/2 lbs and over

4. SIZING CRITERIA EVALUATION

A. INTRODUCTION:

During the test program for the Individual Survival Vest for Aircrewmembers at the USA Aviation Test Board, test subjects complained of poor fitting of both the USAF Survival/Armor Vest and the US Army Survival/Armor Vest and armor insert. Test Project Officers also felt that there was not enough flexibility in the present sizing criteria of both vest systems to adequately fit the aircrewman population. A study was initiated to evaluate the sizing criteria for the USAF and the US Army Armor insert at USA Natick Research and Development Command, since these items could be evaluated together, in order, using the same evaluation guidelines. Primary attention was placed on the armor insert--a non-flexible ceramic armor plate requiring a flexible sizing criterion, to enable these items to be used by a larger number of the aviation population.

B. OBJECTIVE:

To explore the possibility of expanding the present sizing criteria to cover a larger number of people in the aviation community.

C. EVALUATION METHODS AND RESULTS:

Bivariate charts will be used to illustrate and evolve the sizing systems. A bivariate chart is a cross tabulation of two variables presented in a table format. The first variable is along the Y axis and the second along the X axis. The sizing relationship of the two variables can then be blocked out on the charts.

Data from the 1966 US Army Anthropometric Survey and the 1970 US Army Aviators Anthropometry Survey were used to correlate fitting criteria.[3,4] The sample size of the anthropometric data base consisted of seventy body dimensions measured on 6682 individuals. The data were maintained in mass storage file on the Command's Univac 1106 computer facility. Software was developed to produce bivariate distributions of all relevant body dimensions. A data management file was constructed to test various sizing plans and optimize the fit.

The current sizing criteria for the two systems are based upon stature, chest circumference, and waist circumference (see Table 1). The bivariate representations of these systems are shown in Appendix A. An objective of the sizing system is to provide comfort and fit as well as proportionate area coverage for the individuals within a size range. The fit of the armor is primarily related to torso dimensions, and these dimensions should be the prime elements in obtaining the best fit. Correlation coefficients from

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[3]The Body Size of Soldiers US Army Anthropometric 1966, TR-72-51-CE, While R.M., NARADCOM, E. Churchill, Anthropology Research Project, Yellow Springs, OHIO, Dec. 1971.

[4]Anthropometry of US Army Aviators 1970, Dec 1971, TR-72-52-CE, E. Churchill J.T. McConville, L.L. Laubach, Anthropology Research Project, Yellow Springs Ohio and R.M. White US Army NARADCOM, Natick, MA

the 1970 US Army Aviators Anthropometric Survey show that the correlations between stature and waist back and front length are poor, +0.560 and +0.427, respectively. These low correlations indicate that a more optimum sizing system could evolve through the use of a variable which correlates better with the torso dimensions. Such a variable is the standing vertical truck circumference which is measured by a steel tape passing through the crotch and over the midpoints of the right buttock and right shoulder. The correlations between standing vertical trunk circumference and waist back and front length are +0.630 and +0.700, respectively.

The actual surface dimensions of the front and back plates of the three-size body armor are shown in Table 2. These dimensions can be used as minimal fitting guidelines for a sizing system. Bivariate charts which relate these dimensions in terms of the waist back length, interscye breadth, and chest breadth are in Appendix B. The dimension which has the best correlation with waist back and front length is the vertical truck circumference. Bivariate representations of a three-size system utilizing vertical trunk, waist, and chest circumferences are shown in Appendix C. The sizing criteria using this system is shown in Table 3. Table 4 illustrates the fit statistics of both three-size systems. The vertical trunk sizing system as evidenced by Table 4, clearly involves a larger percentage of the population within the fitting scheme.

The same logic can be applied to the four-size aircrew armor system. The actual surface dimensions of the front and back plates of the four-size system are shown in Table 5. The four-size system is different from the three-size in that the difference between the regular and the long size is in the plate length. This arrangement allows for a blocking type of sizing system which does not overlap. Bivariate representations of the current and proposed sizing systems are shown in Appendix D and E. Table 6 shows a comparison of the fit statistics for both four-size systems. This table illustrates the large involvement of individuals within the fitting scheme when the vertical trunk circumference is used as a criterion. Table 7 represents the four-size system incorporating the standing vertical trunk circumference.

D. CONCLUSION:

It is evident that using the vertical trunk circumference as a sizing variable will result in a large involvement of individuals in the fitting scheme.

TABLE 1

Current Sizing Criteria for Air Crew Armor Insert

US Army Three-Size System

Small	
Stature	thru 67.0 in.
Chest Circumference	thru 37.5 in.
Waist Circumference	thru 32.0 in.
Regular	
Stature	67.0 in. thru 70.5 in.
Chest Circumference	37.5 in. thru 41.5 in.
Waist Circumference	32.0 in. thru 40.0 in.
Long	
Stature	greater than 70.5 in.
Chest Circumference	greater than 41.5 in.
Waist Circumference	greater than 36.0 in.

USAF Four-Size System

Medium Regular	
Stature	63.0 in. thru 67.0 in.
Chest Circumference	29.5 in. thru 37.0 in.
Waist Circumference	28.0 in. thru 32.0 in.
Medium Long	
Stature	67.0 in. thru 73.0 in.
Chest Circumference	37.0 in. thru 43.5 in.
Waist Circumference	32.0 in. thru 40.0 in.
Large Regular	
Stature	55.5 in. thru 72.0 in.
Chest Circumference	35.5 in. thru 42.0 in.
Waist Circumference	36.5 in. thru 38.5 in.
Large Long	
Stature	70.5 in. thru 75.0 in.
Chest Circumference	40.5 in. thru 45.5 in.
Waist Circumference	36.5 in. thru 43.0 in.

TABLE 2

Surface Dimension of Front and Back Plate
US Army Aircrewman Body Armor

Dimensions in Inches

Three-Size System

	Waist Back Length	Waist Front Length	Chest Breadth	Interscye Breadth	Waist Circumference	Chest Circumference
Long	18.6	16.10	11.17	14.25	35.8	25.4
Regular	16.6	15.00	9.62	13.00	31.2	22.6
Short	14.7	13.85	9.62	11.25	28.7	20.9

TABLE 3

Proposed Sizing System for Air Crew Armor
Statistics Based on 1966 US Army Data

Unit of Measure is Inches

Three Size System

Measure	Mean	Std. Dev	Minimum	Maximum
Vertical Trunk Circumference	64.6	3.3	53.3	78.2
Chest Circumference	36.9	2.62	28.35	48.89
Waist Circumference	31.6	3.24	23.14	50.27

Sizing Criteria

Small		Vertical Trunk Circumference	LE 64.0 in.
		Chest Circumference	LE 37.5 in.
		Waist Circumference	LE 30.0 in.
Regular	64.0 in. .LT.	Vertical Trunk Circumference	LE 68.0 in.
	35.5 in. .LT.	Chest Circumference	LE 41.5 in.
	30.0 in. .LT.	Waist Circumference	LE 36.0 in.
Long		Vertical Trunk Circumference	GT 68.0 in.
		Chest Circumference	GT 39.5 in.
		Waist Circumference	GT 36.0 in.

TABLE 4

Air Crew Armor Fit Statistics

Total In Survey 6681

Fit Using Stature, Waist & Chest Circumference

No. Short	1081	16.18 %
No. Regular	564	8.44 %
No. Long	63	.94 %
No. No Fits	4973	74.43 %

Fit Using Vertical Trunk, Waist & Chest Circumference

No. Short	1580	23.65 %
No. Regular	1621	24.26 %
No. Long	359	5.37 %
No. No Fits	3121	46.71 %

TABLE 5

Dimensions of Four-Size USAF Air Crew Armor Plates*

	Front Plate			Back Plates		
	Waist Front	Chest Breadth	Waist Breadth	Waist Back	Chest Breadth	Waist Breadth
Medium Regular	13 1/16	8 5/8	12 3/4	15 3/8	9 1/2	12 1/2
Medium Long	14 9/16	8 5/8	12 3/4	16 3/8	9 5/8	12 1/2
Large Regular	14 1/16	10 1/16	15 1/2	15 1/2	10 7/16	14 7/8
Large Long	15 9/16	9 15/16	15 1/2	17	10 1/8	14 3/4

* All dimensions ± 1/8 inch

TABLE 6

Air Crew Armor Fit Statistics

Four Size System

Total in Survey 6681

Fit Using Stature, Waist & Chest Circumferences

Medium Regular	694	10.39 %
Medium Long	1370	20.51 %
Large Regular	176	2.63 %
Large Long	118	1.77 %
No Fits	4323	64.71 %

Fit Using Vertical Trunk, Waist & Chest Circumferences

Medium Regular	2234	33.44 %
Medium Long	1228	18.3 %
Large Reguler	610	9.13 %
Large Long	1124	16.82 %
No Fits	1485	22.23 %

TABLE 7

Proposed USAF Aircrew Armor Insert Four Size System

Medium Regular	
Chest Circumference	31 inches thru 37.5 inches
Waist Circumference	26 inches thru 32 inches
Vertical Trunk Circumference	57 inches thru 64 inches
Medium Long	
Chest Circumference	31 inches thru 37.5 inches
Waist Circumference	26 inches thru 32 inches
Vertical Trunk Circumference	64 inches thru 68 inches
Large Regular	
Chest Circumference	37.5 inches thru 42.5 inches
Waist Circumference	32.0 inches thru 40.0 inches
Vertical Trunk Circumference	59.0 inches thru 66.0 inches
Large Long	
Chest Circumference	37.5 inches thru 44.5 inches
Waist Circumference	32 inches thru 41 inches
Vertical Trunk Circumference	66 inches thru 74 inches

CONSOLIDATED RECOMMENDATIONS

1. STATIC GROUND EVALUATION AND BODY LOAD AND PRESSURE EVALUATION: A dimensional profile study should be conducted to determine suitable height, length, and width measurements that would eliminate the binding on the pilot's body.

Modify the armor carrier to meet those dimensional recommednations developed during the proposal profile study.

2. FLIGHT VIBRATION EVALUATION: Redesign the vest as follows: study the replacement of the raschel knit nomex material as a basic support material; build in a harness under the basic vest material to add strength to support the weight of the armor carrier and insert to restrain its movement. Improve the design by using lighter weight materials for armor carrier construction.

Warnings should be issued to all pilots not to use the survival components pockets under the right arm when flying the OH-58 type helicopter.

3. SIZING EVALUATION: Conduct a human factors evaluation to determine if the proposed computer sizing criteria can be utilized as a practical substitution for the present sizing criteria now used by the USAF Survival/Armor Vest.

Appendix A
Bivariate Representations of Current Sizing Systems

1966 - ARMY ANTHROPOLOGY SURVEY
STATURE (IN) VS CHEST CIRCUMFERENCE (IN)
CURRENT THREE-SIZE SYSTEM

	25.50	27.50	29.50	31.50	33.50	35.50	37.50	39.50	41.50	43.50	45.50	
77.00	.00	.00	.00	.00	.01	.04	.07	.00	.00	.00	.01	.15
76.00	.00	.00	.00	.00	.03	.01	.03	.04	.03	.01	.00	.16
75.00	.00	.00	.00	.00	.06	.09	.24	.07	.04	.06	.00	.57
74.00	.00	.00	.00	.00	.09	.33	.52	.27	.04	.04	.01	1.32
73.00	.00	.00	.00	.07	.54	.73	.81	.57	.19	.04	.01	2.98
72.00	.00	.00	.00	.15	.94	1.68	1.24	1.03	.28	.15	.09	5.57
71.00	.00	.00	.00	.25	1.35	2.87	2.13	.94	.46	.06	.07	8.14
70.00	.00	.00	.00	.43	2.33	3.74	2.59	1.38	.37	.24	.09	11.18
69.00	.00	.00	.04	.69	2.84	4.94	3.40	1.65	.58	.15	.12	14.41
68.00	.00	.00	.03	1.15	3.91	5.21	3.32	1.18	.55	.16	.09	15.61
67.00	.00	.00	.10	1.09	4.09	4.82	2.75	1.23	.30	.10	.03	14.52
66.00	.00	.00	.10	.97	3.23	3.64	2.24	.64	.24	.10	.06	11.24
65.00	.00	.00	.07	.78	2.02	2.08	1.26	.61	.12	.06	.00	7.00
64.00	.00	.01	.06	.51	1.17	1.11	.54	.15	.07	.01	.00	3.64
63.00	.00	.00	.07	.31	.52	.48	.36	.19	.06	.01	.00	2.02
62.00	.00	.00	.00	.22	.30	.19	.15	.00	.00	.00	.00	.87
61.00	.00	.00	.04	.15	.10	.09	.07	.01	.00	.00	.00	.48
60.00	.00	.00	.01	.03	.06	.01	.00	.00	.01	.00	.01	.15
	.00	.01	.55	6.82	23.60	32.07	21.73	9.98	3.38	1.23	.61	100.00

SHORT

REGULAR

LONG

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
STATURE (IN) VS WAIST CIRCUMFERENCE (IN)
CURRENT THREE-SIZE SYSTEM

	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00	44.00	46.00		
77.00	.00	.01	.03	.06	.03	.00	.00	.00	.00	.01	.00	.15
76.00	.00	.00	.03	.03	.06	.01	.03	.00	.00	.00	.00	.16
75.00	.00	.07	.16	.10	.09	.07	.00	.03	.03	.00	.00	.57
74.00	.06	.15	.33	.28	.19	.13	.04	.09	.01	.00	.01	1.32
73.00	.10	.63	.69	.60	.49	.18	.18	.09	.00	.01	.00	2.98
72.00	.16	.99	1.59	1.15	.73	.49	.21	.10	.00	.03	.00	5.57
71.00	.51	1.59	2.42	1.78	.87	.45	.33	.15	.04	.00	.00	8.14
70.00	.49	2.53	2.98	2.50	1.48	.64	.34	.12	.03	.06	.00	11.18
69.00	.87	3.46	4.10	2.65	1.60	1.03	.40	.15	.10	.03	.01	14.41
68.00	1.30	4.22	4.73	2.48	1.32	.82	.45	.18	.07	.00	.03	15.61
67.00	1.05	3.95	4.47	2.35	1.35	.42	.16	.12	.04	.00	.00	14.52
66.00	1.65	3.29	2.95	1.74	.91	.37	.18	.10	.03	.00	.03	11.24
65.00	1.03	2.32	1.59	.94	.51	.39	.12	.07	.03	.00	.00	7.00
64.00	.72	1.14	.88	.49	.21	.15	.01	.03	.00	.00	.00	3.64
63.00	.43	.57	.37	.24	.27	.07	.03	.03	.00	.00	.00	2.02
62.00	.33	.21	.19	.10	.03	.00	.00	.00	.00	.00	.00	.87
61.00	.19	.12	.09	.04	.03	.00	.00	.00	.00	.00	.00	.48
60.00	.07	.03	.00	.01	.00	.01	.00	.00	.01	.00	.00	.15
	9.58	25.28	27.61	17.57	10.18	5.27	2.48	1.27	.52	.15	.09	100.00

LONG

REGULAR

SHORT

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
WAIST CIRCUMFERENCE (IN) VS CHEST CIRCUMFERENCE (IN)
CURRENT THREE-SIZE SYSTEM

	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00	44.00	46.00	48.00		
47.50	.00	.00	.00	.00	.00	.01	.01	.06	.04	.03	.01	.18	
45.50	.00	.00	.00	.01	.06	.04	.09	.15	.04	.03	.00	.43	
43.50	.00	.00	.03	.10	.22	.31	.37	.13	.04	.00	.00	1.23	
41.50	.01	.03	.13	.60	1.14	.81	.49	.13	.01	.01	.00	3.38	
39.50	.16	.81	2.32	3.02	2.39	.94	.30	.03	.00	.00	.00	9.98	
37.50	1.80	6.18	7.42	4.79	1.29	.24	.00	.01	.00	.00	.00	21.73	
35.50	9.50	14.25	6.64	1.47	.10	.10	.00	.00	.00	.00	.00	32.07	
33.50	16.61	5.87	.93	.15	.03	.01	.00	.00	.00	.00	.00	23.60	
31.50	6.21	.48	.09	.01	.03	.00	.00	.00	.00	.00	.00	6.82	
29.50	.54	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.55	
27.50	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	
25.50	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	
	34.85	27.61	17.57	10.18	5.27	2.48	1.27	.52	.15	.07	.01	100.00	

LONG

REG

SHORT

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
CHEST CIRCUMFERENCE VS WAIST CIRCUMFERENCE
CURRENT FOUR-SIZE SYSTEM

	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0	41.0	42.0		
44.50		.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.1	.1	.1	.4	.9
43.50		.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.1	.1	.1	.1	.2	.1	1.0
42.50		.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.1	.3	.2	.2	.2	.1	.1	1.3
41.50		.0	.0	.0	.0	.0	.0	.0	.1	.2	.3	.4	.3	.2	.2	.1	.1	.1	2.1
40.50		.0	.0	.0	.0	.1	.1	.2	.3	.4	.7	.5	.6	.4	.2	.1	.1	.0	4.0
39.50		.0	0	.3	.1	.1	.4	.7	1.0	1.0	.9	.7	.5	.2	.1	.0	.0	.0	6.0
38.50		.0	.0	.1	.4	.7	1.3	1.8	1.7	1.5	1.1	.6	.3	.1	.1	.0	.0	.0	9.7
37.50		.0	.1	.2	1.0	1.8	2.3	2.3	1.5	1.5	.7	.3	.1	.1	.0	.0	.0	.0	12.1
36.50		.1	.2	.9	2.0	2.8	3.5	2.6	1.6	.8	.3	.1	.0	.0	.0	.0	.0	.0	14.8
35.50		.1	.7	1.7	3.9	4.2	3.7	1.8	.7	.3	.1	.0	.0	.0	.0	.0	.0	.0	17.2
34.50		.3	1.5	2.7	4.0	2.9	1.6	.6	.2	.1	.0	.0	.0	.0	.0	.0	.0	.0	13.9
33.50		.6	1.6	3.2	2.6	1.0	.4	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	9.7
32.50		.9	1.8	1.1	.8	.3	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	5.1
31.50		.9	.8	.4	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.3
		2.9	6.7	10.4	14.9	14.0	13.6	10.2	7.4	5.9	4.2	2.9	2.4	1.4	1.1	.8	.5	.8	100.0

1966 - U.S. ARMY ANTHROPOMETRY SURVEY
STATURE (INCHES) VS CHEST CIRCUMFERENCE
CURRENT FOUR-SIZE SYSTEM

	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5	41.5	42.5	43.5	44.5		
75.00		.0	.0	.1	.0	.0	.1	.2	.2	.0	.1	.0	.0	.1	.0	.9
74.00		.0	.0	.0	.0	.2	.2	.3	.3	.1	.1	.0	.0	.0	.0	1.3
73.00		.0	.0	.2	.3	.3	.4	.4	.4	.3	.3	.1	.1	.0	.0	3.0
72.00		.0	.1	.4	.6	.9	.8	.7	.6	.6	.4	.2	.1	.1	.2	5.6
71.00		.0	.2	.5	.9	1.6	1.3	1.2	.9	.6	.3	.3	.1	.0	.1	8.1
70.00		.1	.4	1.0	1.4	1.8	1.9	1.5	1.1	.8	.6	.2	.1	.2	.1	11.2
69.00		.2	.5	1.0	1.8	2.5	2.4	1.8	1.6	1.1	.5	.3	.3	.1	.1	14.4
68.00		.3	.9	1.4	2.5	2.8	2.4	1.9	1.4	.6	.6	.3	.2	.1	.1	15.6
67.00		.3	.9	1.6	2.5	2.9	1.9	1.5	1.3	.7	.5	.2	.1	.1	.0	14.5
66.00		.5	.6	1.3	1.9	2.1	1.6	1.1	1.1	.5	.2	.1	.1	.1	.1	11.2
65.00		.3	.5	1.1	.9	1.2	.9	.8	.4	.3	.3	.1	.0	.0	.0	7.0
64.00		.2	.4	.6	.6	.6	.5	.3	.2	.1	.1	.0	.0	.0	.0	3.6
63.00		.2	.2	.3	.2.	.3	.2	.2	.1	.1	.0	.0	.0	.0	.0	2.0
62.00		.2	.3	.2	.3	.1	.1	.1	.1	.0	.0	.0	.0	.0	.0	1.5
		2.3	5.1	9.7	13.9	17.2	14.8	12.1	9.7	6.0	4.0	2.1	1.3	1.0	.9	100.0

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
STATURE (INCHES) VS WAIST CIRCUMFERENCE
CURRENT FOUR-SIZE SYSTEM

	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0	41.0	42.0		
75.00		.0	.0	.0	.1	.1	.1	.1	.0	.1	.1	.0	.1	.0	.0	.0	.0	.0	.9
74.00		.0	.0	.0	.1	.2	.2	.2	.1	.1	.1	.1	.0	.0	.0	.1	.0	.0	1.3
73.00		.0	.1	.2	.4	.3	.3	.3	.3	.3	.2	.0	.1	.1	.1	.1	.0	.0	3.0
72.00		.1	.1	.3	.7	.7	.9	.6	.5	.5	.2	.2	.3	.1	.1	.1	.0	.1	5.6
71.00		.2	.4	.6	1.0	1.1	1.3	1.0	.8	.4	.4	.3	.2	.2	.2	.1	.1	.0	8.1
70.00		.1	.4	1.0	1.5	1.6	1.4	1.4	1.1	.9	.6	.4	.3	.2	.2	.1	.0	.1	11.2
69.00		.2	.7	1.3	2.2	1.9	2.2	1.7	1.0	1.0	.6	.5	.5	.2	.2	.1	.0	.1	14.4
68.00		.2	1.1	1.7	2.5	2.7	2.1	1.6	.9	.7	.6	.5	.3	.3	.1	.1	.1	.1	15.6
67.00		.6	1.0	1.8	2.1	2.2	2.3	1.3	1.1	.7	.6	.2	.2	.1	.0	.0	.1	.0	14.5
66.00		.5	1.2	1.5	1.8	1.7	1.3	.9	.8	.6	.3	.2	.1	.1	.1	.1	.0	.1	11.2
65.00		.3	.7	1.0	1.3	.8	.8	.7	.3	.3	.3	.2	.1	.0	.1	.1	.0	.0	7.0
64.00		.3	.4	.6	.6	.5	.4	.2	.3	.1	.1	.1	.1	.0	.0	.0	.0	.0	3.6
63.00		.1	.2	.2	.3	.1	.2	.2	.1	.2	.1	.0	.0	.0	.0	.0	.0	.0	2.0
62.00		.3	.3	.2	.2	.1	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.5
		2.9	6.7	10.4	14.9	14.0	13.6	10.2	7.4	5.9	4.2	2.9	2.4	1.4	1.1	.8	.5	.8	100.0

Appendix B

Bivariates of Torso Dimensions as Related to Fit

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
WAIST BACK LENGTH VS INTERSCYE

	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00		
22.00	.00	.00	.01	.03	.00	.00	.01	.03	.03	.01	.00		.16
21.00	.01	.01	.04	.06	.12	.12	.06	.06	.06	.01	.07		.64
20.00	.12	.21	.19	.46	.67	.58	.42	.61	.45	.18	.18		4.09
19.00	.64	.63	.90	1.41	1.72	2.20	1.78	1.62	.87	.57	.51		12.84
18.00	1.32	1.56	2.38	3.17	3.55	4.09	3.19	2.05	1.48	.60	.40		23.78
17.00	1.63	1.63	2.83	4.27	4.50	4.[illegible]	3.28	2.02	1.50	.76	.51		27.19
16.00	1.74	1.57	2.56	3.29	3.83	3.37	2.47	1.30	.91	.24	.24		21.52
15.00	.73	.70	1.32	1.45	1.42	1.11	.73	.45	.19	.06	.01		8.19
14.00	.27	.15	.10	.22	.30	.18	.09	.03	.03	.04	.00		1.51
13.00	.03	.00	.01	.01	.00	.00	.01	.00	.00	.00	.00		.07
	6.50	6.47	10.45	14.38	16.12	15.91	12.05	8.20	5.52	2.48	1.93		100.00

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
WAIST BACK LENGTH VS CHEST BREADTH

	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	
22.00	.00	.00	.01	.04	.03	.01	.00	.04	.00	.00	.01	.16
21.00	.00	.03	.03	.15	.16	.09	.07	.06	.00	.01	.03	.64
20.00	.01	.13	.37	.75	1.03	.79	.48	.30	.16	.04	.00	4.09
19.00	.10	.75	1.63	2.63	3.34	2.10	1.11	.61	.36	.10	.10	12.84
18.00	.30	1.47	4.04	4.92	5.96	3.89	1.04	.87	.36	.10	.03	23.78
17.00	.57	2.26	4.86	6.27	5.94	4.31	1.86	.67	.33	.07	.04	27.19
16.00	.60	2.13	4.18	5.40	4.67	2.74	1.08	.45	.21	.04	.03	21.52
15.00	.36	.97	1.62	2.33	1.54	.90	.34	.10	.01	.00	.00	8.19
14.00	.18	.22	.43	.28	.31	.04	.03	.00	.00	.00	.00	1.51
13.00	.03	.01	.00	.00	.01	.01	.00	.00	.00	.00	.00	.07
	2.16	7.98	17.18	22.79	23.00	14.89	6.81	3.11	1.44	.39	.25	100.00

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
VERTICAL TRUNK CIRCUMFERENCE VS INTERSCYE

	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00		
72.00	.01	.01	.04	.09	.07	.33	.27	.33	.39	.22	.21	1.99
71.00	.03	.01	.03	.12	.15	.13	.22	.28	.10	.09	.12	1.30
70.00	.01	.01	.10	.10	.25	.49	.49	.43	.33	.21	.21	2.66
69.00	.06	.10	.21	.39	.54	.61	.55	.51	.40	.22	.16	3.77
68.00	.09	.09	.39	.54	.91	.94	.79	.69	.52	.28	.25	5.51
67.00	.28	.33	.63	.84	1.02	1.36	1.23	.96	.57	.24	.18	7.63
66.00	.40	.40	.90	1.12	1.65	1.42	1.50	.96	.49	.33	.22	9.40
65.00	.75	.60	1.15	1.62	1.68	1.84	1.71	1.02	.57	.27	.15	11.34
64.00	.72	.78	1.36	1.83	2.29	2.33	1.51	.85	.46	.15	.13	12.42
63.00	.64	.87	1.39	2.02	2.18	1.92	1.15	.61	.49	.19	.15	11.63
62.00	.63	1.03	1.33	1.56	1.80	1.65	.88	.67	.46	.13	.04	10.19
61.00	.97	.90	.99	1.44	1.38	1.29	.84	.37	.40	.06	.03	8.67
60.00	.72	.57	.73	1.27	.87	.72	.51	.28	.22	.04	.04	5.99
59.00	1.17	.75	1.18	1.45	1.33	.87	.39	.22	.09	.03	.01	7.50
	6.50	6.47	10.45	14.38	16.12	15.91	12.05	8.20	5.52	2.48	1.93	100.00

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
VERTICAL TRUNK CIRCUMFERENCE VS CHEST BREADTH

	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00		
72.00	.00	.00	.00	.01	.10	.45	.34	.46	.22	.19	.18		1.99
71.00	.00	.00	.00	.04	.25	.36	.19	.24	.16	.03	.01		1.30
70.00	.00	.00	.07	.21	.57	.61	.55	.37	.21	.06	.00		2.65
69.00	.00	.04	.09	.22	.93	.94	.79	.49	.18	.03	.04		3.77
68.00	.00	.06	.24	.75	1.68	1.45	.75	.39	.16	.03	.00		5.51
67.00	.03	.13	.54	1.20	2.02	2.08	1.14	.28	.21	.00	.00		7.62
66.00	.01	.28	.82	2.16	2.59	2.11	.90	.36	.12	.04	.00		9.40
65.00	.10	.51	1.72	3.19	2.90	1.84	.79	.21	.07	.00	.00		11.34
64.00	.09	.84	2.26	3.13	3.47	1.92	.52	.13	.06	.00	.00		12.42
63.00	.22	.88	2.11	3.50	3.14	1.32	.28	.12	.03	.00	.01		11.63
62.00	.16	1.12	2.45	2.84	2.27	.94	.36	.03	.00	.00	.00		10.19
61.00	.39	1.02	2.48	2.48	1.65	.52	.10	.00	.00	.00	.00		8.67
60.00	.34	.32	1.86	1.78	.78	.21	.07	.01	.00	.00	.00		5.99
59.00	.79	2.15	2.53	1.27	.63	.12	.00	.00	.00	.00	.00		7.50
	2.16	7.98	17.18	22.79	23.00	14.89	6.81	3.11	1.44	.39	.25		100.00

Appendix C

Bivariates of Proposed Fitting Criteria For Three-Size System

1966 - U. S. ARMY ANTRHOPOMETRY SURVEY
VERTICAL TRUNK CIRCUMFERENCE VS CHEST CIRCUMFERENCE

	27.50	29.50	31.50	33.50	35.50	37.50	39.50	41.50	43.50	45.50	47.50		
72.00	.00	.00	.00	.00	.03	.25	.57	.48	.36	.19	.10	1.99	LONG
71.00	.00	.00	.00	.04	.09	.25	.37	.30	.18	.03	.03	1.30	LONG
70.00	.00	.00	.00	.04	.36	.81	.75	.37	.22	.09	.01	2.66	LONG
69.00	.00	.00	.03	.12	.52	1.14	1.35	.42	.15	.03	.01	3.77	LONG
68.00	.00	.00	.00	.34	1.36	2.07	1.17	.45	.08	.03	.00	5.51	LONG
67.00	.00	.00	.04	.84	2.26	2.60	1.35	.45	.06	.03	.00	7.63	REGULAR
66.00	.00	.01	.21	1.03	3.62	2.81	1.24	.33	.10	.01	.01	9.40	REGULAR
65.00	.00	.00	.34	2.35	4.16	3.11	1.09	.24	.03	.01	.00	11.34	REGULAR
64.00	.00	.03	.64	3.28	4.76	2.77	.72	.19	.03	.00	.00	12.42	REGULAR
63.00	.00	.01	.78	3.13	5.01	2.13	.49	.07	.00	.00	.00	11.63	SHORT
62.00	.00	.06	1.05	3.23	3.53	1.78	.49	.04	.00	.00	.00	10.19	SHORT
61.00	.00	.07	1.05	3.23	2.95	1.14	.21	.01	.00	.00	.00	8.67	SHORT
60.00	.00	.12	.81	2.59	1.80	.52	.13	.01	.00	.00	.00	5.99	SHORT
59.00	.03	.24	1.87	3.35	1.62	.34	.04	.00	.00	.00	.00	7.50	SHORT
	.03	.55	6.82	23.59	32.07	21.73	9.98	3.38	1.23	.43	.18	100.00	

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
VERTICAL TRUNK CIRCUMFERENCE VS WAIST CIRCUMFERENCE

	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00	44.00	46.00		
72.00	.00	.01	.00	.07	.27	.48	.09	.40	.19	.10	.06		1.99
71.00	.00	.00	.12	.22	.15	.24	.34	.12	.09	.01	.00		1.30
70.00	.00	.04	.24	.58	.66	.52	.28	.21	.07	.03	.01		2.66
69.00	.03	.09	.51	.79	1.02	.60	.43	.24	.04	.00	.01		3.77
68.00	.10	.30	.97	1.57	1.35	.75	.34	.07	.04	.00	.00		5.51
67.00	.10	.87	1.98	2.08	1.38	.88	.21	.12	.01	.00	.00		7.63
66.00	.22	1.30	3.04	2.44	1.54	.54	.21	.09	.01	.00	.00		9.40
65.00	.39	2.26	4.07	2.63	1.23	.55	.15	.03	.03	.00	.00		11.34
64.00	.64	3.56	4.19	2.41	1.02	.33	.06	.00	.01	.00	.00		12.42
63.00	.97	3.56	4.10	2.10	.61	.22	.06	.00	.00	.00	.00		11.63
62.00	1.17	3.98	3.07	1.30	.52	.15	.00	.00	.00	.00	.00		10.19
61.00	1.48	3.56	2.66	.76	.19	.00	.00	.00	.00	.00	.00		8.67
60.00	1.29	2.63	1.56	.39	.12	.00	.00	.00	.00	.00	.00		5.99
59.00	2.98	3.10	1.09	.21	.12	.00	.00	.00	.00	.00	.00		7.50
	9.56	25.28	27.60	17.57	10.18	5.27	2.48	1.29	.52	.15	.09		100.00

LONG

REGULAR

SHORT

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
CHEST CIRCUMFERENCE VS WAIST CIRCUMFERENCE

	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00	42.00	44.00	46.00		
47.50	.00	.00	.00	.00	.00	.00	.01	.01	.06	.04	.04	.18	
45.50	.00	.00	.00	.00	.01	.06	.04	.09	.15	.04	.03	.43	
43.50	.00	.00	.00	.03	.10	.22	.31	.37	.13	.04	.00	1.23	
41.50	.00	.00	.03	.13	.60	1.14	.81	.49	.13	.01	.01	3.37	
39.50	.01	.15	.81	2.32	3.02	2.39	.94	.30	.03	.00	.00	9.98	
37.50	.12	1.68	6.18	7.42	4.79	1.29	.24	.00	.01	.00	.00	21.73	
35.50	1.05	8.46	14.25	6.64	1.47	.10	.10	.00	.00	.00	.00	32.07	
33.50	4.06	12.56	5.85	.93	.15	.03	.01	.00	.00	.00	.00	23.59	
31.50	3.82	2.39	.48	.09	.01	.03	.00	.00	.00	.00	.00	6.82	
29.50	.49	.04	.00	.00	.01	.00	.00	.00	.00	.00	.00	.55	
27.50	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	
25.50	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.03	
	3.59	25.28	27.60	17.57	10.18	5.27	2.48	1.27	.52	.15	.09	100.00	

SHORT

REG.

LONG

Appendix D

Bivariates of Proposed Fitting Criteria For Four Size System

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
VERTICAL TRUNK CIRCUMFERENCE VS CHEST CIRCUMFERENCE

	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5	41.5	42.5	43.5	44.5		
73.00		.0	.0	.0	.0	.0	.0	.0	.1	.1	.2	.1	.1	.1	.3	1.1
72.00		.0	.0	.0	.0	.0	.0	.0	.1	.1	.2	.2	.1	.1	.1	.9
71.00		.0	.0	.0	.0	.0	.0	.2	.1	.1	.2	.1	.1	.1	.1	1.3
70.00		.0	.0	.0	.0	.1	.2	.3	.5	.3	.4	.2	.2	.2	.1	2.7
69.00		.0	.0	.0	.1	.2	.4	.5	.6	.8	.5	.2	.2	.1	.1	3.8
68.00		.0	.0	.1	.2	.6	.8	1.1	1.0	.6	.6	.3	.2	.1	.0	5.5
67.00		.0	.0	.4	.5	1.0	1.3	1.2	1.4	.9	.5	.3	.1	.0	.1	7.6
66.00		.1	.1	.3	.8	1.8	1.0	1.5	1.3	.8	.4	.2	.1	.1	.0	9.4
65.00		.0	.3	.7	1.6	2.0	2.1	1.8	1.3	.8	.3	.2	.0	.0	.0	11.3
64.00		.1	.6	1.3	1.9	2.6	2.2	1.6	1.1	.4	.3	.1	.0	.0	.0	12.4
63.00		.3	.5	1.2	1.9	2.7	2.3	1.3	.9	.4	.1	.0	.0	.0	.0	11.6
62.00		.3	.8	1.3	2.0	2.1	1.4	1.1	.7	.4	.1	.0	.0	.0	.0	10.2
61.00		.5	.8	1.2	2.0	1.9	1.1	.8	.3	.1	.1	.0	.0	.0	.0	8.7
60.00		.4	.5	1.2	1.4	1.2	.6	.3	.2	.1	.1	.0	.0	.0	.0	6.0
59.00		.2	.6	.9	.8	.6	.3	.1	.1	.0	.0	.0	.0	.0	.0	3.6
58.00		.1	.3	.5	.4	.3	.1	.1	.1	.0	.0	.0	.0	.0	.0	2.0
57.00		.4	.4	.5	.3	.2	.1	.0	.0	.0	.0	.0	.0	.0	.0	1.9
	2.3	5.1	9.7	13.9	17.2	14.8	12.1	9.7	6.0	4.0	2.1	1.3	1.0	.9		100.0

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
CHEST CIRCUMFERENCE VS WAIST CIRCUMFERENCE

	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0	41.0	42.0		
44.50		.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.1	.1	.1	.4	.9
43.50		.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.1	.1	.2	.1	.2	.1	1.0
42.50		.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.1	.3	.2	.2	.2	.1	.1	1.3
41.50		.0	.0	.0	.0	.0	.0	.0	.1	.2	.3	.4	.3	.2	.2	.1	.1	.1	2.1
40.50		.0	.0	.0	.0	.1	.1	.2	.3	.4	.7	.5	.6	.4	.2	.1	.1	.0	4.0
39.50		.0	.0	.0	.1	.1	.4	.7	1.0	1.0	.9	.7	.5	.2	.1	.0	.0	.0	6.0
38.50		.0	.0	.1	.4	.7	1.3	1.8	1.7	1.5	1.1	.6	.3	.1	.1	.0	.0	.0	9.7
37.50		.0	.1	.2	1.0	1.8	2.3	2.3	1.5	1.5	.7	.3	.1	.1	.0	.0	.0	.0	12.1
36.50		.1	.2	.9	2.0	2.8	3.5	2.6	1.6	.8	.3	.1	.0	.0	.0	.0	.0	.0	14.8
35.50		.1	.7	1.7	3.9	4.2	3.7	1.8	.7	.3	.1	.0	.0	.0	.0	.0	.0	.0	17.2
34.50		.3	1.5	2.7	4.0	2.9	1.6	.6	.2	.1	.0	.0	.0	.0	.0	.0	.0	.0	13.9
33.50		.6	1.6	3.2	2.6	1.0	.4	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	9.7
32.50		.9	1.8	1.1	.8	.3	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	5.1
31.50		.9	.8	.4	.1	.1	.0	.0	.0	.0	.0	.0	.0.	.0	.0	.0	.0	.0	2.3
		2.9	6.7	10.4	15.9	14.0	13.6	10.2	7.4	5.9	4.2	2.9	2.4	1.4	1.1	.8	.5	.8	100.0

1966 - U. S. ARMY ANTHROPOMETRY SURVEY
VERTICAL TRUNK CIRCUMFERENCE VS WAIST CIRCUMFERENCE

	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0	41.0	42.0		
73.00		.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.2	.1	.1	.1	.1	.3	1.1
72.00		.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.1	.1	.1	.2	.1	.1	.1	.9
71.00		.0	.0	.0	.0	.0	.1	.1	.1	.1	.1	.1	.1	.2	.1	.1	.0	.1	1.3
70.00		.0	.0	.0	.0	.1	.2	.2	.4	.3	.4	.3	.2	.1	.2	.1	.1	.1	2.7
69.00		.0	.0	.0	.1	.2	.3	.5	.3	.5	.5	.3	.3	.2.	.2	.2	.1	.1	3.8
68.00		.0	.1	.1	.2	.4	.5	.7	.8	.7	.7	.4	.4	.2	.1	.0	.0	.0	5.5
67.00		.0	.1	.2	.6	.8	1.2	1.1	1.0	.9	.5	.5	.3	.1	.1	.1	.0	.0	7.6
66.00		.0	.2	.3	1.0	1.2	1.8	1.4	1.0	.8	.7	.3	.2	.1	.1	.0	.1	.0	9.4
65.00		.1	.3	.6	1.6	2.0	2.1	1.5	1.2	.8	.4	.3	.2	.1	.0	.0	.0	.0	11.3
64.00		.2	.7	1.3	2.2	2.1	2.1	1.5	.9	.6	.4	.2	.1	.0	.0	.0	.0	.0	12.4
63.00		.2	.7	1.5	2.1	2.2	1.9	1.3	.8	.4	.2	.2	.0	.0	.0	.0	.0	.0	11.6
62.00		.3	.9	1.8	2.2	1.0	1.3	1.0	.3	.4	.1	.1	.1	.0	.0	.0	.0	.0	10.2
61.00		.4	1.1	1.5	2.0	1.5	1.2	.5	.3	.1	.1	.0	.0	.0	.0	.0	.0	.0	8.7
60.00		.6	.7	1.3	1.3	1.0	.6	.2	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	6.0
59.00		.3	.8	.0	.8	.5	.2	.1	.0	.1	.0.	.0	.0	.0	.0	.0	.0	.0	3.6
58.00		.3	.5	.4	.4	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.0
57.00		.5	.7	.2	.3	1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.9
		8.9	6.7	10.4	14.9	14.0	13.6	10.2	7.4	5.9	4.2	2.9	2.4	1.4	1.1	.8	.5	.5	100.0