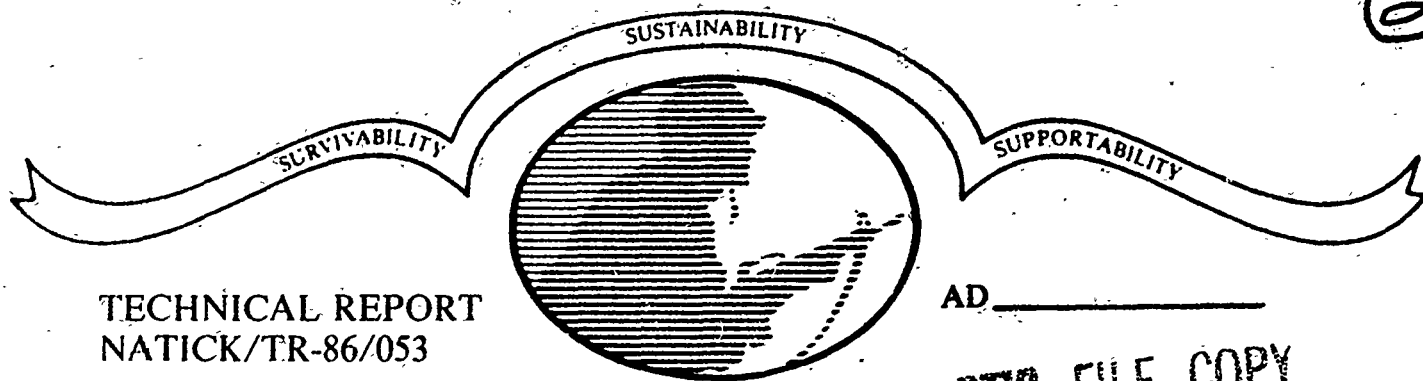


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SELECTION OF DIMENSIONS FOR AN ANTHROPOMETRIC
DATA BASE
VOLUME I: RATIONALE, SUMMARY, AND CONCLUSIONS

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BY

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MAY 1986

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<p>A large number of body size variables were examined and rated for their usefulness in an anthropometric data base designed to serve present and future needs of the U.S. Army. These dimensions are assembled in groups representing various uses to which the Army might put these data, ranging from the design of clothing, personal protective equipment, and workspaces, to the development of link systems and human analogues. A total of 362 dimensions analyzed in this study were rated as marginal, useful or essential to one or more of these applications. Some 194 dimensions are suggested as candidates for measurement in a proposed new large-scale multipurpose survey of Army personnel.</p> <p>Sources for the study included 34 anthropometric surveys of U.S. and foreign military and civilian subjects, as well as questionnaire surveys and interviews with clothiers, modelers, design engineers, physical anthropologists, and others experienced in the</p>				
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application of anthropometric data to military design problems. Dimension lists from fourteen large-scale surveys were selected for detailed review. Descriptions and analyses of all the dimensions measured in those surveys appear in Volume II of this report.

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PREFACE

This study represents a unique approach to developing a list of candidate dimensions for inclusion in a large-scale, multipurpose anthropometric survey of military personnel, and we would like to acknowledge the significant input of many individuals to its preparation.

Review of the utility of 362 dimensions for an Army anthropometric data base was greatly enhanced by the input and critique of several organizations. We especially wish to acknowledge the clothing designers of the Individual Protection Laboratory, United States Army Natick Research, Development and Engineering Center, who participated in a questionnaire survey of dimensions they use in the design and construction of clothing. We particularly thank Mr. William Amico, Ms. Martha Brown, and Mr. Guy Muto of this group for their patient discussions with us concerning the application of anthropometric data to clothing design.

We also gratefully acknowledge the assistance of clothing designers of the Air Force Aeronautical Systems Division's Clothing Branch at Wright-Patterson Air Force Base (WPAFB), Ohio, who participated in the questionnaire survey. Among these, we are particularly grateful to Mr. Norman Childs and Mr. Herman Hill for their several personal consultations.

Mr. Steven Brunelle, Individual Equipment Technologist, and Mr. Larry McManus, Helmet Technologist, of the Individual Protection Laboratory, gave us valuable insights into the design of load carrying systems and body armor, respectively.

The following individuals of the Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL) at WPAFB gave unstintingly of their time in sharing with us their many years of experience in the collection and effective application of anthropometric data to systems, personal protective equipment, and anthropomorphic analogue design: Mr. Milton Alexander, Research Physical Anthropologist; Dr. Kenneth Kennedy, Research Physical Anthropologist; Dr. Joe McDaniel, Research Industrial Engineer; and Mrs. Kathleen Robinette, Research Physical Anthropologist.

Dr. Ints Kaleps, Chief, Modeling and Analysis Branch of AAMRL and Dr. Robert Beecher of the University of Dayton Research Institute (UDRI) were particularly helpful in reviewing with us dimensions required for the development of kinematic analogues used to assess the body's response to high acceleration environments. Mr. Medhat Korna of UDRI and members of his staff were very helpful in exploring with us dimensions useful for the development of anthropomorphic analogues used for the design and evaluation of workspaces of military systems.

We very gratefully acknowledge the many contributions of our Anthropology Research Project (ARP) colleagues. Mr. James Annis, Dr. Bruce Bradtmiller, and Mr. Gregory Zehner contributed significantly to the development and review of the dimensions under study.

The dedication of Ms. Belva Hardin and Ms. Sherri Upchurch in preparing the manuscript and, in particular, its second volume was inspiring. We wish to express our appreciation to Dr. Bradtmiller, Ms. Patty Daziens, Ms. Elizabeth

Dumont, Mrs. Cay Ervin, and Miss Jo Ross for the arduous task of reviewing and checking the more than 400 pages of Volume II.

We thank Mr. Thomas Churchill and Mrs. Mary Gross, of ARP, for developing the computer printouts which formed the basis of our judgements on the effects of race and sex on body size measurements.

As always, we are indebted to Mrs. Jane Reese of ARP who not only typed the reference section but kept the flow of paper under control.

Finally, we would like to thank those individuals at NRDEC who carefully reviewed this manuscript and offered helpful suggestions: Dr. Carolyn Bense, Leader of the Human Factors Group; Mr. Charles Williams, Chief of the Life Support Systems Division; Mr. Kenneth Reinhart, Director of the Individual Protection Directorate; Mrs. Edna Albert, Technical Publications Editor; and Research Anthropologists in the Human Factors Group: Dr. Kenneth Parham, Mr. Steven Paquette and Ms. Brenda Baker.

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SELECTION OF DIMENSIONS FOR AN ANTHROPOMETRIC DATA BASE

VOLUME I: RATIONALE, SUMMARY, AND CONCLUSIONS

INTRODUCTION

To meet the demands for anthropometric data describing their personnel, the Army, Navy, and Air Force periodically conduct large-scale, multipurpose body-size surveys. The number of dimensions measured during the surveys of U.S. and foreign military personnel has varied from 32 (Australian Tri-Service Anthropometric Survey, 1977)¹ to 188 (USAF, 1967)². This disparity in numbers reflects trade-offs between establishing a viable data base for a single pressing need and the need for multipurpose surveys that are designed to provide a data base to meet different types of current and anticipated requirements. Cost, time, and equipment constraints are also mandatory considerations affecting the number and type of dimensions measured.

The costs in dollars and manpower of any large-scale, multipurpose survey are high, and the steps involved in its execution are complex and time-consuming. Clearly it is impossible to measure all dimensions required to meet all needs in a single multipurpose survey, even if these needs were all known. The goal must be to measure the maximum number of dimensions identified as valuable to designers and engineers, while recognizing the need for reasonable limitations on the resources of the sponsoring agency.

The impetus for conducting new anthropometric surveys comes from either or both of two major deficiencies in an existing data base: (1) the data are no longer representative of the demographics of the population they are supposed to describe and, (2) the data are inadequate to meet a variety of current and anticipated design and engineering requirements. It has already been demonstrated that the current anthropometric data base of the Army is not demographically representative of today's Army personnel in either age, sex, or racial admixture.³ The research reported here examines the adequacy of the Army's anthropometric data base to meet a number of current and future design needs. Of particular concern are those anthropometric dimensions needed to support designers of U.S. Army clothing, personal protective equipment, and military systems in the near and long-term future.

The central purpose of this study is thus to provide guidelines for the selection of measurements to be included in a new anthropometric survey which will be used to update the existing U.S. Army data base.

Applications for Survey Data

Hundreds of measured dimensions were reviewed for their potential usefulness in a new Army data base, and a number of categories were established to make the final selection process more manageable. Of these, 11 represent various uses to which the Army might put these data in designing clothing, weapon systems, personal protective equipment, or workspaces. Two additional groups do not have direct design applications, but represent (1) dimensions describing overall body size and proportions, and (2) dimensions recommended for inclusion in all anthropometric surveys by several international standardization organizations.

Following are descriptions of each group:

Basic Body Descriptors: These are dimensions of overall body size and proportion which should be obtained in every anthropometric survey. Not only are they basic body size and body proportion descriptors; they are also required for comparing populations and for selecting samples of subjects that are anthropometrically representative of a particular population.

Key Dimensions/Microcosm Selection: These dimensions serve as key or control dimensions for the design, sizing, procurement, and issuing of clothing and personal equipment. In addition, key dimensions are useful for selecting anthropometrically representative samples of test subjects for evaluating new items of equipment or for smaller, single-purpose anthropometric surveys. They are also used to generate matched samples for meeting many design problems.

Garments (Clothing/Personal Equipment): These dimensions are useful for the design and sizing of Army uniforms, utility garments, and personal protective equipment, e.g., body armor.

Manikins: Three-dimensional forms developed to represent specific body sizes and shapes are valuable guides for the design and sizing of clothing and equipment worn on the body. Clothing manikins are used by all services, and the more accurately they reflect the sizes of their personnel, the better the fit and the less the alteration required of garments designed over them.

Load-Carrying Systems: These dimensions are useful for the design and sizing of systems for carrying full-field gear and other types of equipment. This group was selected for special attention because of the critical importance of load-carrying systems to the combat effectiveness and well-being of Army troops and support personnel.

Head and Face Equipment: The dimensions in this group are used primarily in the design of personal protective equipment worn on the head and face, and for the design of optical and auditory devices.

Gloves: These are hand, finger, wrist, and forearm measurements used in the design and sizing of gloves and in the construction of hand forms.

Shoe Lasts/Foot Gear: These foot and ankle dimensions are needed for the design and sizing of shoes and boots.

Workspace and Body Clearance: Dimensions in this group are central to the design and layout of single- and multi-person workstations occupied by Army personnel. They are also of paramount importance in the design and layout of workstations of Army weapon systems, particularly those in which space is at a premium. Tanks, for example, are operated by personnel with a wide range of body sizes, yet crews must be able to operate weapons, controls, instruments, switches, and optical devices, often with the body restrained. These dimensions are also required for the design of major support equipment, such as consoles and panels at which an operator either sits or stands and over which he or she may be required to see. Body clearance dimensions dictate the size of escape hatches and limited-size passageways that must be designed to allow quick and safe passage of an individual. In the field or in a depot, the performance of maintenance activities is also greatly enhanced if personnel have ready physical

and visual access to maintenance and inspection ports, and have the reach capabilities to perform necessary service, repair, or replacement activities, often conducted under adverse conditions.

Aircraft Accommodation: The dimensions in this group are those that have been or are likely to be used to restrict individuals from operating aircraft with which they are anthropometrically incompatible. That is, certain aircraft of all services do not safely and efficiently accommodate the complete range of body sizes found in their flying populations. Ideally, the availability of population data in this category can be applied to avoid such problems in the future.

Body Links: These dimensions are needed for developing the link or "skeletal" system, which is the foundation for all three-dimensional kinematic anthropomorphic analogues used to assess the body's reaction to hazardous environments, and for two- and three-dimensional analogues used in the design and evaluation of Army crew- and workstations. Theoretically, links are straight-line distances between instantaneous centers of joint rotation. Owing to the complexity of actual joint motions, link length dimensions are usually average straight-line distances between adjacent joint centers in their mid-range position.⁴ Link lengths are estimated from anthropometry of the living by two basic methods: from measurements between two bony points (e.g., Acromion-Radiale Length, Trochanterion-Lateral Femoral Epicondyle Length) or approximations from body segment lengths (e.g., Shoulder-Elbow Length, Buttock-Knee Length). The link-related dimensions included in this group are measurements to bony points. Segment lengths from which link lengths can be approximated are grouped under the next category, anthropomorphic analogues, since they represent enflashed links, which are actually depicted in either physical or computer-generated analogues.

Anthropomorphic Analogues: The dimensions in this group are useful for the development of four general types of analogues: three-dimensional anthropomorphic dummies and three-dimensional computer-generated analogues used to assess the body's reaction to high acceleration environments; and two-dimensional drawing-board manikins and three-dimensional computer-generated human-engineering analogues used to guide the design and evaluation of workstations. The ubiquity of powerful computers is leading to increasing dependence upon analogues in preliminary design preparation and evaluation of weapon systems workstations. Analogues are extremely cost-effective tools in ensuring that man/machine interface errors or problems are identified during initial design studies rather than in the mock-up, preproduction, or production stages, where corrections or modifications become increasingly costly. Furthermore, evaluating the adequacy of existing workstations to efficiently and safely accommodate the human operator in the mock-up stage of a system is analogous to a fit and evaluation test of a new garment. This means that a representative sample of the population who will operate or occupy a system must try it for "fit" and operability. Finding a representative sample among plant personnel or Army representatives is often difficult and may be neglected. Computer-generated analogues reduce this problem by permitting a model of any body size and proportion to be evaluated in any workstation geometry early in the design cycle.

International Standards: Dimensions in this group have been recommended for inclusion in anthropometric surveys by one of three organizations: the

International Organization for Standardization (ISO), the International Biological Programme (IBP), or the Air Standardization Coordinating Committee (ASCC). Details of each organization's purposes and recommendations are given in the Appendix. Although the Army is required to respond only to those guidelines set forth in ASCC Air Standards, potential for data exchange and comparability should be a consideration in any anthropometric survey, and so dimensions in this group were noted and reviewed for potential inclusion in the Army's anthropometric survey.

It is emphasized that the categories described above are not mutually exclusive and, therefore, many dimensions will appear in more than one grouping.

PROCEDURES FOR EVALUATING DIMENSIONS

A comprehensive list of candidate measurements was reviewed and assessed in several different ways. First, a list of 298 dimensions measured in one or more of 32 anthropometric surveys of men and women, both military and civilian, was circulated among Anthropology Research Project (ARP) investigators, the Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL), and its University of Dayton contract personnel. The surveys are listed below:

Air Force Women - 1968⁵
Air Traffic Controllers - 1961 (male)⁶
Airline Stewardesses - 1971⁷
Army Aviators - 1959 (male)⁸
Army Aviators - 1970 (male)⁹
Army Female Separates - 1946¹⁰
Army Personnel - 1966 (male)¹¹
Army Women - 1977 (includes male subsample)¹²
Australian Tri-Service - 1977 (male)¹
British Army Surveys - 1972/76 (male)¹³
Canadian Forces - 1974 (male)¹⁴
Federal Republic of Germany Air Force - 1968 (male)¹⁵
French Aircrewmembers - 1972¹⁶
German Women - 1983¹⁷
Health and Nutrition Examination Survey - 1971/74 (male and female)¹⁸
Health Examination Survey - 1959/62 (male and female)^{19,20}
Iranian Military Forces - 1969 (male)²¹
Israeli Aircrew - 1981 (male)²²
Korean Armed Forces - 1966 (male)²³
Latin American Armed Forces - 1965/66 (male)²⁴
Law Enforcement Officers - 1974 (male)²⁵
NATO - Turkey, Greece, and Italy - 1960/61 (male)²⁶
Royal Air Force - 1970/71 (male)²⁷
Royal Australian Air Force - 1972 (male)²⁸
Royal New Zealand Air Force - 1973 (male)²⁹
U.S. Miners - 1981 (male and female)³⁰
USAF Flying Personnel - 1950 (male)³¹
USAF Flying Officers - 1967 (male)²
USAF Personnel - 1965 (male)³²
USN and USMC Aviation Personnel - 1981 (male and female)³³
USN Aviators - 1964 (male)³⁴
Vietnamese Military Personnel - 1963 (male)³⁵

Persons who reviewed the dimension list assembled from these surveys represent many decades of experience in applying anthropometric data to the design of military systems, equipment, and clothing. Each was asked to choose from the list those dimensions considered essential or useful in his or her work and to supplement his or her choices with additional dimensions not found on the list.

After the lists were returned, personal contact was made with each respondent in order to verify the dimensions selected and to gain an appreciation of how the dimensions were used in a particular application. Summaries such as those in the Appendix were then prepared. Table A-1, for example, lists the body dimensions used in or requested for two-dimensional and three-dimensional human body models.

For some applications such as the design of three-dimensional head, face, and body forms, individuals who had been responsible for their development were solicited to determine specifically what dimensions had been incorporated in these forms and what other dimensional data had been needed which had not been available. Responses were then reviewed with each investigator to evaluate how essential or useful each dimension was for his or her purposes.

A second line of inquiry involved a questionnaire survey which was administered to 22 Army and Air Force clothing designers and patternmakers to ascertain what dimensions they required for their work. The results of this survey and of meetings with Army and Air Force designers and patternmakers are summarized in the Appendix, Table A-2.

Other sources of variables reviewed were listings by various international standards and practices groups. These are dimensions that have been proposed by the Air Standardization Coordinating Committee³⁶ and the International Organization for Standardization³⁷ as dimensions to be measured in all anthropometric surveys, or they have been recommended for measurement by the International Biological Programme (IBP)³⁸ for use in biological studies of human populations. Brief descriptions of these organizations and lists of dimensions appear in the Appendix.

Finally, dimension lists from 14 surveys of U.S. and foreign military personnel and U.S. civilians were selected for detailed review. All the dimensions measured in these surveys were studied and evaluated for their potential usefulness in the proposed Army survey. These 14 surveys, listed below, were chosen on the basis of their sample size ($n \geq 500$), the number of dimensions measured (representing both highly selective and more comprehensive collections), measuring techniques (representing both U.S. and British methods), and recentness.

- Air Force Women - 1968⁵
- Army Aviators - 1970 (male)⁹
- Army Personnel - 1966 (male)¹¹
- Army Women - 1977 (includes male subsample)¹²
- Australian Tri-Service - 1977 (male)¹
- British Army Surveys - 1972/76 (male)¹³
- Canadian Forces - 1974 (male)¹⁴
- Health and Nutrition Examination Survey - 1971/74 (male and female)¹⁸
- Health Examination Survey - 1959/62 (male and female)^{19,20}
- Royal Air Force (RAF) - 1970/71 (male)²⁷
- USAF Flying Officers - 1967 (male)²
- USN Aviators - 1964 (male)³⁴
- U.S. Department of Agriculture, Bureau of Home Economics - 1939/40 (female)³⁹
- Federal Republic of Germany - 1970/71 (male)⁴⁰

Emphasis was placed on military surveys since they were the most likely to contain dimensions of utility for an Army anthropometric data base. The Health Examination Survey (HES) and the Health and Nutrition Examination Survey (HANES) were included since the National Health surveys, conducted every 10 years, provide the only anthropometric data purported to be representative of the U.S. adult civilian population. Though not contemporary, the 1939/40 anthropometric survey of U.S. women sponsored and supervised by the Bureau of Home Economics

was added to the list because the dimensions measured in it are often used in the design and construction of women's clothing, and the data resulting from it serve as the basis for garment pattern standards promulgated by the Bureau of Standards. Furthermore, in many respects it has served as a model for subsequent anthropometric surveys of military personnel.

A dimension evaluation sheet was prepared for each dimension measured in each of the 14 surveys. Figure 1 is a sample evaluation sheet used for dimensions measured in U.S. military surveys. Separate forms were used for foreign military and civilian surveys. A detailed explanation of the information recorded on these forms appears below:

- A. 1. DESCRIPTION: a short description of the dimension in lay terms.
- A. 2. BODY POSITION: For obtaining comparable measurements of like dimensions, consistency of body position is often as critical as the definition and interpretation of landmarks. The significant aspects of the position of the body and/or a part of the body that affect the measurement are described for each dimension.
- A. 3. LANDMARK(S): a mark placed on the body or body-surface feature used to identify the origin, end-point, or level of a measurement.
- A. 4. INSTRUMENTS/EQUIPMENT: the instrument and/or equipment used to measure a dimension.
- A. 5. SIGNIFICANT DIFFERENCES IN MEASURING TECHNIQUES: a statement calling attention to any differences, between surveys, in Body Position, Landmarks(s), or Instruments/Equipment that may affect the measurements.

ALTERNATIVES: dimensions that can serve a similar function.

- B., C. DATA: filled-in values indicate that the dimension was measured in a specific survey. Coefficients of variation, percentiles, and correlation statistics are given only for the U.S. Army 1966 and 1977 surveys. The data presented on the evaluation sheets for U.S. military personnel and from the HES and HANES surveys are from the Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL) anthropometric data bank. (The HES and HANES data are from subsamples of 18-45 year old subjects.) The values in the data bank were generated from the raw data of surveys that had been treated with editing routines, such as XVAL and EDIT which were developed by ARP for AAMRL. Summary statistics and correlation coefficients were calculated from the edited data. Therefore, the data shown on the sheets may not agree exactly with the data in the published reports of the surveys. Data from the other surveys reviewed are from the published reports of the surveys.

- D. THOUGHT TO BE OF Essential, Useful, OR Marginal VALUE TO A U.S. ARMY ANTHROPOMETRIC DATA BASE:

Marginal dimensions are those of which no known use has been made or that were measured to serve a unique or very limited purpose not considered germane to Army needs.

ANTHROPOMETRIC SURVEYS OF U.S. MILITARY PERSONNEL

VARIABLE NAME:

A. THE DIMENSION AND MAJOR ELEMENTS OF ITS MEASUREMENT:

1. DESCRIPTION:

2. BODY POSITION:

3. LANDMARK(S):

4. INSTRUMENTS/EQUIPMENT:

5. SIGNIFICANT DIFFERENCES IN MEASURING TECHNIQUES:

ALTERNATIVE DIMENSIONS:

B. DIMENSION WAS MEASURED IN THE FOLLOWING U.S. SURVEYS:

SURVEY	\bar{X}	SD	SURVEY	\bar{X}	SD
1 AF Women '68	_____	_____	4 USAF '67	_____	_____
2 Army Women '77	_____	_____	5 US Army '66	_____	_____
3 USN '64	_____	_____	6 Army Av. '70	_____	_____

		STATURE	WEIGHT	AGE
C. CORRELATION WITH:	US Army '66	_____	_____	_____
	US Army '77	_____	_____	_____

COEFFICIENT OF VARIATION: US Army '66 _____
US Army '77 _____

1st and 99th US ARMY '66 and '77 PERCENTILE VALUES: MALE _____ and _____
FEMALE _____ and _____

D. THOUGHT TO BE OF Essential, Useful, Marginal VALUE FOR A U.S. ARMY ANTHROPOMETRIC DATA BASE.

E. REASON FOR RATING IN D IS:

F. RACE SENSITIVE? YES ☐ NO ☐ GENDER SENSITIVE? YES ☐ NO ☐
IN WHAT WAY?

G. REPRODUCIBILITY: A ☐ B ☐ C ☐

IF B OR C, THE PROBLEM IS:

H. PARTICULARLY SENSITIVE TO:

Figure 1. Dimension Evaluation Sheet.

Useful is the rating given those dimensions of proven benefit in the design of clothing, personal equipment, workspaces, and two- and three-dimensional anthropomorphic analogues.

Essential is the rating assigned to those dimensions that are useful but also: (1) establish overall body size descriptions and distributions of a population and are particularly useful for comparing such distributions between populations, (2) serve as criteria for developing microcosms of populations used for special anthropometric studies including the test and evaluation of end items, (3) are used as key dimensions for the development of sizing systems and for the procurement and issuing of clothing and personal equipment, (4) determine critical design criteria required for the design and layout of workspaces, (5) are required for the development of either computer-generated or three-dimensional anthropomorphic analogues, or (6) may serve as body-size selection or elimination criteria for specific workspaces such as helicopter crewstations.

- E. REASON FOR RATING: a statement supporting the ranking of a dimension as being of marginal, useful, or essential value for a U.S. Army data base.
- F. RACE SENSITIVE (U.S. Military only): statements concerning the racial sensitivity of dimensions measured on U.S. military personnel are based primarily upon racial analyses of data from the 1965 survey of USAF men³² and the 1966 Army surveys of U.S. Army, Navy and Marine men.⁴¹ Long and Churchill³² report the differences between 157 dimensions measured on 343 White and 343 Black men matched by Stature and Weight. (Most men in this sample were between 17 and 21 years old). Comparisons between Whites and Asians* are based on a sample of 97 Whites and 97 Asians matched by Stature and Weight drawn from the 1966 surveys during which 70 dimensions were measured.⁴¹ (These, too, were young men having a mean age of 21.1 years.)

Like comparisons were made between matched samples of 396 Whites and 396 Hispanics measured during the Army's 1966 surveys (their mean age was 20.9 years).⁴¹ The data revealed a slight tendency for Whites to have shorter torsos and longer extremities than Hispanics of like body size, but not enough is yet known about this group to assess the effect of these differences on design.

Since Whites constitute the majority of Army personnel, Whites were considered as the base upon which comparisons were made. That is, a typical race sensitive statement reads: "Among Whites, Blacks, and Asians of like body size, Whites tend on the average to have shorter upper extremities than Blacks and longer upper extremities than Asians."

The criterion for declaring a dimension to be race-sensitive is a difference between mean values equaling or exceeding 1.0 cm or one-half of a unit of the standard deviation of measurement for the White sample.

* Asians as used here are those subjects who classified themselves as: Chinese, Guamanians, Hawaiians, Japanese, Koreans, Filipinos, or simply Asians.

Race-sensitive statements for dimensions not measured in a survey from which matched samples were drawn are based on similarities between body dimensions. For example, since matched-sample data demonstrate that Crotch Height is a race sensitive dimension between Whites and Asians, one can assume that Trochanteric Height, which was not measured in the U.S. Army 1966 surveys, also demonstrates a similar degree of sensitivity.

It should be noted that the racial composition of previous survey samples limits the types of racial comparisons that can be made with confidence. Both White and Black men are well represented in military surveys. However, there are too few Asians, Hispanics, and American Indians represented in those surveys to assess in detail the anthropometric uniqueness (or lack thereof) of these populations. Racial differences in body size of military women have never been documented at all. A new survey, demographically representative of the contemporary Army, should shed considerable light on this problem since relatively large samples of each population group, and both sexes, will have been measured by a single team of observers.

GENDER SENSITIVE (U.S. Military only): statements describing dimensions as being gender sensitive, with respect to their significance for design are based primarily on data reported by Robinette et al.⁴² This study presents an analysis of anthropometric differences between men and women measured in the 1977 U.S. Army survey of women. [Forty-four dimensions were measured on a subsample of men for the express purpose of obtaining comparable data for men and women (i.e., data having the same inter/intra-observer errors using the same measuring techniques)]. From the subjects measured in this survey, a sample of 204 men and 204 women were matched by Stature and Weight. The same criterion used to classify a dimension as being race-sensitive is used to label a body dimension as gender-sensitive. Since only three head dimensions (Head Length, Head Breadth, Head Circumference) were among the forty-four dimensions measured, the classification of other head and face dimensions as being gender-sensitive was largely based on the authors' judgement. Judgements were based on comparisons of male and female head data from the 1965 and 1967 surveys of USAF men,^{32,2} the 1968 USAF and 1977 U.S. Army surveys of women^{5,12} and the authors' experience in developing sizing systems for personal-protective equipment worn on the head and/or face. No attempt was made to develop matched samples from the U.S. Army and USAF surveys since data generated from matched samples drawn from multiple surveys may be unreliable due to differences in measuring techniques and levels of observer error.

G. REPRODUCIBILITY: an expression of the demonstrated or anticipated level of repeatability of a measurement, and the reason for the rating if it is B or C. "A" denotes a test/retest correlation ≥ 0.90 ; "B" denotes a test/retest correlation of $0.80 - 0.89$; "C" denotes a test/retest correlation < 0.79 . Reliability studies were conducted during the 1965 survey of Air Force men³² and the 1977 Australian Tri-Service survey.⁴³ During the Air Force study, 157 dimensions were measured twice on a group of 41 men undergoing basic training. This was primarily a study of intra-observer error. The Australian effort represents both intra- and inter-observer differences of measurements of 32 dimensions measured twice, as the

opportunity arose on 50 subjects. The reliability of measurements not taken in either the USAF 1965 or Australian 1977 surveys are estimates based on the authors' judgement as to their similarity to measurements for which test/retest results are available.

- H. PARTICULARLY SENSITIVE TO: a caution that either a landmark definition and/or its location, measuring technique, or subject position requires special attention or presents special problems. (It is, of course, understood that all dimensions are sensitive to one degree or another to the above factors.) Generally, precautionary remarks are made only for those dimensions with a reproducibility rating of A, since problems with dimensions assigned reproducibility ratings of B and C are noted along with the rating.

RESULTS

The dimensions from all surveys reviewed, and dimensions not previously measured in any of them but identified as being useful by clothiers, engineering anthropologists, and international committees were combined and are listed in Table 1. This table is designed to serve as the basis for developing the list of dimensions to be measured in a new anthropometric survey of Army men and women. Listed on the table are 362 anthropometric variables and their assignments to designated design/application groups. Approximately 85 percent of the listed dimensions have been measured in one or more of 34 surveys of U.S. and foreign military personnel and U.S. and foreign civilians. The remaining 15 percent were not measured in any of the surveys reviewed but have been identified as having utility by specialists in the application of anthropometric data to the design of military clothing, personal equipment, and weapon systems.

Each dimension was evaluated for its utility in terms of the various purposes for which the Army may require anthropometric data. On Table 1 each of the 362 dimensions is rated as being of either essential (E), useful (U), or marginal (M) value for one or more of the relevant applications.

Dimension evaluation sheets for all dimensions measured in the 14 closely reviewed surveys appear in Volume II. Abbreviated descriptions of an additional 84 dimensions listed on Table 1 but not measured in those surveys are also given in Volume II.

TABLE 1. Dimensions Evaluated for An
Army Anthropometric Data Base.

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal ○ -measured 1966, 1970, and 1977 Army surveys ▲ -measured 1966 survey of U.S. Army men ▼ -measured 1970 survey of U.S. Army aviators ★ -measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
★	ABDOMINAL EXTENSION ARC ABDOMINAL EXTENSION BREADTH, SITTING ABDOMINAL EXTENSION CIRCUMFERENCE ABDOMINAL EXTENSION CIRCUMFERENCE, OFG* ABDOMINAL EXTENSION DEPTH			M M U M U	M U U					M				U	
★	ABDOMINAL EXTENSION DEPTH, OFG* ABDOMINAL EXTENSION DEPTH, SITTING ABDOMINAL EXTENSION HEIGHT ABDOMINAL EXTENSION HEIGHT, OFG* ABDOMINAL EXTENSION HEIGHT, SITTING			M U U M	U					E U			E U		
○	ABDOMINAL EXTENSION-WALL DEPTH ACROMIAL HEIGHT ACROMIAL HEIGHT, SITTING ACROMION-BICEPS CIRC LEVEL LENGTH ACROMION-LATERAL HUMERAL EPICONDYLE LENGTH		E	U	U M					E		E E E	U E E	AI AI	
★ ○ ○ ★	ACROMION-RADIALE LENGTH ACROMION-WALL DEPTH AGE ANKLE CIRCUMFERENCE ANKLE HEIGHT		E E	U U U	U U U				U U			E	U E U	B AB B	
	ANTERIOR CHEST/BUST ARC ANTERIOR CROTCH LENGTH ANTERIOR NECK LENGTH ANTERIOR WAIST ARC ARM LENGTH (SHOULDER TO SCYE)			U U M U M	U U M U M									M	
★ ★ ★ ★	ARM REACH FROM WALL ARM REACH FROM WALL, MAXIMUM AXILLA HEIGHT AXILLA-WAIST LENGTH AXILLARY ARM CIRCUMFERENCE			U U U U	U U U U	U U				E E			E E E	A	

* OVER FOUNDATION GARMENT (OFG)

** Air Standarization Coordinating Committee (ASCC); International Organization for Standardization (ISO); International Biological Programme (IBP).

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential A=ASCC** U=Useful I=ISO** M=Marginal B=IBP**	○ -measured 1966, 1970, and 1977 Army surveys ▲ -measured 1966 survey of U.S. Army men ▼ -measured 1970 survey of U.S. Army aviators ★ -measured 1977 survey of U.S. Army women	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
★ BACK ARC (BUTTOCK)					U	U									
★ BACK ARC (CHEST)					U	U	U								
★ BACK ARC (WAIST)					U	U	U								
○ BALL OF FOOT CIRCUMFERENCE										U				U	
○ BALL OF FOOT LENGTH			E							E					
BALL OF HUMERUS HEIGHT, SITTING													M		
BALL OF HUMERUS-LAT HUMERAL EPICONDYLE LGTH													E	E	AIB
★ BIACROMIAL BREADTH					U	U	U						E		
BIAURICULAR BREADTH							U								
○ BICEPS CIRCUMFERENCE						U								U	
○ BICEPS CIRCUMFERENCE, FLEXED					U	U									B
BICRISTAL BREADTH					U	U									B
○ BIDELOID BREADTH					U						E	E		E	B
BIGONIAL BREADTH								U	U						
BIGONION-CHIN PROMINENCE ARC								U	U						
BIGONION-SUBLABIAL ARC								U							
BIMALLEOLAR BREADTH (ANKLE BREADTH)					M			U		U				M	B
★ BIOCLAR BREADTH								U							
★ BISPINOUS BREADTH								U					E		
○ BITRAGON BREADTH								U							
★ BITRAGON-CORONAL ARC								U							I
BITRAGON-CRINION ARC								U							
★ BITRAGON-MENTON ARC								U							
★ BITRAGON-MINIMUM FRONTAL ARC								U							
BITRAGON-POSTERIOR ARC								M							
★ BITRAGON-SUBMANDIBULAR ARC								U							
BITRAGON-SUBNASALE ARC								U							
○ BIZYGOMATIC BREADTH			E					U						U	B
BUST CIRCUMFERENCE, OFG*					M			E							
★ BUST DEPTH					U	U	U				E			E	

* OVER FOUNDATION GARMENT (OFG)

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal ○-measured 1966, 1970, and 1977 Army surveys ▲-measured 1966 survey of U.S. Army men ▼-measured 1970 survey of U.S. Army aviators ★-measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
★ BUSTPOINT HEIGHT					U	U	U							E	
BUSTPOINT/THELION-WALL DEPTH					U	U	U							U	
BUSTPOINT-BUSTPOINT BREADTH					U	U	U							U	AI
○ BUTTOCK CIRCUMFERENCE			E		E	U									
★ BUTTOCK CIRCUMFERENCE, SITTING					U										
BUTTOCK CIRCUMFERENCE, SITTING, OFG*					M	U	U				U			E	
BUTTOCK DEPTH					U										
BUTTOCK DEPTH, OFG*					M	U								U	
★ BUTTOCK HEIGHT					U	U								E	
○ BUTTOCK-KNEE LENGTH					U						E	E		E	AIB
▲▼ BUTTOCK-POPLITEAL LENGTH											E		E	E	I
BUTTOCK-TROCHANTERION, SITTING (HORIZONTAL)													E		
○ CALF CIRCUMFERENCE					U	U								U	
CALF DEPTH					U	M				U				M	
○ CALF HEIGHT					U	U								U	
○ CERVICALE HEIGHT					U	U	U						E	E	A
CERVICALE HEIGHT, SITTING													E	E	I
CERVICALE-ANTERIOR WAIST LENGTH					M	M	M								
CERVICALE-BACK OF KNEE LENGTH					U	U									
CERVICALE-BUTTOCK LEVEL LENGTH					U	U									
CERVICALE-TRAGION HEIGHT													U		
○ CHEST BREADTH					U	U	U							E	B
○ CHEST/BUST CIRCUMFERENCE			E		E	E	E							E	AI
★ CHEST CIRCUMFERENCE AT SCYE					E	E	U							U	I
★ CHEST CIRCUMFERENCE BELOW BUST					U	U	U								I
CHEST CIRCUMFERENCE, EXPIRED															B
▲▼ CHEST DEPTH					U	U	U				E			E	B***
CHEST DEPTH AT SCYE					M	M	M							M	
CHEST DEPTH, SITTING														U	
CHEST HEIGHT					U	U	U							E	

* OVER FOUNDATION GARMENT (OFG)

*** SPINE-MESOSTERNUM DEPTH

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential A=ASCC** U=Useful I=ISO** M=Marginal B=IBP**	○ -measured 1966, 1970, and 1977 Army surveys ▲ -measured 1966 survey of U.S. Army men ▼ -measured 1970 survey of U.S. Army aviators ★ -measured 1977 survey of U.S. Army women	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
CHEST HEIGHT, SITTING CHIN PROMINENCE-TOP OF HEAD CHIN PROMINENCE-WALL ○ CROTCH HEIGHT ★ CROTCH LENGTH				E	E	E		U			U			U	AI
DACTYLION HEIGHT DELTOID ARC EAR BREADTH EAR LENGTH EAR LENGTH ABOVE TRACION			E		M	M		U			M			M	B B
EAR PROTRUSION ECTOCANTHUS-OTOBASION SUPERIOUS LENGTH ★ ECTOCANTHUS-TOP OF HEAD ★ ECTOCANTHUS-WALL ★ ELBOW CIRCUMFERENCE						U		U						E	
ELBOW CIRCUMFERENCE, FLEXED ELBOW CIRCUMFERENCE, FULLY BENT ELBOW FUNCTIONAL REACH ★ ELBOW REST HEIGHT ELBOW REST HEIGHT, STANDING					U						U			U	AI I
★ ELBOW-CENTER OF GRIP LENGTH ELBOW-ELBOW BREADTH ELBOW-ELBOW SPAN EYE HEIGHT ○ EYE HEIGHT, SITTING				E							E		E	E	AI I AI
FEMORAL EPICONDYLE BREADTH FIBULAR HEIGHT FINGER DIAMETER (DIGIT III) FIRST PHALANX LENGTH (DIGIT III) FIST CIRCUMFERENCE									U		U		M		B

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal ○-measured 1966, 1970, and 1977 Army surveys ▲-measured 1966 survey of U.S. Army men ▼-measured 1970 survey of U.S. Army aviators ★-measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
○ FOOT BREADTH				E						E			E	E	AI
○ FOOT LENGTH				E						E			E	E	AIB
★ FOREARM CIRCUMFERENCE					U	U			U					U	B
○ FOREARM CIRCUMFERENCE, FLEXED															
▲ FOREARM-FOREARM BREADTH											E	E		E	
○ FOREARM-HAND LENGTH															
FOREARM-WRIST LENGTH					U						E	E		E	I
FUNCTIONAL GRIP REACH											E	E		E	A
FUNCTIONAL GRIP REACH, EXTENDED											E	E		E	
★ FUNCTIONAL LEG LENGTH											E	E		U	
★ GLABELLA-TOP OF HEAD								U							
★ GLABELLA-WALL								U							
GLUTEAL ARC					M										
★ GLUTEAL FURROW HEIGHT					U	U								U	B
GONION-TOP OF HEAD								U							
GONION-WALL															
GRIP AXIS HEIGHT											U				I
GRIP DIAMETER (INSIDE)											U				
GRIP DIAMETER (OUTSIDE)											U			U	
GRIP STRENGTH	M														
HALFWAY TO HIP CIRCUMFERENCE LENGTH						M	M								
○ HAND BREADTH				E					E		E			E	AIB
HAND BREADTH ACROSS THUMB															
○ HAND CIRCUMFERENCE				E					E		U				AI
HAND CIRCUMFERENCE INCLUDING THUMB									U						
○ HAND LENGTH				E					E		E	E	E	E	AI
HAND THICKNESS															
○ HEAD BREADTH				E				E			U			U	AIB
○ HEAD CIRCUMFERENCE				E	E			E						E	AIB
HEAD DIAGONAL MAXIMUM (MENTON-NUCHALE)								M							

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal ○-measured 1966, 1970, and 1977 Army surveys ▲-measured 1966 survey of U.S. Army men ▼-measured 1970 survey of U.S. Army aviators ★-measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
▲	HEAD DIAGONAL MAXIMUM (MENTON-Occiput)			U				M							
	HEAD DIAGONAL (PRONASALE-INION)							M							
	▲ HEAD HEIGHT (see TRAGION-TOP OF HEAD)							U						U	B
	○ HEAD LENGTH		E					E						U	AIB
	○ HEEL BREADTH									U					
○	HEEL-ANKLE CIRCUMFERENCE				U					U					
	HEEL-ANKLE CIRCUMFERENCE, EXTENDED									U					
	HEEL-LATERAL MALLEOLUS (HORIZONTAL) LENGTH				M	M							U		
	HIGHEST BUST LEVEL BREADTH														
	○ HIP BREADTH				U	U								E	I
▲ ▼	HIP BREADTH, OFG*			M											
	HIP BREADTH, SITTING			U							E			E	AI
	HIP CIRCUMFERENCE AT TROCHANTERION			M	M									M	
	HIP CIRCUMFERENCE AT TROCHANTERION, OFG*			M											
	HIP CIRCUMFERENCE 7" BELOW WAIST			U	U										
.	HIP CIRCUMFERENCE 7" BELOW WAIST, OFG*			M											
	HIP CIRCUMFERENCE 9" BELOW WAIST			U	U										
	HIP CIRCUMFERENCE 9" BELOW WAIST, OFG*			M											
	HIP HEIGHT (AT TROCHANTER)			M	M										
	HIP-WAIST LENGTH			U	U										
▲ ▼	HUMERAL EPICONDYLE BREADTH														B
	ILIOCRISTALE HEIGHT			U	U	M								U	
	ILIOSPINALE-WALL DEPTH													U	
	INDEX FINGER LENGTH								U						I
	○ INSTEP CIRCUMFERENCE									U					
○	INTEROCULAR BREADTH							U							
	○ INTERPUPILLARY BREADTH			E	U			U					E	E	
	○ INTERSCYE			U	U	U									
	★ INTERSCYE (FRONT)			M	M	M									
	▲ INTERSCYE, MAXIMUM			U											

*OVER FOUNDATION GARMENT (OFG)

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
	○ -measured 1966, 1970, and 1977 Army surveys ▲ -measured 1966 survey of U.S. Army men ▼ -measured 1970 survey of U.S. Army aviators ★ -measured 1977 survey of U.S. Army women														
★	KNEE CIRCUMFERENCE KNEE CIRCUMFERENCE AT TIBIALE KNEE CIRCUMFERENCE, FULLY BENT KNEE CIRCUMFERENCE, SITTING KNEE HEIGHT (INFRAPATELLA)				U M U U M	U M M								E M U M	
○ ○	KNEE HEIGHT (MIDPATELLA) KNEE HEIGHT (SUPRAPATELLA) KNEE HEIGHT, SITTING KNEE PIVOT HEIGHT† KNEE-KNEE BREADTH, CLOSED				U M	U M						E M		E M E	AI
	KNEE-KNEE BREADTH, OPEN LARYNX-WALL DEPTH LATERAL FEMORAL EPICONDYLE HEIGHT LATERAL HUMERAL EPICONDYLE-STYLION LENGTH LATERAL MALLEOLUS HEIGHT					M				U			E E E	M U	
★	LATERAL NECK HEIGHT LEG INSEAM LEG OUTSEAM LIP LENGTH LIP LENGTH, SMILING				U M U	U M U		U U							I B
▲ ▼	LIP PROTRUSION-WALL LIP-LIP HEIGHT LOWER THIGH CIRCUMFERENCE MAXIMUM FRONTAL BREADTH MAXIMUM FRONTAL-TOP OF HEAD				U	U		U U U						U	B
	MAXIMUM FRONTAL-WALL MAXIMUM THIGH CIRCUMFERENCE MEDIAL FEMORAL EPICONDYLE HEIGHT MEDIAL MALLEOLUS CIRCUMFERENCE MEDIAL MALLEOLUS HEIGHT				M M	M M		U		U U			E		

† see LATERAL and MEDIAL FEMORAL EPICONDYLE HEIGHTS

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal ○-measured 1966, 1970, and 1977 Army surveys ▲-measured 1966 survey of U.S. Army men ▼-measured 1970 survey of U.S. Army aviators ★-measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
MENTON PROJECTION								M							
★ MENTON-CRINION LENGTH								U							
○ MENTON-SELLION LENGTH			E					E						E	I
MENTON-SUBNASALE LENGTH								U							
★ MENTON-TOP OF HEAD								U						E	
★ MENTON-WALL								U							
★ METACARPALE III HEIGHT											M			M	
▲ MIDSHOULDER HEIGHT, SITTING					M	M					E			E	
MIDTHIGH CIRCUMFERENCE								U						M	
MINIMUM FRONTAL ARC															
MINIMUM FRONTAL BREADTH								U							B
MINIMUM FRONTAL-TOP OF HEAD								U							
MINIMUM FRONTAL-WALL								U							
★ NASAL BREADTH								U							B
NASAL ROOT BREADTH								U							
NASAL ROOT HEIGHT								M							
NASION-TOP OF HEAD								M							
▲ NECK CIRCUMFERENCE			E	E	E									E	AIB
★ NECK CIRCUMFERENCE (BASE)				U	U										
★ NECK-BUSTPOINT LENGTH				U	U	U									
NOSE LENGTH (see SUBNASALE-SELLION LENGTH)								U							B
NOSE PROTRUSION								U							
NUCHALE HEIGHT						U								U	
OMPHALION-WALL DEPTH													U	U	
○ PALM LENGTH									U					U	
PENALE HEIGHT					M			U			M				
PHILTRUM LENGTH															
○ POPLITEAL HEIGHT					U	U					E			E	AI
POSTERIOR CHEST BREADTH					U	U	U								
POSTERIOR CROTCH LENGTH															

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal ○-measured 1966, 1970, and 1977 Army surveys ▲-measured 1966 survey of U.S. Army men ▼-measured 1970 survey of U.S. Army aviators ★-measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC AN. LOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
POSTERIOR NECK LENGTH POSTERIOR SUPERIOR ILIAC SPINE HEIGHT ★ PRONASALE-TOP OF HEAD ○ PRONASALE-WALL PUPIL-TOP OF HEAD					U	U								E	
PUPIL-WALL ★ RADIALE HEIGHT ★ RADIALE-STYLION LENGTH ★▼ SAGITTAL ARC ○ SCYE CIRCUMFERENCE								U							
SCYE DEPTH ★ SELLION-TOP OF HEAD ○ SELLION-WALL ○ SHOULDER CIRCUMFERENCE ○ SHOULDER LENGTH					U	U	U	U							
○ SHOULDER-ELBOW LENGTH SHOULDER-WAIST LENGTH ○ SITTING HEIGHT SITTING HEIGHT, RELAXED SITTING SPREAD CIRCUMFERENCE					U	U	U				E	E	E	E	AIB
SITTING SPREAD HEIGHT SKINFOLD: ABDOMINAL ★ SKINFOLD: BICEPS SKINFOLD: JUXTA-NIPPLE ▼ SKINFOLD: MEDIAL CALF					M	M									B B B B
★▼ SKINFOLD: MIDAXILLARY LINE AT XIPHOID ★▼ SKINFOLD: SUBSCAPULAR ★▼ SKINFOLD: SUPRAILIAC SKINFOLD: TRICEPS ○ SLEEVE INSEAM															B B B B

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal O-measured 1966, 1970, and 1977 Army surveys A-measured 1966 survey of U.S. Army men V-measured 1970 survey of U.S. Army aviators ★-measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
★ SLEEVE LENGTH SEGMENT (SPINE-ELBOW LENGTH) SLEEVE LENGTH SEGMENT (SPINE-SCYE LENGTH) ★ SLEEVE LENGTH (SPINE-WRIST LENGTH) ★ SLEEVE OUTSEAM SLOPE (SHOULDER)				E	U	U									
SPAN ★ SPHYRION HEIGHT SPHYRION (FIBULARE) HEIGHT O STATURE O STATURE, ESTIMATED			E	E	U		U				U	E		U	
STOMACH BREADTH ★ STOMION-TOP OF HEAD ★ STOMION-WALL STRAP LENGTH ★ SUBNASALE-SELLION LENGTH (NOSE LENGTH)					M	M		U						M	B
★ SUBNASALE-TOP OF HEAD ★ SUBNASALE-WALL ★ SUBSTERNAL HEIGHT ★ SUPRASTERNAL HEIGHT TENTH RIB HEIGHT					U	U		U					U	U	B
O THIGH CIRCUMFERENCE THIGH CIRCUMFERENCE, SITTING ★ THIGH CLEARANCE THIGH DEPTH ★ THIGH-THIGH BREADTH, SITTING					U	U					E			E	AB
THIGH-THIGH BREADTH, SITTING, OFG* A THUMB CROTCH LENGTH THUMB LENGTH O THUMB TIP REACH ★ THUMB TIP REACH, EXTENDED					M				U		U	E		E	A

* OVER FOUNDATION GARMENT (OFG)

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal O—measured 1966, 1970, and 1977 Army surveys A—measured 1966 survey of U.S. Army men V—measured 1970 survey of U.S. Army aviators ★—measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
★ FIBIALE HEIGHT					M								M		IB
TOTAL POSTERIOR ARM LENGTH					M										
TRACION HEIGHT														U	
TRACION HEIGHT, SITTING													U	U	
TRACION-PUPIL LENGTH								U					U	U	
○ TRACION-TOP OF HEAD (HEAD HEIGHT)								U						U	B
○ TRACION-WALL								U						U	
TRIGGER POSITION					E										
★ TROCHANTERIC HEIGHT													E		
TROCHANTERIC HEIGHT, SITTING													E		
TROCH-LAT FEMORAL EPICONDYLE LGTH, SITTING													E	U	
TROCHANTERION-WALL DEPTH														U	
V TRUNK HEIGHT, SITTING					U	U								U	B
UPPER ARM CIRCUMFERENCE					M	M									B
UPPER EXTREMITY LENGTH			E												B
UPPER POSTERIOR ARM LENGTH					M										
VERTICAL GRIP REACH											E			E	
○ VERTICAL GRIP REACH, SITTING										E	E			E	
VERTICAL REACH										E	E			E	
VERTICAL REACH, SITTING										E	E			E	
VERTICAL THUMB TIP REACH, SITTING										E				E	A
○ VERTICAL TRUNK CIRCUMFERENCE				E	E	E	U								
★ VERTICAL TRUNK CIRCUMFERENCE, SITTING					U										
VERTICAL WRIST HEIGHT										E				E	
VERTICAL WRIST HEIGHT, SITTING										E	E			E	
VERTICAL WRIST HEIGHT EXTENDED										E					
○ VERTICAL WRIST HEIGHT EXTENDED, SITTING										E				E	
○ WAIST BACK LENGTH					U	U	U								
★ WAIST BREADTH					U	U								E	
WAIST BREADTH, OFG*					M										

* OVER FOUNDATION GARMENT (OFG)

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal O=measured 1966, 1970, and 1977 Army surveys A=measured 1966 survey of U.S. Army men V=measured 1970 survey of U.S. Army aviators ★=measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
○ WAIST CIRCUMFERENCE (NATURAL INDENTATION)†† ○ WAIST CIRCUMFERENCE (OMPHALION)†† ★ WAIST CIRCUMFERENCE (PREFERRED)††§ WAIST CIRCUMFERENCE, OFG* WAIST CIRCUMFERENCE, SITTING				M	M	M	M							M	I
				E	E	E	E							E	AIB
				E	U	U	M							M	
					M									M	
					M									M	
★ WAIST DEPTH WAIST DEPTH, OFG* WAIST DEPTH, SITTING ★ V WAIST FRONT LENGTH ★ WAIST HEIGHT					U	U	U							E	
					M									M	
				E	E	U	U				M	M		M	
					U	U	U				U			U	A
WAIST HEIGHT, OFG* WAIST HEIGHT, SITTING WAIST-FLOOR OVER BUTTOCK LENGTH WAIST-STOMACH HEIGHT WAIST-WAIST OVER SHOULDER					M									M	
					U						M				
					U	U									
					M	M									
					U	U	U								
○ WEIGHT ○ WEIGHT, ESTIMATED WRIST BREADTH (BONE) WRIST CIRCUMFERENCE, DISTAL§§ ○ WRIST CIRCUMFERENCE, PROXIMAL§§			E	E	E						E	E		E	AIB
						M	M							M	B
						U	U		U					E	I
															B
WRIST HEIGHT WRIST HEIGHT, SITTING WRIST-CENTER OF GRIP LENGTH WRIST-INDEX FINGER LENGTH WRIST-THUMB TIP LENGTH											U			U	A
											E			E	
											E	E		E	
											E			E	
											E	E		E	

†† see WAIST CIRCUMFERENCE

* OVER FOUNDATION GARMENT (OFG)

§ Essential only for procurement purposes for those women's garments that use this dimension as a key sizing dimension

§§ DISTAL to ULNAR and RADIAL STYLOID PROCESSES
PROXIMAL to ULNAR and RADIAL STYLOID PROCESSES

TABLE 1. (cont'd)

IN CURRENT ARMY DATA BASE	E=Essential U=Useful M=Marginal ○-measured 1966, 1970, and 1977 Army surveys ▲-measured 1966 survey of U.S. Army men ▼-measured 1970 survey of U.S. Army aviators ★-measured 1977 survey of U.S. Army women	A=ASCC** I=ISO** B=IBP**	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES	INTERNATIONAL STANDARDS GROUPS (ASCC, ISO, IBP)
WRIST-WALL LENGTH															
WRIST-WALL LENGTH, EXTENDED															
WRIST-WRIST SPAN															
ZYGION-TOP OF HEAD															
ZYGION-WALL															
ZYGOMA-TOP OF HEAD															
ZYGOMA-WALL															

The following lists of dimensions, broken down by category, are likely candidates for inclusion in a new Army data base. Some dimensions designated in Table 1 as either essential (E) or useful (U) may not appear in the candidate dimension lists below. Reasons for these omissions are given in the section entitled "Non-Candidate Dimensions," pp. 36-38.

Basic Body Descriptors

Acromial Height	Stature
Age	Stature, Estimated
Dactylion Height	Upper Extremity Length
Sitting Height	Weight
	Weight, Estimated

Age is generally considered a demographic variable similar to sex and race, but it is also considered here as an anthropometric variable due to its influence on body size and its use as a selection criterion for entry into the Army and into flight training. All these dimensions are rated as essential in Table 1.

Key Dimensions/Microcosm Selection

Age	Head Circumference
Ball of Foot Length	Head Length
Bizygomatic Breadth	Menton-Sellion Length
Buttock Circumference	Neck Circumference
Chest/Bust Circumference	Shoulder Circumference
Chest Circumference at Scye	Sitting Height
Crotch Height	Sleeve Length (Spine-Wrist Length)
Eye Height, Sitting	Stature
Foot Breadth	Vertical Trunk Circumference
Foot Length	Waist Circumference, Omphalion
Hand Breadth	(men and women)
Hand Circumference	Waist Circumference, Preferred
Hand Length	(women)
Head Breadth	Waist Front Length
	Weight

All dimensions in this group are rated as essential in Table 1.

Garments (Clothing/Personal Equipment)

Abdominal Extension Circumference	Acromial Height
Abdominal Extension Depth	Acromion-Radiale Length
Abdominal Extension Depth, Sitting	Ankle Circumference
Abdominal Extension Height	Ankle Height

Anterior Chest/Bust Arc	Knee Circumference
Anterior Crotch Length	Knee Circumference, Fully Bent
Anterior Waist Arc	Knee Circumference, Sitting
Axilla Height	Knee Height (Midpatella)
Axilla-Waist Length	Lateral Neck Height
Axillary Arm Circumference	Leg Outseam
Back Arc (Buttock)	Lower Thigh Circumference
Back Arc (Chest)	*Neck Circumference
Back Arc (Waist)	Neck Circumference, Base
Biacromial Breadth	Neck-Bustpoint Length
Biceps Circumference, Flexed	Posterior Chest Breadth
Bicristal Breadth	Posterior Crotch Length
Bideltoid Breadth	Posterior Neck Length
Bust Depth	Scye Circumference
Bustpoint Height	Scye Depth
Bustpoint-Bustpoint Breadth	*Shoulder Circumference
*Buttock Circumference	Shoulder Length
Buttock Circumference, Sitting	Shoulder-Elbow Length
Buttock Depth	Shoulder-Waist Length
Buttock Height	Sleeve Inseam
Buttock-Knee Length	Sleeve Length Segment (Spine-Elbow Length)
Calf Circumference	Sleeve Length Segment (Spine-Scye Length)
Calf Height	*Sleeve Length (Spine-Wrist Length)
Cervicale Height	Sleeve Outseam
Cervicale-Back of Knee Length	Slope (Shoulder)
Cervicale-Buttock Level Length	Span
Chest Breadth	*Stature
*Chest/Bust Circumference	Strap Length
*Chest Circumference at Scye	Substernale Height
Chest Circumference Below Bust	Suprasternale Height
Chest Depth	Tenth Rib Height
Chest Height	Thigh Circumference
*Crotch Height	Thigh Clearance
Crotch Length	Thigh-Thigh Breadth, Sitting
Elbow Circumference, Flexed	*Trigger Position
Elbow Circumference, Fully Bent	Trunk Height, Sitting
Forearm Circumference, Flexed	*Vertical Trunk Circumference
Forearm-Wrist Length	Vertical Trunk Circumference, Sitting
Gluteal Furrow Height	Waist Back Length
*Head Circumference	Waist Breadth
Head Diagonal Maximum (Menton-Occiput)	*Waist Circumference, Omphalion (men and women)
Heel-Ankle Circumference, Extended	Waist Circumference, Preferred (women)
Hip Breadth	Waist Depth
Hip Breadth, Sitting	*Waist Front Length
Hip Circumference 7" Below Waist	Waist Height
Hip Circumference 9" Below Waist	Waist Height, Sitting
Hip-Waist Length	Waist-Floor Over Buttock Length
Iliocristalle Height	Waist-Waist Over Shoulder
*Interpupillary Breadth	*Weight
Interscyce	Wrist Circumference, Proximal
Interscyce, Maximum	

Dimensions in this category that are, or may be used as, key dimensions to control the sizing, procurement, and issuing of equipment are rated essential. Essential dimensions are indicated by an asterisk, and with the exception of Interpupillary Breadth and Trigger Position, they all appear in the Key Dimensions/Microcosm Selection list. The other dimensions were identified as being of value to 22 Army and Air Force designers and patternmakers currently engaged in the design and sizing of clothing and personal equipment (see the Appendix).

Clothing Manikins

Abdominal Extension Circumference	Gluteal Furrow Height
Abdominal Extension Depth	Hip Breadth
Abdominal Extension Height	Hip Circumference 7" Below Waist
Abdominal Extension-Wall Depth	Hip Circumference 9" Below Waist
Acromial Height	Hip-Waist Length
Acromion-Wall Depth	Iliocristale Height
Ankle Circumference	Interscye
Ankle Height	Knee Circumference
Anterior Chest/Bust Arc	Knee Height (Midpatella)
Anterior Crotch Length	Lateral Neck Height
Anterior Waist Arc	Leg Outseam
Axilla Height	Lower Thigh Circumference
Axilla-Waist Length	*Neck Circumference
Axillary Arm Circumference	Neck Circumference, Base
Back Arc (Buttock)	Neck-Bustpoint Length
Back Arc (Chest)	Omphalion-Wall Depth
Back Arc (Waist)	Posterior Chest Breadth
Biacromial Breadth	Posterior Crotch Length
Biceps Circumference	Posterior Neck Length
Bicristal Breadth	Scye Circumference
Bust Depth	Scye Depth
Bustpoint Height	Shoulder Length
Bustpoint /Thelion-Wall Depth	Shoulder-Waist Length
Bustpoint-Bustpoint Breadth	Sleeve Inseam
Buttock Circumference	Sleeve Outseam
Buttock Depth	Slope (Shoulder)
Buttock Height	Strap Length
Calf Circumference	Suprasternale Height
Calf Height	Thigh Circumference
Cervicale Height	Thigh Depth
Cervicale-Back of Knee Length	Trochanterion-Wall Depth
Cervicale-Buttock Level Length	*Vertical Trunk Circumference
Chest Breadth	Waist Back Length
*Chest/Bust Circumference	Waist Breadth
*Chest Circumference at Scye	*Waist Circumference, Omphalion
Chest Circumference Below Bust	Waist Circumference, Preferred
Chest Depth	Waist Depth
Chest Height	Waist Front Length
*Crotch Height	Waist Height
Crotch Length	Waist-Floor Over Buttock
Elbow Circumference	Waist-Waist Over Shoulder
Forearm Circumference	Wrist Circumference, Proximal

Dimensions marked by asterisks are, or may be used as, key dimensions to control the sizing of an upper-, lower-, or single-body garment.

Though most clothing manikins currently purchased incorporate only a few dimensions, they can be custom made to include "...every measurement and contour" the customer desires.⁴⁴ About one-half of the dimensions appearing in this list were identified by pattern designers as being useful to their work if they were incorporated into manikins (Appendix). The others have proved to be useful for developing manikins for the design and sizing of full-body close-fitting personal-protective equipment,⁴⁵ i.e., high altitude and space suits, and thermal protective suits for divers. With a broad data base and the use of available computer techniques, clothing manikins can be made which incorporate the dimensions their customers deem useful, or pattern designers can generate their own models for their specific needs.

Load-Carrying Systems

Axilla Height	Interscye
Axilla-Waist Length	Neck-Bustpoint Length
Back Arc (Chest)	Posterior Chest Breadth
Back Arc (Waist)	Scye Depth
Biacromial Breadth	Shoulder Length
Bust Depth	Shoulder-Waist Length
Bustpoint Height	Stature
Bustpoint-Bustpoint Breadth	Strap Length
Cervicale Height	Vertical Trunk Circumference
Chest Breadth	Waist Back Length
*Chest/Bust Circumference	Waist Breadth
Chest Circumference at Scye	*Waist Circumference, Omphalion
Chest Circumference Below Bust	Waist Depth
Chest Depth	Waist Front Length
Chest Height	Waist Height
	Waist-Waist Over Shoulder

Those dimensions rated as essential in Table 1 are indicated by asterisks. They also appear in the Key Dimension/Microcosm Selection list.

Head and Face Equipment

Biauricular Breadth	*Head Circumference
*Bizygomatic Breadth	Head Height
Ear Breadth	*Head Length
Ear Length	Interpupillary Breadth
*Head Breadth	*Menton-Sellion Length
	*Pupil-Top of Head

The core series of head and face dimensions listed above is customarily measured in all military surveys. Those marked with an asterisk are considered essential; the others are widely used for a variety of design purposes.

A much more comprehensive list of dimensions is needed, however, to provide adequate data for design of head and face equipment. Traditional 'flat' anthropometric data are not particularly suitable for the design of close-fitting items such as respirators. To assist designers in such applications, anthropologists have developed methods for translating univariate body descriptors into three-dimensional sizing guides.⁴⁶ These methods are dependent upon the ability of anthropologists to tie the various descriptors of size into a system with a common reference point and to supervise the translation of the sizing data into three-dimensional forms by an expert sculptor.⁴⁷

One class of dimensions, created to permit the development of three-dimensional face forms for sizing of facial gear, is referred to as the headboard series. This group of dimensions represents distances measured between planes tangential to the top and back of the head, and specific head and facial landmarks. These headboard dimensions include:

... to top of head

Chin Prominence
Ectocanthus
Glabella
Gonion
Maximum Frontal
Menton
Minimum Frontal
Pronasale
Sellion
Stomion
Subnasale
Zygion
Zygoma

... to wall

Chin Prominence
Ectocanthus
Glabella
Gonion
Lip Protrusion
Maximum Frontal
Menton
Minimum Frontal
Pronasale
Pupil
Sellion
Stomion
Subnasale
Tragion
Zygion
Zygoma

Most of these dimensions are of limited value as isolated dimensions but are required as a group in the preparation of head and face models.

Given such points in three-dimensional space and the assumption of bilateral symmetry, a series of head and facial lengths, breadths, and arcs are incorporated into the face forms. These lengths and breadths may include the following:

Bigonial Breadth
Biocular Breadth
Bitragion Breadth
Ear Length Above Tragion
Ear Protrusion
Interocular Breadth

Interpupillary Breadth
Lip Length
Lip Length, Smiling
Lip to Lip Height
Maximum Frontal Breadth
Menton-Crinion Length

Menton-Subnasale Length
Minimum Frontal Breadth
Nasal Breadth
Nasal Root Breadth

Nose Protrusion
Philtrum Length
Subnasale-Sellion Length
Tragion to Pupil Length

The arcs may include:

Bigonion-Chin Prominence Arc
Bigonion-Sublabial Arc
Bitragion-Coronal Arc
Bitragion-Crinion Arc
Bitragion-Menton Arc

Bitragion-Minimum Frontal Arc
Bitragion-Submandibular Arc
Bitragion-Subnasale Arc
Minimum Frontal Arc
Sagittal Arc

The increasingly critical need for better, more closely-fitting personal protective equipment (particularly head and face gear to protect personnel from chemical and biological agents) has spurred the search for more precise means of acquiring and using three-dimensional data. While no new method is presently available that is clearly superior to using a headboard for locating selected landmarks in three-dimensional space, Anthropology Research Project (ARP) is currently investigating efficient methods for obtaining such data, as well as methods for summarizing them for design purposes (U.S. Air Force Contract No. F33615-85-C-0531).

In the meantime, inclusion of the complete list of 65 head and face dimensions required for the design of respirators and face forms in a general Army survey is not recommended because: (1) it is difficult to obtain extensive three-dimensional data with traditional measuring techniques; (2) the very precise control of subject position needed to insure accurate measurement of 65 head and face dimensions would take more time than is available in a general survey; and (3) the sample size ordinarily acquired in a general survey may be larger than that needed for a valid head/face data base. Instead, it is recommended that only a limited series of head/face dimensions be included in the Army's general survey, and that a special purpose head/face survey be conducted separately, perhaps when a three-dimensional measuring device has been validated for survey use.

Gloves

*Hand Breadth
*Hand Circumference

*Hand Length
Palm Length

The dimensions rated as essential are marked by asterisks. A large number of additional dimensions have been measured for glove sizing and design, but these are normally obtained in single-purpose, small-sample surveys,^{48,49,50,51} since the type of glove sometimes guides the choice of dimensions and the measurement techniques used. The dimensions measured most often include the heights from a base line (constructed at a level similar to the distal wrist crease) to the finger crotches and tips of the digits, digit lengths, breadths,

and circumferences at the interphalangeal joints, and some wrist and arm girths. Since these may include 30 to 40 dimensions on the hand alone, a comprehensive list of dimensions needed to provide anthropometric design criteria for gloves would be better measured during a single-purpose smaller-sample survey.

Shoe Lasts/Foot Gear

Ankle Circumference	Calf Height
Ankle Height	*Foot Breadth
Ball of Foot Circumference	*Foot Length
*Ball of Foot Length	Lateral Malleolus Height

The dimensions rated as essential are marked by asterisks. A large number of additional dimensions have been measured for shoe last sizing and design but these have normally been obtained in single-purpose surveys. The well known Fort Knox foot survey conducted by Freedman and others in 1946⁵² included some 26 measured foot and lower leg variables which apparently have provided the data base for the current Mil 5 Army lasts. A special foot study recently directed by Bense⁵³ on U.S. Army men and women included some 25 measured foot and lower leg dimensions plus stature and weight. While the variables in the list above are normally included as a part of such special purpose foot studies, there are usually twenty or more additional dimensions required for quantification of foot size and shape. Thus a comprehensive list of dimensions needed to provide anthropometric design criteria for lasts and foot gear would be better measured during a single-purpose smaller-sample survey.

Workspace and Body Clearance

*Abdominal Extension Depth, Sitting	*Forearm-Forearm Breadth
Abdominal Extension Height, Sitting	*Forearm-Hand Length
*Acromial Height, Sitting	*Forearm-Wrist Length
*Bideloid Breadth	*Functional Leg Length
*Bust Depth	Grip Axis Height
Buttock Depth	Grip Diameter (Inside)
*Buttock-Knee Length	Grip Diameter (Outside)
*Buttock-Popliteal Length	*Hand Breadth
*Chest Depth	Hand Breadth Across Thumb
Chest Height, Sitting	*Hand Length
Elbow Functional Reach	Hand Thickness
*Elbow Rest Height	*Hip Breadth, Sitting
Elbow Rest Height, Standing	*Knee Height, Sitting
*Elbow-Center of Grip Length	Knee-Knee Breadth, Open
Elbow-Elbow Span	*Midshoulder Height, Sitting
*Eye Height	*Popliteal Height
*Eye Height, Sitting	Radiale Height
Fist Circumference	*Shoulder-Elbow Length

*Sitting Height	Waist Height
Span	*Weight
*Stature	Wrist Height
*Thigh Clearance	*Wrist Height, Sitting
*Thigh-Thigh Breadth, Sitting	*Wrist-Center of Grip Length
Thumb Length	*Wrist-Index Finger Length
*Vertical Wrist Height	*Wrist-Thumb Tip Length
*Vertical Wrist Height, Sitting	*Wrist-Wall Length
*Vertical Wrist Height, Extended	*Wrist-Wall Length, Extended
*Vertical Wrist Height, Extended, Sitting	*Wrist-Wrist Span

Dimensions rated as essential are marked by asterisks. Hand Length and the "Wrist-" dimensions are included in this list, and the Aircraft Accommodation list following, for use in deriving various reach dimensions.

Aircraft Accommodation

Bideltoid Breadth	Span
Buttock-Knee Length	Vertical Wrist Height, Sitting
Forearm-Forearm Breadth	Weight
Forearm Wrist Length	Wrist Height, Sitting
Functional Leg Length	Wrist-Center of Grip Length
Hand Length	Wrist-Thumb Tip Length
Sitting Height	Wrist-Wall Length
	Wrist-Wrist Span

All dimensions in this group are rated essential. Understanding the relationships between these and other dimensions related to cockpit geometry can help avoid future problems of cockpit accommodation or what is more commonly termed "cockpit disaccommodation."

Body Links

*Acromial Height	*Interpupillary Breadth
*Acromial Height, Sitting	*Lateral Femoral Epicondyle Height
*Acromion-Radiale Length	*Lateral Malleolus Height
*Biacromial Breadth	Palm Length
*Bispinous Breadth	*Posterior Superior Iliac Spine Height
*Cervicale Height	*Radiale-Stylian Length
*Cervicale Height, Sitting	*Sitting Height
*Eye Height, Sitting	*Stature
*Foot Length	*Trochanteric Height
*Hand Length	

Dimensions rated as essential are marked by asterisks. A number of these dimensions have been considered in the past as actual link lengths. Now,

however, modelers require more precise measures of the distance between adjacent joint centers than were previously available in an anthropometric data base. The upper arm link length, for example, was often measured as Acromion-Radiale Length. This was based on the use of the traditional anthropometric landmarks of acromion and radiale. In reality, this length exceeds the actual link length, which would more appropriately be the distance between the superior edge of the intertubercular groove (approximates the center of the ball of the humerus) and the lateral humeral epicondyle. In many instances, the more precise landmarks are difficult to palpate and locate and therefore become too labor-intensive for the anthropometrist and too time-consuming for the subject to be considered for a general survey.

Algorithms needed for predicting actual link lengths can be developed from dimensions listed above, plus a supplementary list of specialized dimensions which can be measured on relatively small samples ($n < 100$) in a laboratory-like environment where precision of landmark location and measurement procedures can receive the necessary attention. Dimensions suitable for measurement in a small-scale survey devoted specifically to developing prediction equations for link lengths from general survey dimensions appear below:

*Acromion-Lateral Humeral Epicondyle Length	*Lateral Humeral Epicondyle-Styloid Length
*Ball of Humerus-Lateral Humeral Epicondyle Length	*Medial Femoral Epicondyle Height
*Buttock-Trochanterion, Sitting (Horizontal)	*Sphyrion (Fibulare) Height
Cervicale-Tragion Height	Suprasternale Height
*Elbow-Center of Grip Length	Tragion-Pupil Length
Heel Lateral Malleolus (Horizontal) Length	*Trochanteric Height, Sitting
	*Trochanterion-Lateral Femoral Epicondyle Length, Sitting

Anthropomorphic Analogues

Abdominal Extension Depth	*Bustpoint Height
*Abdominal Extension Depth, Sitting	Bustpoint/Thelion-Wall Depth
Abdominal Extension Height, Sitting	Buttock Circumference
Abdominal Extension-Wall Depth	*Buttock Depth
*Acromial Height	Buttock Height
*Acromial Height, Sitting	*Buttock-Knee Length
Acromion-Wall Depth	*Buttock-Popliteal Length
*Ankle Circumference	Calf Circumference
Ankle Height	Calf Height
*Axillary Arm Circumference	*Cervicale Height
Ball of Foot Circumference	*Cervicale Height, Sitting
*Biacromial Breadth	*Chest Breadth
Biceps Circumference	*Chest/Bust Circumference
*Bideltoid Breadth	Chest Circumference Below Bust
Bizygomatic Breadth	*Chest Depth
*Bust Depth	Chest Depth, Sitting
	*Chest Height
	Chest Height, Sitting

Crotch Height
 *Elbow Circumference
 Elbow Functional Reach
 *Elbow Rest Height
 Elbow Rest Height, Standing
 *Elbow-Center of Grip Length
 *Eye Height
 *Eye Height, Sitting
 Fist Circumference
 *Foot Breadth
 *Foot Length
 Forearm Circumference
 *Forearm-Forearm Breadth
 *Forearm-Hand Length
 *Forearm-Wrist Length
 Functional Leg Length
 Gluteal Furrow Height
 Grip Diameter (Outside)
 *Hand Breadth
 *Hand Length
 Hand Thickness
 Head Breadth
 *Head Circumference
 Head Length
 *Hip Breadth
 *Hip Breadth, Sitting
 Iliocristale Height
 Iliospinale-Wall Depth
 *Interpupillary Breadth
 *Knee Circumference
 Knee Circumference, Sitting
 *Knee Height (Midpatella)
 *Knee Height, Sitting
 Lateral Malleolus Height
 Lower Thigh Circumference
 *Menton-Sellion Length
 *Menton-Top of Head
 *Midshoulder Height, Sitting
 *Neck Circumference

Nuchale Height
 Omphalion-Wall Depth
 Palm Length
 *Popliteal Height
 Radiale Height
 *Shoulder Circumference
 *Shoulder-Elbow Length
 *Sitting Height
 Span
 *Stature
 Tenth Rib Height
 *Thigh Circumference
 *Thigh Clearance
 Thigh Depth
 *Thigh-Thigh Breadth, Sitting
 Tragion Height
 Tragion Height, Sitting
 Tragion-Pupil Length
 Tragion-Top of Head
 Tragion-Wall
 Trochanterion-Wall Depth
 Trunk Height, Sitting
 *Vertical Wrist Height
 *Vertical Wrist Height, Sitting
 *Vertical Wrist Height, Extended,
 Sitting
 *Waist Breadth
 *Waist Circumference (Omphalion)
 *Waist Depth
 Waist Height
 *Weight
 *Wrist Circumference, Proximal
 Wrist Height
 *Wrist Height, Sitting
 *Wrist-Center of Grip Length
 *Wrist-Index Finger Length
 *Wrist-Thumb Tip Length
 *Wrist-Wall Length
 *Wrist-Wall Length, Extended
 *Wrist-Wrist Span

Dimensions rated as essential are marked by asterisks.

Non-Candidate Dimensions

Slightly more than half of the 362 dimensions reviewed are suggested for consideration in a large-scale, multipurpose survey. Reasons for regarding the others as unlikely candidates follow.

It is apparent from Table 1 that no dimension measured over foundation garments (OFG) is a likely candidate. An inconsequential number of today's Army women wear the various kinds of girdles worn by 83 percent of USAF enlisted women and 72 percent of USAF female officers in 1968.

There appear to be no practical applications for skinfold thickness data and other measures of body composition obtained from previous U.S. military surveys. The USAF 1968 survey was the only one in which body density was measured.⁵ Thus it is the only one from which estimates of body density from skinfold thickness can be compared to measured body density and new equations derived. Neither has been done. Furthermore, measures of skinfold thickness obtained during multipurpose anthropometric surveys of military personnel do not meet the rigid control criteria required for studies of body composition or for estimating the variability of body fat of the subject population(s). Test/retest correlations of skinfold thickness dimensions measured during the USAF 1965 survey ranged from 0.388 for Dorsal Hand to 0.959 for Triceps. During the USAF 1967 survey,² the dimensions required to calculate Parnell's anthropometric phenotypes⁵⁴ were measured. Phenotypes were calculated,⁵⁵ but no known use of them has been made.

A number of reach dimensions rated as essential in Table 1 (e.g., Thumb Tip Reach, Extended; Forearm Hand Length; Vertical Grip Reach) need not be measured directly, because they can be derived from dimensions measured to the wrist (e.g., Wrist-Wall Length). Adding the appropriate hand-related dimensions (Wrist-Thumb Tip Length, Wrist-Center of Grip Length, Wrist-Index Finger Length, and Hand Length) will satisfy the requirements for arm reaches with pinching, gripping, and fingertip end points.

In three major USAF surveys (1950, 1965, and 1967)^{31,32,2}, and in a NATO-sponsored survey of Turkey, Greece, and Italy,²⁶ Air Force investigators took somatotype photographs of their subjects. Only those somatotypes of subjects from the USAF 1950 and NATO surveys were assessed.^{56,26} The somatotype photographs from the 1965 and 1967 surveys were, however, a useful adjunct to a data-editing routine for confirming or rejecting a computer-suggested alternate value to a suspect value. They have also been a useful source for measuring new dimensions to meet unanticipated or special requirements. However, owing to the sensitivity of photographing nude or minimally clothed subjects, little consideration should be given to photographing subjects in the Army survey.

As already noted, many head and face dimensions deemed useful in the design of personal protective equipment are not regarded as candidate dimensions for a large Army survey since they are more appropriately measured in a smaller-sample, single-purpose survey. There are, in addition, several head and face dimensions, designated as marginal on Table 1, which are not suggested for inclusion, even in a specialized head and face survey, since no demonstrated uses have been found for these dimensions.

Similarly, many of the hand and foot dimensions deemed useful in the design of protective handwear and footwear are most appropriately measured in a smaller-sample, single-purpose, anthropometric survey. Thus only those hand

and foot dimensions used as key dimensions or critical to microform selection have been suggested for further consideration.

In addition to the classes of dimensions discussed above, the following individual dimensions from Table 1 were excluded for the reasons stated:

(1) Dimensions considered unlikely candidates because they were not identified as being useful by any of the users surveyed:

***Abdominal Extension Breadth, Sitting (1977)**

Acromion-Biceps Circumference Level Length

Anterior Neck Length

Arm Length (Shoulder to Scye)

Cervicale-Anterior Waist Length

Chest Depth at Scye

Deltoid Arc

Ectocanthus to Otobasion Superious Length

Gluteal Arc

Halfway-to-Hip Circumference

Highest Bust Level Breadth

Hip Circumference at Trochanterion

Knee-Knee Breadth

Larynx-Wall Depth

Maximum Thigh Circumference

Midthigh Circumference

Nasal Root Height

Sitting Spread Circumference

Sitting Spread Height

Thigh Circumference, Sitting

Waist Circumference, Sitting

Wrist Breadth (Bone)

(2) Dimensions considered unlikely candidates because they are made redundant by one or more of the recommended dimensions:

Abdominal Extension Arc made redundant by Anterior Waist Arc

Ball of Humerus Height, Sitting made redundant by Ball of

Humerus-Lateral Humeral Epicondyle Length

Chest Depth (Sitting) made redundant by Chest Depth (Standing)

*Elbow-Elbow Breadth (1970) made redundant by Forearm-Forearm Breadth

Fibular Height made redundant by Tibiale Height

Hip Height at Trochanter made redundant by Buttock Height

Interscye Front made redundant by Anterior Chest/Bust Arc

Knee Circumference at Tibiale made redundant by Knee

Circumference (Midpatella)

Knee Height (Infrapatella) made redundant by Knee Height (Midpatella)

*Knee Height (Suprapatella) (1966, 1970, 1977) made redundant by Knee Height (Midpatella)

*Included in the current Army data base. The year in parenthesis indicates the survey(s) in which the dimension was measured.

Knee Pivot Height made redundant by Lateral Femoral Epicondyle Height
 Leg Inseam made redundant by Crotch Height
 *Metacarpale III (1977) made redundant by Grip Axis Height
 Nasion-Top of Head made redundant by Sellion-Top of Head
 *Sphyrion Height (1977) made redundant by Sphyrion (Fibulare) Height
 Stomach Breadth made redundant by Waist Breadth
 *Tibiale Height (1977) made redundant by Knee Height and by Medial and
 Lateral Femoral Epicondyle Heights
 Total Posterior Arm Length made redundant by Sleeve Length (Spine-Wrist
 Length)
 Upper Arm Circumference made redundant by Biceps Circumference
 Upper Posterior Arm Length made superfluous by Sleeve Length Segments
 Waist Circumference (Natural Indentation) made redundant by Waist
 Circumference (Preferred), and Waist Circumference (Omphalion)
 *Waist Circumference (Preferred) (1977) made redundant for men by Waist
 Circumference (Omphalion)
 Waist Depth, Sitting made redundant by Abdominal Extension Depth, Sitting

(3) Dimensions suggested for elimination since they can be derived:

*Back Arc (Chest) (1977) derived by subtracting Anterior Chest/Bust Arc from
 Chest/Bust Circumference
 *Back Arc (Waist) (1977) derived by subtracting Anterior Waist Arc from
 Waist Circumference
 Chest Height, Sitting derived by subtracting the computed variable Stature
 minus Chest Height from the measured Sitting Height
 Eye Height derived by subtracting the computed variable Sitting Height
 minus Eye Height, Sitting from Stature
 Grip Axis Height derived by subtracting Wrist-Center of Grip Length from
 Wrist Height
 Posterior Crotch Length derived by subtracting Anterior Crotch Length from
 Crotch Length
 Slope (Shoulder) derived by subtracting Acromial Height from Lateral Neck
 Height
 Span derived by adding two times Hand Length to Wrist-Wrist Span
 Tragon Height derived by subtracting the computed variable Sitting Height
 minus Tragon Height, Sitting from Stature
 Upper Extremity Length derived by subtracting Dactylion Height from
 Acromial Height

(4) Dimensions considered unlikely candidates because they are not believed to be relevant to U.S. Army missions:

Bitracion-Posterior Arc	Menton Projection
Calf Depth	Penale Height
Chest Circumference, Expired	*Sitting Height, Relaxed (1977)
Grip Strength	Waist-Stomach Height

*Included in the current Army data base. The year in parenthesis indicates the survey(s) in which the dimension was measured.

SUMMARY AND CONCLUSIONS

The human body can be dimensionally described by an infinite series of measurements. In an evaluation of candidate measurements to be considered for an effective U.S. Army anthropometric survey, some 362 body dimensions measured in previous surveys or suggested by members of the user community were examined. This analysis has led to the selection of 194 body dimensions that should be considered as candidates for inclusion in a new large-scale anthropometric survey of U.S. Army personnel. These dimensions are listed under one or more application areas delineating uses to which they might be put.

Of these 194 dimensions, 92 are considered as essential for one or more military purposes. An additional 102 dimensions are classified as useful. Ten of these 194 dimensions can be derived (see page 38) and probably need not be measured. The remaining list may still be too extensive to include in a single, general purpose anthropometric survey, given the restraints imposed by time and cost. In reducing the dimensions that are to be considered, the most important criterion for retention or deletion of an essential or useful dimension becomes the area of application. It is possible that certain of the application areas are far more relevant to the mission of the U.S. Army than are others. If a reduction of candidate dimensions for the U.S. Army is necessary, then the application areas that appear to have the least relevance for the long-range U.S. Army data base must be identified. From each application area so identified, the candidate dimensions that are classified as useful or even essential may prove to be superfluous and can be deleted without a serious loss to the effectiveness of the anthropometric data base. However, the dimensions that have been identified as essential in each application area should be deleted only with strong justification.

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APPENDIX

DIMENSIONS IDENTIFIED AS USEFUL BY PRINCIPAL USERS

HUMAN BODY MODELS

A listing of anthropometric dimensions similar to that in Table 1 was prepared and circulated to nine individuals currently engaged in the development of two- and three-dimensional human body models. These people were asked to review the list and indicate which of the dimensions are essential or useful in their modeling research. In addition, they were asked to add any body dimensions which were not on the list but which would be of value to them in their work. The responses were examined and ambiguities clarified. When measurement data not now available were indicated, the individual was queried to determine how the dimension would be used in modeling and what, specifically, was required in terms of the measurement. Alternative dimensions currently in the data base were suggested and considered. If no measurement currently in the data base would suffice, the suggested dimension was included in the list to be evaluated. Dimensions used or desired by modelers are listed in Table A-1.

A number of models, currently in relatively widespread use, were also examined to determine what anthropometric dimensions were incorporated in each. These models included COMBIMAN,⁵⁷ CREW CHIEF,⁵⁸ CAR,⁵⁹ CAPE,⁶⁰ the HANAVAN model,⁶¹ and ATBM.⁶² The results of the assessment of the dimensions used for the above models are also listed in Table A-1.

TABLE A-1. Dimensions Identified as Useful to Modelers
of Drawing Board Manikins and Human Body
Analogues (* = Essential, U = Useful).

VARIABLE	USAF			CREW†				
	WORK- SPACE	LINKS	COMBIMAN	CHIEF	CAR	CAPE	HANAVAN	ATBM
ACROMIAL HEIGHT	U		U	*			*	*
ACROMIAL HEIGHT, SITTING	*	*	U	*		*		
ACROMION-BICEPS CIRCUMFERENCE LEVEL LENGTH				*				
ACROMION-RADIALE LENGTH		*	*	*			*	
ANKLE CIRCUMFERENCE				*			*	*
ANKLE HEIGHT				*				*
ANTERIOR NECK LENGTH				*				
AXILLA HEIGHT								*
AXILLARY ARM CIRCUMFERENCE							*	
BALL OF FOOT CIRCUMFERENCE				*				
BALL OF HUMERUS-LATERAL HUMERAL EPICONDYLE LENGTH		U						
BIACROMIAL BREADTH		*	U	*		*		
BICEPS CIRCUMFERENCE				*				*
BIDELTOID BREADTH	*		*	*	*	*		*
BIOCULAR BREADTH				*				
BISPINOUS BREADTH				*				
BITRAGION BREADTH				*				
BIZYGOMATIC BREADTH				*				
BUTTOCK CIRCUMFERENCE				*				
BUTTOCK DEPTH	U			*			*	*
BUTTOCK HEIGHT	U							
BUTTOCK-KNEE LENGTH	*	U	*	*	*	*		
BUTTOCK-POPLITEAL LENGTH	*	U				*		
BUTTOCK-TROCHANTERION SITTING, (HORIZONTAL)		*						
CALF CIRCUMFERENCE				*				*
CALF DEPTH				*				
CALF HEIGHT				*				
CERVICALE HEIGHT	U	*		*				
CERVICALE HEIGHT, SITTING	*							
CERVICALE-TRAGION HEIGHT		*						
CHEST BREADTH				*			*	*
CHEST/BUST CIRCUMFERENCE				*				
CHEST DEPTH	*		*	*			*	*
CHEST HEIGHT	U							
CHEST HEIGHT, SITTING	U							

†The CREW CHIEF model is now under development and a large number of body dimensions are currently being evaluated for functions such as link development, enfleshment, centers of rotation, etc.

TABLE A-1. (cont'd)

VARIABLE	USAF			CREW†		CAR	CAPE	HANAVAN	ATBM
	WORK- SPACE	LINKS	COMBIMAN	CHIEF					
CROTCH HEIGHT				*					
ELBOW CIRCUMFERENCE				*				*	*
ELBOW REST HEIGHT	*						*		
ELBOW-CENTER OF GRIP LENGTH	*	U	U	*					
EYE HEIGHT	U			*					
EYE HEIGHT, SITTING	*		*	*	*	*			
FIST CIRCUMFERENCE				*				*	
FOOT BREADTH				U					*
FOOT LENGTH		*	U	*	*			*	*
FOREARM CIRCUMFERENCE				*					*
FOREARM-FOREARM BREADTH	U								
FOREARM-HAND LENGTH	*	U		*	*	*			*
FOREARM-WRIST LENGTH	*	U	U	*					
FUNCTIONAL GRIP REACH							*		
GLUTEAL FURROW HEIGHT									*
HAND BREADTH ACROSS THUMB				*					
HAND BREADTH				*					
HAND CIRCUMFERENCE				*					
HAND LENGTH		*	*	*	*				
HAND THICKNESS				*					
HEAD BREADTH				*					*
HEAD CIRCUMFERENCE				*				*	
HEAD LENGTH				*					*
HEEL-LATERAL MALLEOLUS (HORIZONTAL) LENGTH		*							
HIP BREADTH	U		U	*				*	*
HIP BREADTH, SITTING	*		*	*	*	*			
ILIOCRISTALE HEIGHT				*					
INTERPUPILLARY BREADTH		*		*					
KNEE CIRCUMFERENCE				*				*	*
KNEE HEIGHT (INFRAPATELLA)		*							
KNEE HEIGHT (MIDPATELLA)	*								
KNEE HEIGHT, SITTING	*	U	*	*		*			*
LATERAL MALLEOLUS HEIGHT		*		*					
MENTON-SELLION LENGTH				*					
MENTON-TOP OF HEAD									*
MIDSHOULDER HEIGHT, SITTING	*								
MIDTHIGH CIRCUMFERENCE				*					
NECK CIRCUMFERENCE									*
PALM LENGTH		*							
POPLITEAL HEIGHT	*	U			*	*			

TABLE A-1. (cont'd)

VARIABLE	USAF			CREW†				
	WORK- SPACE	LINKS	COMBIMAN	CHIEF	CAR	CAPE	HANAVAN	ATBM
POSTERIOR SUPERIOR ILIAC				*				
SPINE HEIGHT								
RADIALE-STYLION LENGTH		*	*	*			*	
SCYE CIRCUMFERENCE				*				
SHOULDER CIRCUMFERENCE				*				
SHOULDER-ELBOW LENGTH	*	U	U	*	*	*		*
SITTING HEIGHT	*		*	*	*	*	*	*
SKINFOLD THICKNESS:								
BICEPS				*				
SKINFOLD THICKNESS:								
MEDIAL CALF				*				
SPAN	U			*				
SPHYRION HEIGHT							*	
STATURE	*			*	*		*	*
SUBSTERNAL HEIGHT				*			*	
THIGH CIRCUMFERENCE				*			*	*
THIGH CLEARANCE	*							
THUMB TIP REACH	*	U	*	*		*		
THUMB TIP REACH, EXTENDED	*							
TIBIALE HEIGHT		*					*	
TRAGION HEIGHT, SITTING		*						
TRAGION-PUPIL LENGTH		*						
TROCHANTERIC HEIGHT				*			*	
TROCHANTERIC HEIGHT, SITTING		*						
TROCHANTERION-LATERAL FEMORAL EPICONDYLE LENGTH, SITTING		*						
VERTICAL GRIP REACH				*				
WAIST BREADTH				*				*
WAIST CIRCUMFERENCE (OMPHALION)				*				
WAIST DEPTH				*				*
WAIST DEPTH, SITTING	*						*	
WAIST HEIGHT	U			*	*			*
WAIST HEIGHT, SITTING	*							
WEIGHT			*	*			*	*
WRIST CIRCUMFERENCE, PROXIMAL				*			*	*

ARMY CLOTHING

A primary purpose of a new anthropometric survey of Army men and women is to collect the body-size data required for the design, sizing, procurement and issuing of Army clothing. Since Army clothing designers and patternmakers will be among the principal users of the new data, their input to the selection of the dimensions suggested for the survey was given due attention. A questionnaire survey, asking clothing designers what dimensions they use, or would use if the dimensions were available in an anthropometric data base, was administered to 22 Army and Air Force clothiers. In addition, meetings were held with Army and Air Force designers and patternmakers to receive their direct input. The results of this survey and these meetings are listed in Table A-2.

TABLE A-2. Dimensions Identified as Being Useful to Army and Air Force Clothing Designers and Patternmakers.

<div>N=NATICK W=WRIGHT-PATTERSON AFB X=NATICK & WRIGHT-PATTERSON AFB</div>											
ACROMION-RADIALE LENGTH											
ANKLE CIRCUMFERENCE		X	N			N		N			
AXILLA-WAIST LENGTH			W							W	
BACK ARC (WAIST)											
BIACROMIAL BREADTH	W					W			W	W	
BICEPS CIRCUMFERENCE, FLEXED	W		X				X				
BICRISTAL BREADTH		N				N	N	N	N		N
BIDELTOID BREADTH			X						N	W	
BUST DEPTH									W		
BUSTPOINT HEIGHT										N	
BUSTPOINT-BUSTPOINT BREADTH			X							W	
BUTTOCK CIRCUMFERENCE	N	X		X		X	N	N	X		X
BUTTOCK CIRCUMFERENCE, SITTING		N		N	N	N		N			
BUTTOCK DEPTH									N		
CERVICALE HEIGHT						N					
CHEST BREADTH	N					N	N		W	W	
CHEST/BUST CIRCUMFERENCE			X							X	
CHEST CIRCUMFERENCE AT SCYE			N							N	
CHEST CIRCUMFERENCE BELOW BUST			X							N	
CHEST DEPTH								W			
CROTCH HEIGHT		X		X		X		X			X
CROTCH LENGTH				X							X
FOREARM-WRIST LENGTH			W								
HIP BREADTH										X	N
HIP BREADTH, SITTING		N				N		N			
HIP CIRC. 7" BELOW WAIST			N	W	W						W
HIP CIRC. 9" BELOW WAIST			N	W	W						W
INTERSCYE	X		N			W	X		X	X	
INTERSCYE, MAXIMUM			N			N	N		N	N	
KNEE CIRCUMFERENCE		X		X		N		X			W

TABLE A-2. (Cont'd)

<p>N=NATICK W=WRIGHT-PATTERSON AFB X=NATICK & WRIGHT-PATTERSON AFB</p>										
KNEE HEIGHT (SUPRAPATELLA)										
LEG INSEAM		N								
LEG OUTSEAM		X								
LOWER THIGH CIRCUMFERENCE		X								
MENTON-TOP OF HEAD*		X								
NECK CIRCUMFERENCE	X					N	X			
NECK CIRCUMFERENCE, BASE				X					X	X
NECK-BUSTPOINT LENGTH				N					N	W
SCYE CIRCUMFERENCE				N		N			N	N
SHOULDER CIRCUMFERENCE	N		W				N		X	W
SHOULDER LENGTH	X		X			N	W		X	W
SHOULDER-ELBOW LENGTH									W	
SLEEVE INSEAM	X		X			X	N		N	N
SLEEVE LENGTH (SPINE-WRIST LENGTH)	N		N			X	X		N	
SLEEVE LTH SEGMENT (SPINE-SCYE LTH)						N				
SLEEVE OUTSEAM	W		W							
SLOPE (SHOULDER)										
STATURE	N	N	N	N	X	N	N	N		W
STRAP LENGTH			X							W
THIGH CIRCUMFERENCE		N		N		N		N		X
THIGH DEPTH		W		W						
TIBIALE HEIGHT					N					
TROCHANTERIC HEIGHT				N	N					
VERTICAL TRUNK CIRCUMFERENCE						X				
WAIST BACK LENGTH	X		X			X	X		X	X
WAIST BREADTH (OMPHALION)**		N						N		
WAIST BREADTH (PREFERRED)**									W	W
WAIST CIRCUMFERENCE (OMPHALION)**	N	N		W		N	N	N	X	X
WAIST CIRCUMFERENCE (PREFERRED)**	W	W	X	X	X	W	W	W	W	X
WAIST DEPTH									W	W

* Test of hypothesis of body proportions (N).

** Clothiers made the distinction between omphalion and "preferred" waist levels for this dimension.

INTERNATIONAL STANDARDS

In addition to querying clothiers, modelers, systems engineers, workspace designers, and other users, standards proposed by three international organizations were examined to determine whether any additional dimensions should be considered for the Army survey.

The Air Standardization Coordinating Committee (ASCC) is an organization made up of representatives of the air services of Australia, Canada, New Zealand, the United Kingdom, and the United States. Its purpose is to achieve standardization of aircraft related equipment and practices among the member nations. The committee is composed of a number of separate disciplines termed Working Parties. Aircrew Anthropometry, a subcommittee of Working Party 61, Aerospace Medicine and Life Support Systems, has proposed a list of dimensions and measurement descriptions designed to assist ASCC member countries in pursuing common practices in the conduct of anthropometric surveys to provide a reliable basis for comparing the anthropometric data of member countries.³⁶ Proposed dimensions appear on the list below with ASCC terminology in parentheses.

Acromial Height (Acromial Height, Standing)	Hand Breadth
Acromial Height, Sitting	Hand Circumference (Hand Circumference, Metacarpale)
Age	Hand Length
Axilla Height	Head Breadth
Biacromial Breadth	Head Circumference
Buttock Circumference	Head Length
Buttock-Knee Length	Hip Breadth, Sitting
Cervicale Height	Knee Height, Sitting
Chest/Bust Circumference (Chest Circumference)	Neck Circumference
Crotch Height	Popliteal Height
Elbow Rest Height (Elbow Rest Height, Sitting)	Sitting Height
Elbow-Elbow Breadth (Inter-Elbow Breadth, Sitting)	Stature
Eye Height, Sitting	Thigh Circumference
Foot Breadth	Thumb-Tip Reach
Foot Length	Vertical Trunk Circumference
Forearm-Wrist Length (Elbow-Wrist Length)	Waist Circumference (Omphalion)
	Waist Height
	Weight (Mass)
	Wrist Height (Wrist Height, Standing)

The International Organization for Standardization (ISO) is a worldwide federation of national standards institutes. The work of developing international standards is carried out through ISO technical committees. The list of dimensions which appears below (with ISO terminology in parentheses) was developed by Technical Committee ISO/TC133, Sizing systems and designations for clothes⁶³ and has been approved by the United States.

Buttock Circumference (Hip Circumference)	Foot Length
Chest/Bust Circumference (Bust Circumference)	Hand Circumference
Chest Circumference at Scye (Chest Circumference)	Hand Length
Chest Circumference Below Bust (Underbust Girth)	Head Circumference
Crotch Height (Inside Leg Length)	Leg Outseam (Outside Leg Length)
	Neck Circumference
	Stature
	Waist Circumference, Natural Indentation

The dimensions listed below (with ISO terminology in parentheses) are proposed in draft ISO/DIS7250, Basic list of anthropometric measurements, developed by Technical Committee ISO/TC 159 Ergonomics.³⁷

Acromial Height (Shoulder Height)	Hand Breadth (Hand Breadth at Metacarpal)
Acromial Height, Sitting (Shoulder Height, Sitting)	Hand Length
Biacromial Breadth	Head Breadth
Bitracion Coronal Arc (Bitracion Arc)	Head Circumference
Buttock-Knee Length	Head Length
Buttock-Popliteal Length [Body Depth, Sitting (Seat Depth)]	Hip Breadth
Cervicale Height, Sitting	Hip Breadth, Sitting
Crotch Height	*(Index Finger Breadth, Distal)
Elbow Rest Height (Elbow Height, Sitting)	*(Index Finger Breadth, Proximal)
Elbow Rest Height, Standing (Elbow Height)	Index Finger Length
Elbow-Elbow Breadth	Knee Height, Sitting (Knee Height)
Eye Height	Menton-Sellion Length (Face Length)
Eye Height, Sitting	Popliteal Height (Lower Leg Length)
Foot Breadth	Sagittal Arc
Foot Length	Sitting Height
Forearm-Hand Length	*(Spina Iliaca Height, Standing)
*[Forward Reach (Grip Axis)]	Stature
Grip Axis Height (Fist Height)	Tibiale Height
	Waist Circumference (Omphalion)
	Weight
	Wrist Circumference, Distal (Wrist Circumference)

The International Biological Programme (IBP) was established by the International Council of Scientific Unions in 1964 as a counterpart of the International Geophysical Year. After a decade of work, the program ended in June 1974. The subject of the IBP was defined as "The Biological Basis of Productivity and Human Welfare", an enterprise which brought together biologists from around the world to work in an integrated and concerted examination of a

* Since this dimension was not measured in any of the 34 surveys, or cited by specialists queried for this study, it does not appear on Table 1.

wide range of problems.⁶⁴ Anthropometry as the means of quantifying the variables of body size and shape is one of the basic techniques of human biology. Practically all biological functions are related in some way to one aspect or another of body dimensions. It is not the primary purpose of the type of engineering anthropometric surveys discussed in this effort to obtain data for serving as bases for biological studies. However, data from them have served, and will continue to serve, investigators of human biological phenomena. In light of this, the dimensions listed below (with IBP terminology in parentheses) are those recommended for measurement by the Human Adaptability Section of the International Biological Programme in studies of growth and physique, work capacity, pulmonary function, climatic tolerance, nutrition status and body composition, genetics, exposure to radiation, metabolism, and the like. The IBP recommends that all dimensions measured only on one side of the body be measured on the left side of the body.

Acromion-Radiale Length (Upper Arm Length)	Humeral Epicondyle Breadth (Bicondylar Humerus)
Age	Lip Length (Mouth Width)
Ankle Circumference	Lip-Lip Height (Lip Thickness)
Biacromial Breadth	*(Maximum Calf Circumference, Relaxed)
Biceps Circumference, Flexed (Upper Arm Circumference, Contracted)	Minimum Frontal Breadth
Bicristal Breadth (Biiliocrystal Breadth)	*[Morphological Face Height (Gnathion-Nasion Length)]
Bigonial Breadth	Nasal Breadth
Bimalleolar Breadth (Ankle Breadth)	Neck Circumference
Bizygomatic Breadth	Nose Length
Buttock-Knee Length	Radiale-Stylian Length (Forearm Length)
Chest Breadth (Transverse Chest)	Sitting Height
Chest Circumference, Expired	Skinfold: Abdominal
Chest Depth (Antero-Posterior Chest)	*(Skinfold: Anterior Thigh)
Ear Breadth	Skinfold: Biceps
Ear Length	*(Skinfold: Forearm)
Femoral Epicondyle Breadth (Bicondylar Femur)	Skinfold: Juxta-Nipple
Foot Length	Skinfold: Medial Calf
Forearm Circumference	Skinfold: Midaxillary Line at Xiphoid
Gluteal Furrow Height (Buttocks-Ground Height)	Skinfold: Subscapular
Hand Breadth	Skinfold: Suprailiac
Head Breadth	Skinfold: Triceps
Head Circumference	Stature
Head Height	Stomion-Top of Head (Upper Face Height)
Head Length	Suprasternal Height
*(Height of Anterior Superior Iliac Spine)	Thigh Circumference (Upper Thigh Circumference)
	Tibiale Height

* Since this dimension was not measured in any of the 34 surveys, or cited by specialists queried for this study, it does not appear on Table 1.

*(Tibiale Length)

Upper Arm Circumference (Relaxed)

Upper Extremity Length (Total
Arm Length)

Waist Circumference (Omphalion)

[Abdomen Circumference, (Umbilical
Level)]

Weight

Wrist Breadth

Wrist Circumference, Proximal

* Since this dimension was not measured in any of the 34 surveys, or cited by specialists queried for this study, it does not appear on Table 1.