REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1991	Magazine

4. TITLE AND SUBTITLE
Gateway: Volume II Number 4

5. FUNDING NUMBERS
SPO900-94-D-0001

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER

GWII4

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Defense Technical Information Cntr.
DTIC/AI
Cameron Station
Alexandria, VA 22304-6145

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.
Free to public by contacting the Human Systems IAC.

12b. DISTRIBUTION CODE
A

13. ABSTRACT ***(Maximum 200 Words)***

This issue contains articles on the following subjects: 1.Human-Centered Design: Creating Successful Products, Systems, and Organizations; 2.Ergonomic Design Issues for the Composite Armored Vehicle (CAV); 3.Aircrew Coordination Training (ACT) Program; 4.Mannequin: Human Computer-Aided Design on a PC; 5.CSERIAC's New Technology Transfer Program;

14. SUBJECT TERMS
Human Factors Human Computer-Aided Design Composite Armored Vehicle Vehicle Concept Programs Aircrew Coordination Training

15. NUMBER OF PAGES
20

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

VOLUME 2: NUMBER 4, FALL 1991

CSERIAC GATEWAY

PUBLISHED BY THE CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER

In this issue:

CSERIAC is a United States Department of Defense information analysis center hosted by the Armstrong Laboratory, Wright-Patterson Air Force Base, Ohio, and operated by the University of Dayton Research Institute.

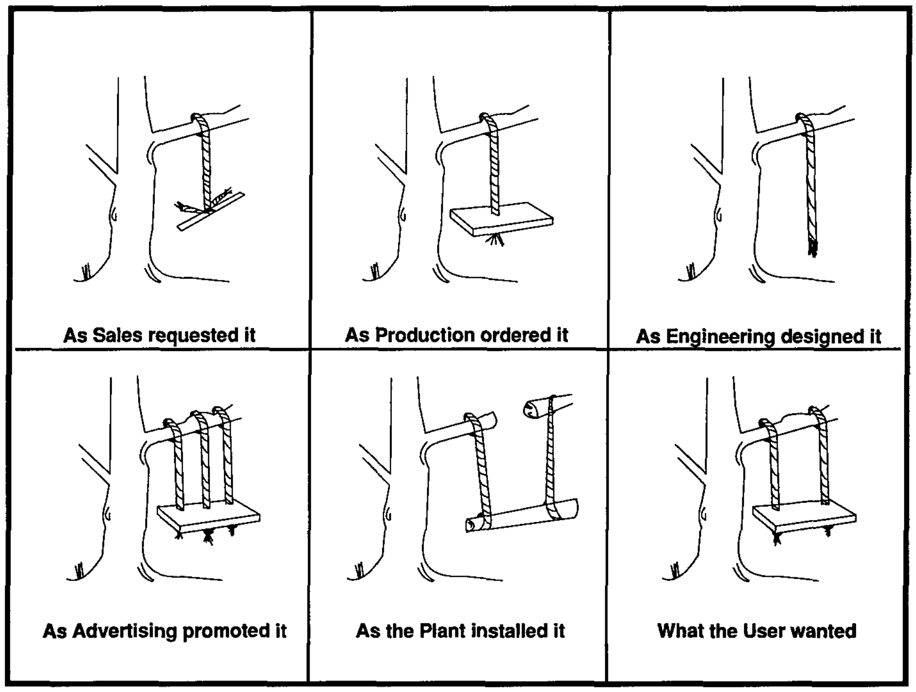

Figure 1. Problems in design

Human-Centered Design: Creating Successful Products, Systems, and Organizations

William B. Rouse

Everyone wants new products and systems to be user friendly, user centered, and ergonomically designed. Everyone endorses these goals. However, as illustrated in Figure 1, many products and systems fall far short of achieving them. Why?

One answer is that human factors concepts, principles, and methods are not sufficiently advanced to meet this need. However, this is only a partial explanation. The fact is that most currently available concepts, principles, and methods have relatively little impact on product and system design. Clearly, therefore, more unused results will not improve the situation.

Thus, the question shifts to the reasons why current concepts, principles, and methods do not impact design. The answer lies in understanding the human factors of design — in other words, understanding the abilities, limitations, and preferences of those who are expected to employ the products of human factors research and development (R&D).

The Nature Of Design

To understand the human factors of design, we must focus on the engineering functions within industrial and governmental enterprises responsible for developing products and systems. The necessary understanding cannot be

Continued on page 2

found within aircraft cockpits or maintenance depots. The people who should be studied are designers and managers, not pilots and maintainers. Several studies of the human factors of design have been performed (e.g., Rouse & Boff, 1987; Rouse, Cody, & Boff, 1991). These studies used interviews, questionnaires, and observational methods involving 240 individuals, roughly half of whom were from industry and half from government.

Designers spend their time in both group and individual activities. For journeymen and seasoned designers, the time allocation is typically 30 percent in group activities and 70 percent in individual activities. Junior designers spend more time in group activity for the purpose of learning. Very senior designers spend more time in group activity, serving as coaches and mentors.

The design group or team has several roles. The group is usually involved with decomposing the statement of work or other descriptions of objectives, requirements, and specifications. Based on this decomposition, the group will set technical goals, as well as allocations of person-hours and schedule, for members of the group. Pursuit of these technical goals is predominantly an individual activity. The group subsequently reviews the results of these individual efforts.

The organization, both of the company and the marketplace, strongly affects both group and individual activities. Company policies and procedures directly influence activities. Success criteria and reward mechanisms, both internal and external to the company, affect motives and values. Corporate and market cultures influence, for example, relative weightings on performance, cost, and quality.

Thus, design involves a complex social and organizational network within which designers and managers seek information, formulate problems, synthesize and integrate solutions, advocate positions, and negotiate compromises. Within this often chaotic world, little time is devoted to seeking human factors concepts, principles, and methods.

Human-Centered Design

What designers need are methods and tools that help them succeed in complex environments such as described above. Recognition of this need led to the development of a concept called human-centered design (Rouse, 1991). Succinctly, human-centered design is a process of ensuring that the concerns, values, and perceptions of all stakeholders in a design effort are considered and balanced.

Thus, human-centered design focuses on stakeholders, not just users. To illustrate, pilots as users of aircraft cockpits are important stakeholders. However, pilots do not build, buy, regulate, or maintain aircraft. There are many more stakeholders in aircraft than just pilots, and the concerns, values, and perceptions of all these stakeholders should be addressed.

We have found that the seven issues listed in Figure 2 are formed by combining the interests of all stakeholders. Human-centered design involves pursuing these issues starting at the top. Thus, the last concern is "Does it run?" while the first concern is "What matters?" or "What constitutes benefits and costs?"

If the issues in Figure 2 were each pursued independently, as if they were ends in themselves, the costs of design would be untenable. However, each issue is important and should not be neglected. What is needed, therefore, is an overall approach to design that balances the allocation of resources among the issues of concern at each stage of design. This can be accomplished by viewing design as a process involving the four phases shown in Figure 3.

The naturalist phase involves understanding the domains and tasks of users from the perspective of individuals, the organization, and the environment. The focus is on understanding the nature of viability, acceptability, and validity in the domain for which the product or system is targeted.

The marketing phase involves introducing product and system concepts to potential customers, users, and other stakeholders. Their reactions are needed relative to viability, acceptability, and validity. In other words, one wants to determine whether a product or system concept is perceived as solving an important problem, solving it in an acceptable way, and solving it at a reasonable cost.

The engineering phase concerns trading off conceptual functionality and technological reality. As indicated in Figure 3, technology development will

VIABILITY	→	Are the benefits of system use sufficiently greater than its costs?
ACCEPTANCE	→	Do organizations/individuals use the system?
VALIDATION	→	Does the system solve the problem?
EVALUATION	→	Does the system meet requirements?
DEMONSTRATION	→	How do observers react to the system?
VERIFICATION	→	Is the system put together as planned?
TESTING	→	Does the system run, compute, etc,?

Figure 2. Design issues

usually have been pursued prior to and in parallel with the naturalist and marketing phases. In the engineering phase, one becomes very specific about how desired functionality is to be provided, what performance is possible, and the time and dollars necessary to provide it. In this process, evaluation, demonstration, verification, and testing are pursued.

In the sales and service phase, one follows the product or system into service to gain closure on viability, acceptability, and validity. Implementation problems are solved during this phase. Further, relationships are maintained and new opportunities recognized. This typically expedites the next naturalist and marketing phases.

The human-centered design methodology tersely outlined in this section potentially enables creation of products and systems that are user friendly, user centered, ergonomically designed, and much more. For this potential to be fully realized, the human-centered concept must be expanded.

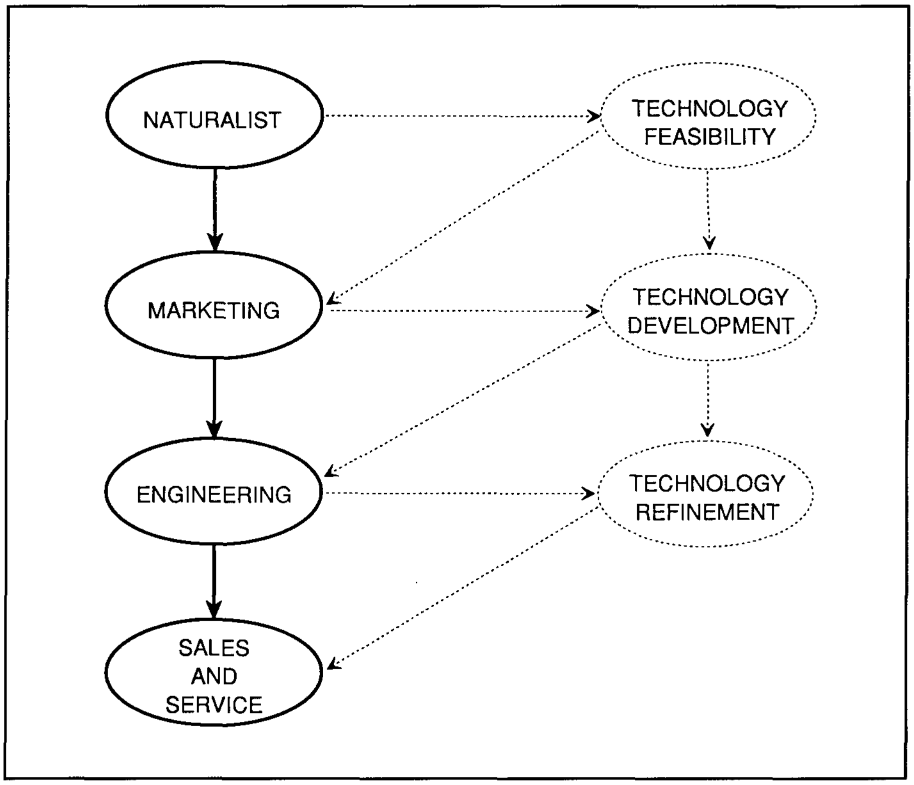

Figure 3. A framework for design

The Human-Centered Enterprise

The methodology discussed in the last section provides the technical basis for human-centered design. Also required, however, is an appropriate managerial basis. Traditionally, the three pillars of management are planning, organization, and control. Thus, the human factors of management must address human abilities, limitations, and preferences in these activities.

Studies of management of design in particular, and technology-based enterprises in general, led to the concept of human-centered planning, organization, and control (Rouse, 1992). More specifically, the concern was with how enterprises should be designed to best support development, marketing, and service of human-centered products and systems.

The resulting approach to management includes a variety of elements. For example, methods of planning, organization, and control are simplified and streamlined to emphasize usability and usefulness. As another illustration, explicit models of the enterprise's functioning are developed. Training is provided to ensure that these models are shared by all stakeholders within the enterprise.

The concept of a human-centered enterprise is important in that it enables, perhaps even empowers, designers to pursue human-centered design of products and systems. Consequently, it is not a matter of management simply allowing human-centered design; it is important for management to extol this approach.

Summary

Human factors professionals often view themselves as advocates of end users — for example, aircraft pilots. They research pilots' abilities, limitations, and preferences and develop end user-centered concepts, principles, and methods. Unfortunately, however, they typically ignore their own customers and their own users. They concern themselves little with the usefulness and usability of the products of human factors R&D. Consequently, human factors often fails to have an impact. However, by considering the human factors of design, as well as the human factors of management, it is quite possible to provide concepts, principles, and methods that will be embraced and, subsequently, provide the intended benefits to end users. ●

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William B. Rouse, Ph.D., is Chairman and Chief Scientist of Search Technology, Norcross, GA.

The COTR Speaks

Reuben L. Hann

CSERIAC is celebrating its third anniversary this month. It is hard to believe that three years have passed since the realization of Dr. Ken Boff's dream: to establish an analysis center which serves the information needs of human factors practitioners and users across the entire federal, academic, and industrial spectrum. As with any new enterprise, there has been the usual frustration with slower progress than expected in some areas. However, we are proud of CSERIAC's accomplishments in this short time. Hundreds of technical inquiries from every conceivable type of user have been processed, and feedback has been overwhelmingly favorable. It is clear that CSERIAC is providing a valuable service. In addition, almost twenty different technical products are available for purchase, and a whole range of in-house and distributed publications, as well as workshop and seminar services, are available. The greatest challenge continues to be getting the word out to the user community. If you know of anyone who should be on our mailing list, please let us know. Help us to spread the word.

The lead article in this issue is contributed by William Rouse, one of the leaders in the application of human factors to the design process. Dr. Rouse stresses the importance of considering *all* users of human factors, not just the end user. Through the application of his "Human-Centered Design" principles, he asserts, the resulting system will have maximum overall acceptance and will provide optimum benefit to the end user.

This month's "government" article presents an approach to dealing with the problem of aircrew error mishaps. Robert Alkov, of the Naval Safety Center, describes a special training program using crew coordination and situational awareness techniques to enhance cockpit communications.

This month's Chief Scientist's Report is a special article by CSERIAC Senior Analyst Mike Gravelle. He describes how CSERIAC is providing extensive information search, review, and analysis services for the U.S. Army Tank-Automotive Command (TACOM). A variety of questions need to be addressed in the development of the new Composite Armored Vehicle concept. As you will see, many of the questions deal with problems you may have encountered in your own situation.

Clifford Gross of the Biomechanics Corp. of America describes a new software package, *Mannequin*. It provides the capability to investigate humans in their environment, in 3-D, using a standard PC system. It has built-in anthropometric percentile data for multiple nationalities, operates under a window-like environment, and offers a variety of special capabilities for interacting with other software packages.

A primary objective of CSERIAC is to assist in transitioning technology developed in government and academic laboratories to the greater user community—to become a technology transfer "gateway." One of our newest staff members, Craig Dye, presents a detailed discussion of the CSERIAC Tech Transfer Program, covering background, present capability, benefits to contributors, and future plans. With Craig on board we expect to see the Tech Transfer Program accelerate. Please contact him if you think any of your own technical products would benefit others. CSERIAC will see that you get full credit for your work.

Speaking of CSERIAC Tech Transfer products, one of our more impressive offerings is the Biodynamics Data Bank (BDB), described in this issue by staff member Trudy Abrams. Based on research conducted over a 15-year period by the Armstrong Laboratory, it includes data from 4900 impact tests collected from 28 individual experiments. Trudy gives a detailed account of the BDB structure and the kinds of analyses offered, including a couple of examples.

CSERIAC has only been in existence three years, but has already built a reputation for being the first place to turn when quick, authoritative answers to ergonomics questions are needed. We have plans for many exciting new projects and services in the years ahead. They will be described in future *Gateway* issues. We hope you will avail yourself of our services, and please, tell your colleagues about the CSERIAC "Human Factors Technology Store."●

Reuben "Lew" Hann, Ph.D., is the Contracting Officer's Technical Representative (COTR) who serves as the Government Technical Monitor for the CSERIAC Program.

Request for Topics For State-of-the-Art-Reports (SOARS)

CSERIAC makes every effort to be sensitive to the needs of its users. Therefore, we are asking you to suggest possible topics for future SOARS that would be of value to the Human Factors/Ergonomics community. Previous SOARs have included *Hypertext: Prospects and Problems for Crew System Design* by Robert J. Glushko, and *Three Dimensional Displays: Perception, Implication, Applications* by Christopher D. Wickens, Steven Todd, & Karen Seidler. Your input would be greatly appreciated. We are also looking for sponsors of future SOARs. CSERIAC is a contractually convenient, cost effective means to produce rapid authoritative reports.

Send your suggestions and other replies to Dr. Lawrence Howell, Associate Director CSERIAC Program Office, AL/CFH/CSERIAC, Wright-Patterson AFB, OH 45433-6573.

Chief Scientist's Report Special:

Ergonomic Design Issues for the Composite Armored Vehicle (CAV)

Michael D. Gravelle

Not often is one given the opportunity to assist in the conceptual design and development of an advanced person-machine system. Traditionally, a great deal of human factors involvement has taken place in the later stages of the system development process, or after problems have been identified in existing systems. Recently, CSERIAC initiated work on a series of technical inquiries relating to the ergonomic design of the Composite Armored Vehicle (CAV). The CAV program is managed by the Advanced Systems Concepts Division of the U.S. Army Tank-Automotive Command (TACOM). Its Research, Development, and Engineering Center has created a series of Technology Base vehicle concept programs to develop, demonstrate, and exploit the technologies and design techniques in preparation for the next generation of armored vehicles to follow the Armored Systems Modernization (ASM) program. The CAV program is looking at advanced technologies that provide a more survivable, lethal, lighter, and deployable ground combat vehicle, such as composite structures, lightweight armors, advanced armaments, integrated 2-person crew station, advanced propulsion, active suspension, and advanced integrated survivability technology. See the figure for a conceptual perspective.

To facilitate TACOM's CAV concept design and development, CSERIAC is performing six Search and Summary tasks and seven Review and Analysis tasks. These efforts will help to formulate ergonomic design guidelines for the CAV concept design and parametric analysis. Following are the general questions TACOM has asked us to investigate. In a future Chief Scientist's Report we will inform you of our responses and recommendations.

What are the effects of crew encapsulation?

It is likely that crew members will be confined to the vehicle for extended missions. The effects of crew encapsulation fall under the general notion of habitability. Hunt (1987) defined habitability as the elements in an environment that influence crew comfort, performance, and productivity. Some of these critical elements include mission duration; crew characteristics (e.g., crew size, gender, training, educational background and skill levels); operational factors (e.g., work-rest cycles, workspace volume, personal hygiene, confinement); and various environmental factors (e.g., temperature, noise, vibration). We are investigating all these issues.

What are the effects of varying anthropometric sizes?

The CAV program is interested in a variety of anthropometric issues. One concern is the effect of different anthropometric sizes (e.g., 95th, 75th, 50th, 25th, and 5th percentile male) on various crew tasks, such as reaching all the controls, viewing all displays, using all vision devices effectively, and entering and exiting the vehicle. They are also interested in identifying anthropometric databases and models that can be used to facilitate the design of vehicles.

What types of crew restraints exist for armored vehicles?

In an effort to increase safety and enhance the crew performance, effective restraint systems are being investigated for open and closed hatch operations. Since the crew will likely be traveling over degraded terrain for extended periods, the need exists to support or restrain these crew members from jarring that will occur. We are attempting to identify restraint systems from two domains: (1) commercial, industrial, and military motor vehicles, and (2) aerospace vehicles, including restraint systems developed by the Army, Air Force, Navy, and NASA.

Manned versus unmanned turrets?

A tank turret can be either manned or unmanned. In a manned turret, the crew member (gunner) is slaved with the gun. That is, when the gunner points in a certain direction with the direct-view optic system, the gun also rotates to that position. In this case, the gunner is coupled with turret and thus rotates with the gun. However, in an unmanned turret, the gunner is positioned down in the hull of a tank, and uses a remote-view optic system to operate the gun. The gunner is now separated from the turret, and the gunner no longer rotates directly with the gun system. We are identifying research related to these rotation and separation issues, and (dis)orientation effects associated with turrets.

Remote- versus direct-view optics?

As a supplement to some of the manned versus unmanned turret concerns, we are also investigating visual performance issues (e.g. depth/distance perception, range-finding performance, target acquisition, etc.) associated with remote- and direct-view optics in general, and as a function of varying display parameters (e.g. field-of-view, color, contrast, etc.).

Continued on page 6

What are the effects on wheeled versus tracked vehicles?

Wheeled and tracked vehicles can have dramatically different effects on crew comfort and performance. Stressors such as noise and whole-body vibration can significantly impair crew member performance. We are exploring the effects of these and other related stressors on crew performance and comfort in both types of vehicles.

What are the implications of crew size reduction?

With advancements in technology, especially in terms of automation, the required crew size for a tank is likely to be reduced. Presently, most tanks are operated by a crew of four. The CAV program is exploring the implications involved with three- and two-crew member tanks. Some of the important issues we are reviewing include task distributions, workload concerns (both mental and physical), fightability, and sustainability among other factors.

What are the effects of various crew seating arrangements?

The CAV is expected to be much smaller, in terms of size and volume, than any of its predecessor armored vehicles. With reduced tank volume, and thus compacted workspace, the normal, upright seating posture may be unacceptable. Therefore, we are investigating the effects of alternative seating positions (e.g., sitting at an angle, prone, supine, kneeling, etc.) on crew performance.

How does the crew dispose of any waste?

Since crew members may be operating the CAV in a nuclear, biological, and chemical (NBC) environment for extended periods of time, they will need access to a waste disposal system without having to leave and reenter the vehicle. Many questions need to be answered, such as: Do any systems currently exist? Can any system be adapted? Where should the system be located? How can comfort be increased? How can privacy be maintained? What implication will a waste disposal system have on the overall CAV design and weight?

How much water and food are needed for each crew member?

The amount of accessible water and food should be great enough to support the crew for the entire length of the mission. Given the mission profile, how much water will be needed per crew member for drinking, food preparation, personal hygiene, and waste disposal? What is the best method for feeding crew members, with respect to heating, storing, and preparation? How will these issues impact the CAV design?

What are the effects of electromagnetic gun systems?

The CAV designers are very concerned about the short- and long-term effects of electromagnetic gun systems on crew safety, health, and performance. The following characteristics of electromagnetic gun systems are of particular interest: pulses, wave effects, fields, and heat.

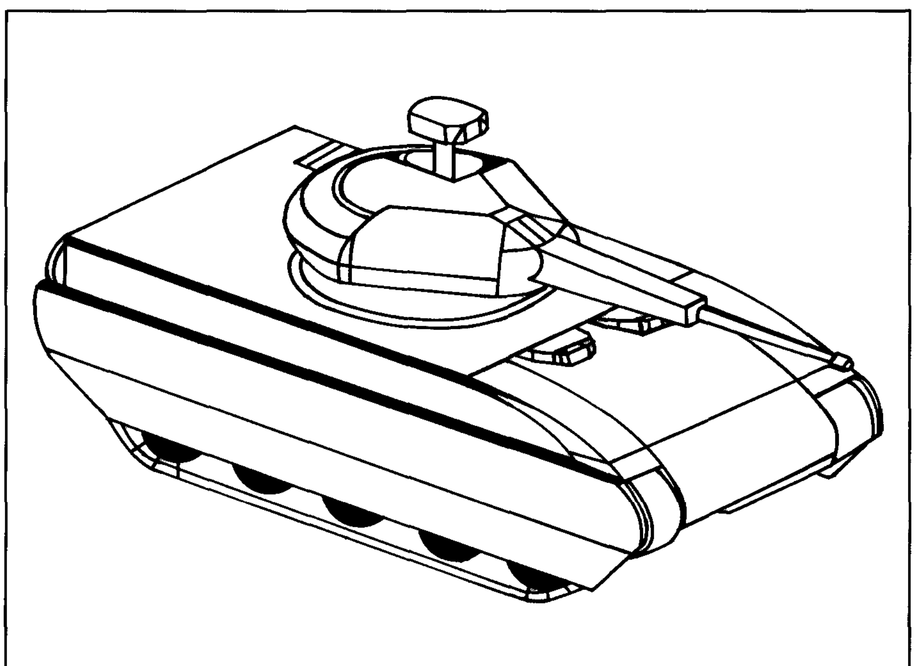
How to configure a 2-person control-display layout?

As part of a crew reconfiguration, it is likely that two crew members will work in tandem at an integrated crew station. The design, selection, and arrangement of a 2-person control-display layout will be reviewed and analyzed in terms of ergonomic criteria. We also will investigate existing integrated crew stations to determine their applicability to the CAV design.

Concluding Remarks

We are still exploring and identifying bibliographic information, research activities, and subject-matter experts relevant to all these technical inquiries. If you can assist us in answering any of these questions, please contact me at the CSERIAC Program Office at (513) 255-4842 or DSN 785-4842. ●

Michael D. Gravelle is the Senior Technical Analyst for CSERIAC.



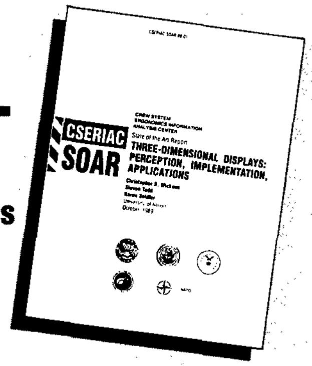
A possible configuration of the CAV concept

GATEWAY

State-of-the-Art Report

THREE-DIMENSIONAL DISPLAYS

Perception, Implementation, Applications



Christopher D. Wickens, Steven Todd, and Karen Seidler
University of Illinois

The perceptual basis of three-dimensional (3D) representation, recent advances in 3D display implementation, and current 3D design applications are examined in this authoritative review of the state of the art in 3D display technology.

The report catalogues the basic perceptual cues that can be built into a display to convey a sense of "natural" 3D viewing or depth. It describes how the various cues interact and how cues can be combined appropriately to create the strongest sense of depth.

Techniques for implementing perspective and stereoscopic displays are described in detail. The report identifies some potential costs and risks associated with 3D display technology, including the potential for perceptual ambiguity. Ways of constructing 3D displays to reduce ambiguities are suggested.

The efficacy of 3D vs. 2D representation is compared for various display contexts, and the most useful 3D applications environments are noted.

The report reviews 3D display technology applications in several major areas: flight deck displays, air traffic control, meteorology, teleoperation and robotics, computer-aided design, and graphic data analysis and imaging.

Senior author of the report, Dr. Christopher Wickens, is head of the Aviation Research Laboratory, University of Illinois.

The report is 126 pages and includes 22 figures. Cost is $75. To order, contact the CSERIAC Program Office.

Letter From The Editor

Jeffrey A. Landis

For the past two years, CSERIAC has distributed *Gateway* free of charge to its readers. To keep doing this, however, we need to reduce costs, especially with regard to unwanted copies. You can help us by providing a positive response on the card inserted in this section. This will tell us that you are an interested reader of *Gateway* and wish to keep receiving it. The card will take only a minute or two to complete, is mailable without an envelope, and is stamped with a return address and proper postage.

Please help us to continue offering *Gateway* as a quality publication without charge to its readers, by returning the card no later than 1 January 1992.

If you have any questions regarding this procedure or any questions, suggestions, or comments regarding *Gateway*, please direct them to me. Thank you for your cooperation.

CALENDAR

December 15-18, 1991
San Antonio, TX
Hypertext '91, sponsored by the Association for the Computing Machinery SIGLINK, SIGCHI, SIGOIS, and SIGIR. Contact John J. Leggett, General Chair , Hypertext Research Lab, Dept. of Computer Sciences, Texas A&M University, College Station, TX 77843-31112; (409) 845-0298, fax (409) 847-8578, Email: leggett@bush.tamu.edu

April 7-10, 1992
Southampton, England
The Ergonomics Society 1992 Annual Conference, at the Aston University and Business Centre. Theme: "Ergonomics For Industry." Contact E.J. Lovesy, Lynton, Horseshoe Lane, Ash Vale, Aldershot, Hants GU12 5LJ; 02522 24461 ext. 4082. Abstract deadline: October 4, 1991.

May 17-22, 1992
Boston, MA
SID '92 International Symposium, Seminar, and Exhibition, sponsored by the Society for Information Display, at Hynes Convention Center. Contact Paul M. Alt, SID '92 Conference Chair, IBM Watson Research Center, P.O. Box 218, Yorktown Heights, NY 10598; (914) 945-2437, fax (914) 945-1974, Email alt@watson.ibm.com. Abstract deadline: November 15, 1991.

February 18-21, 1992
Miami, FL
3rd International Conference on Management of Technology, sponsored by the University of Miami and the Institute of Industrial Engineers. Contact Tarek M. Kahalil, Industrial Engineering Dept., University of Miami, P.O. Box 248294, Coral Gables, FL 33124-0623; (305) 2284-2344.

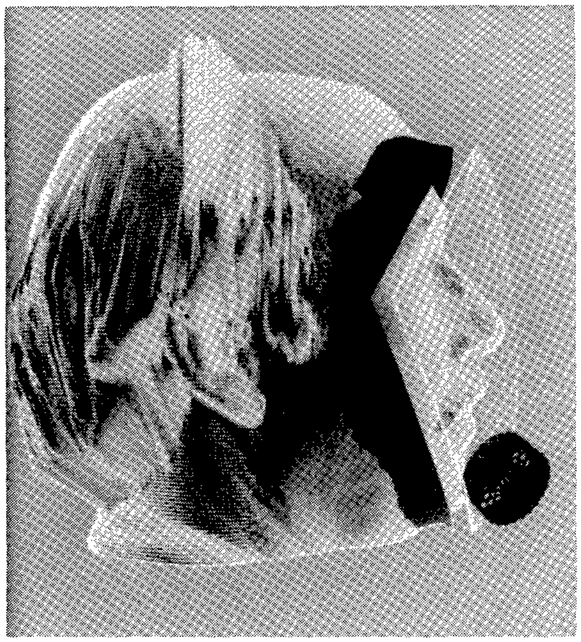
May 3-7, 1992
Monterey, CA
CHI '92, the 1992 ACM Conference on Human Factors in Computing Systems, sponsored by ACM SIGCHI, SIGGRAPH, SIGCAPH, HFS, and others. Theme: "Striking a Balance." Contact Carol Klyver, CHI '92 Executive Administrator, P.O. Box 1279, Pacifica, CA 94044 (Express Mail address: CHI '92 Office, 1355 Redwood Way, Pacifica, CA 94044); (415) 738-1200, fax (415) 738-1280, Email: klyver.chi@xerox.com.

May 18-22, 1992
Dayton, OH
NAECON '92, the National Aerospace and Electronics Conference, sponsored by HFS, IEEE, Aerospace and Electronic Systems Society, and others, at the Dayton Convention Center. Contact Mohammad Karim, Center for Electro-Optics, University of Dayton, 300 College Park, Dayton, OH 45469-0227, Abstract deadline: November 15, 1991.

Notices for the calendar should be sent at least four months in advance to:
CSERIAC Gateway Calender, CSERIAC Program Office, AL/CFH/CSERIAC, Wright-Patterson AFB, OH 45433-6573

Working Group: ELECTRONIC IMAGING OF THE HUMAN BODY March 9-11 92

The Human Engineering Division of the Armstrong Laboratory; the Mallinckrodt Institute of Radiology; the Washington University School of Medicine; and the Lister-Hill National Center for Biomedical Communication, National Library of Medicine are sponsoring a working group on electronic imaging of the human body. Electronic imaging of the surface of the human body has been pursued and developed by a number of disciplines including radiology, forensics, surgery, engineering, medical education, and anthropometry. The applications range from reconstructive surgery to computer-aided design (CAD) of protective equipment. Although these areas appear unrelated, they have a great deal of commonality. All the organizations working in this area are faced with the challenges of collecting, reducing, and formatting the data in an efficient and standard manner; storing this data in a computerized database to make it readily accessible; and developing software applications that can visualize, manipulate, and analyze the data.



This working group is being established to encourage effective use of the resources of all the various groups and disciplines involved with electronic imaging of the human body surface by providing a forum for discussing progress and challenges with these types of data.

Parties wishing to participate in this workshop are invited to submit a position paper on a topic that they are qualified to discuss and explore. A detailed information packet discussing the workshop and position paper requirements can be obtained by contacting the CSERIAC conference coordinator.

POTENTIAL TOPICS

- **Development of Scanning Systems**
- **Data Storage and Interchange Format Standards**
- **Calibration, Validation, and Evaluation of Scan ning Systems**
- **Data Analysis: Image Processing and Display**
- **Physically Based Modeling of Deformable Objects**

Location:
Dayton Marriott Hotel, Dayton, Ohio
Date:
March 9-11, 1992
For more information contact:
Wes Grooms, Conference Coordinator
CSERIAC Program Office
AL/CFH/CSERIAC
Wright-Patterson AFB, OH 45433-6573
TEL: 513 255-4842 FAX: 513 255-4823
DSN: 513 785-4842 FAX: 513 785-4823
Paper submission deadline:
31 December 1991

Aircrew Coordination Training (ACT) Program

Robert A. Alkov

Aircrew error mishaps accounted for 63% of all flight mishaps in Navy/Marine rotary wing aviation in 1988 for a rate of 6.5 per 100,000 flight hours. For two-thirds of these, some degree of poor aircrew coordination was a contributing factor. For the EA-6 and A-6 attack bomber aircraft, aircrew error during 1988 accounted for 46% of all their flight mishaps. Of these, 78% were related to poor aircrew coordination, a loss of situational awareness, or pilot judgment. The human error rate for all flight mishaps in this community was 7.61 in 1988.

With advances in aircraft design, maintenance procedures, and standardized operations, aircraft have become more reliable. However, their aircrews, who are highly trained in dealing with programmed mechanical problems, are not preventing aircraft accidents. Concentrating on human engineering design of cockpits, better pilot training programs, and improved training procedures has helped, but pilot factor mishaps continue. Aircraft mishaps tend to be attributed less to mechanical failure and more to human error. In recent years, there has been a growing realization that crew coordination and situational awareness contribute significantly to multi-crewed aircraft mishaps. With this realization has come the understanding that training can help.

Factors such as flight experience, proficiency, lifestyle, and personality affect the quality of cockpit communications. Crew coordination is adversely affected where communications break down in the cockpit. Aircrew members should be encouraged to offer verbal assistance, including opinions on mission parameters, regardless of the pilot's seniority. Naval aviators must be impressed with the need to heed the inputs of their crewmembers. Mission briefing must include discussing specific cockpit procedures and communication feedback responsibilities.

Sponsored by the Naval Safety Center, a trial program to teach aircrew coordination skills to helicopter fleet Replacement Training Squadrons (RTSs) was undertaken during fiscal year (FY) 1988. The training went beyond the usual leadership and assertiveness training used by various airlines under their cockpit resource management training themes. Curriculum content covered aircrew judgment, loss of situational awareness, stress coping, risk management, workload assessment, the use of check lists, and flight planning, in addition to developing communications skills.

The goal of the program was to develop a standardized aircrew coordination training program to be managed and run by Navy and Marine Corps aviation training squadrons. A cadre of Navy and Marine helicopter flight instructors was trained at CAE-Link in Dallas. They then returned to their RTSs to set up the training with the help of the contractor.

A follow-on contract to expand the program into fixed-wing tactical aviation began in FY 1988. This included carrier-borne aircraft such as the A-6 attack bomber, the F-14 fighter, the S-3 anti-submarine warfare aircraft, and the E-2 airborne early-warning aircraft. Additional funding was granted during FYs 1989 and 1990 to add training for the aircrews of all multi-crewed transport and patrol aircraft including the P-3, E-6, C-2, C-9 and C-130. The Naval Air Training Command received the program during FY 1991.

Navy and Marine Corps helicopter and fighter/attack aircraft training squadrons were the first to receive aircrew coordination training (ACT) because of their high aircrew error mishap rates. The project was funded by fiscal year which runs from 1 October to 30 September. The course content and curriculum were developed during FY 1988. The program was introduced into the aviation training squadrons' syllabi during FY 1989. By FY 1990, aircrews instructed in the training squadrons began to take the principles they learned into fleet operational squadrons.

The training squadrons attending the program have largely reported that they benefitted from it and wish it to continue. Many commanding officers of fleet replacement squadrons, although skeptical at the onset, now endorse the training for all aircraft squadrons. They report that it has contributed to better communications

Continued on page 10

between RTS instructors and replacement pilots. Because of better preflight briefings and postflight debriefings, ACT has increased the overall efficiency of their syllabus flight time. What of the mishap experience? The aircrew error mishap rate has declined dramatically in the aircraft communities into which the program was first introduced (see figure).

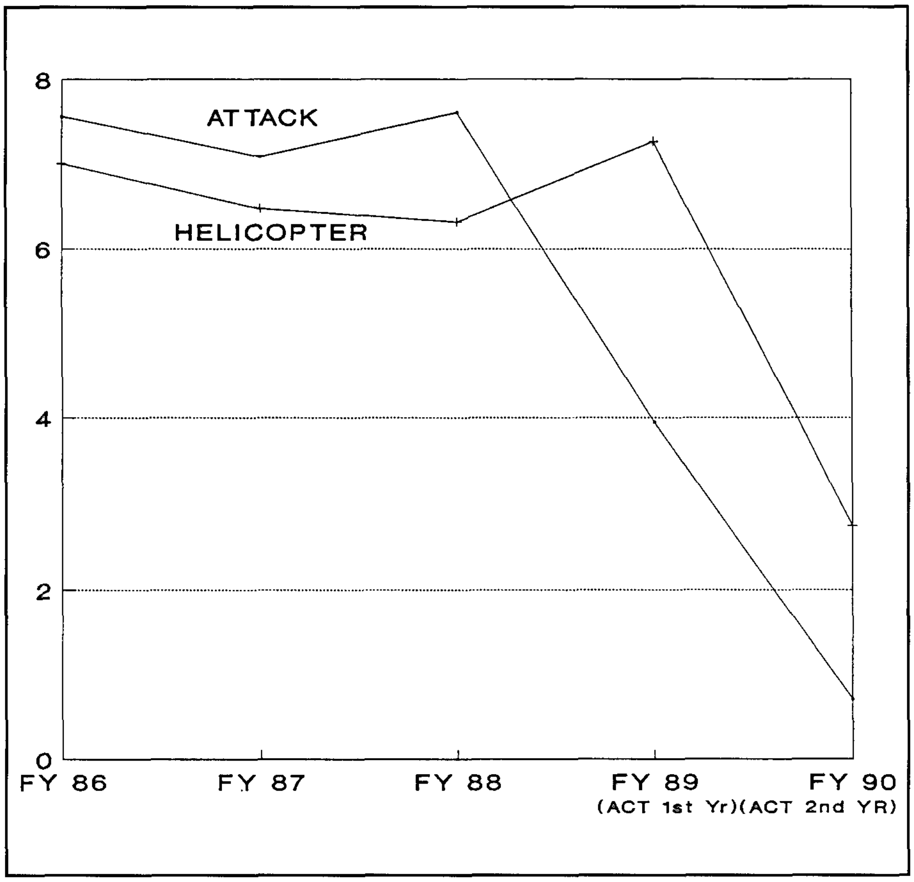
New aircraft procurements, such as the V-22 "Osprey" will have aircrew coordination training integrated into their simulators, manuals, and training programs from the beginning. Infra-red video cameras will be installed in weapons systems trainers and operational flight trainers to enable aircrew trainees to get feedback of their performance.

Because of the success of the project, the Marine Corps Combat Development Command at Quantico, Virginia; the US Air Force's Air Training Command; and the US Army Apache Helicopter Training Brigade at Fort Hood, Texas have now adopted the Naval Safety Center's ACT program, purchasing it from CAE-Link "off-the-shelf."

The ACT program is currently under the sponsorship of the Chief of Naval Operations, (CNO OP-59). Plans are forming for continuing follow-up training of replacement instructors. The Naval Air Systems Command (PMA-205) has funded the Naval Training Systems Center in Orlando, Florida to "institutionalize" this training throughout naval aviation.

As new information and techniques are developed they will be included in the training. ACT, as a viable and useful program must grow and change to meet the new challenges to aircrews that the next generation of aircraft will impose. It's a concept whose time has come. ●

Robert A. Alkov, Ph.D., is a Research Psychologist in the Aeromedical Division, Aviation Safety Programs, Naval Safety Center, Norfolk, VA.



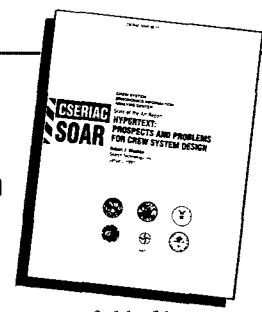
Impact of ACT as measured by the US Navy Aircrew error mishap rates per 100,000 flight hours (Class A, B, & C flight mishaps)

State-of-the-Art Report

HYPERTEXT

Prospects and Problems for Crew System Design

Robert J. Glushko
Search Technology



This informative report reviews the state of the art in the important new field of hypertext, an innovative concept for displaying information on computers that uses nonlinear methods for linking related information. Hypertext can significantly improve the accessibility and usability of on-line information for crew system designers and users. The report discusses:

Definitions and historical context: What hypertext is and why it has recently emerged as an important design concept.

Hypertext applications: How hypertext concepts can be applied in crew system design, including on-line presentation of handbooks, standards documents, software manuals, and maintenance aids.

Hypertext design and technology: The elements of hypertext, and software and hardware to support its implementation.

Hypertext development: Practical advice for designing hypertext capabilities into information systems.

The report is 88 pages and includes 17 figures. The cost is $75. To order, contact the CSERIAC Program Office.

Mannequin™: Human Computer-Aided Design on a PC

Clifford M. Gross

HUMANCAD®

Mannequin is a PC-based ergonomic design and analysis program used to evaluate the interaction between people and products. Numerous human models exist and are used in computer environments (i.e., Combiman, Jack, etc). However, a sophisticated, easy to use, PC-based, three-dimensional model has been lacking. Mannequin was developed as a portable tool for field ergonomists. The product effectively combines the standard "tools" of the trade (i.e. biomechanical models and databases) with sophisticated computer-aided-design capabilities suitable for operation on a small laptop or notebook sized computer (i.e., 386 16 MHz).

With Mannequin, the user can create and articulate three-dimensional human figures of men and women from the 2.5th to 97.5th percentile (Fig. 1) from ten countries. Additionally, somatotypes may be selected for thin, average, and heavy builds. Children are available for ages three through twelve. Mannequin articulates human figures allowing them to walk, bend, reach, grasp, and see.

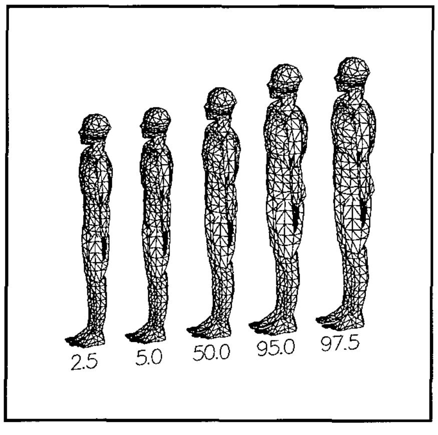


Figure 1. Mannequin percentiles for U.S. males

The goal of Mannequin is to allow designers and engineers to evaluate "human fit." This has been shown to have a positive effect on customer satisfaction as well as compressing the product development cycle.

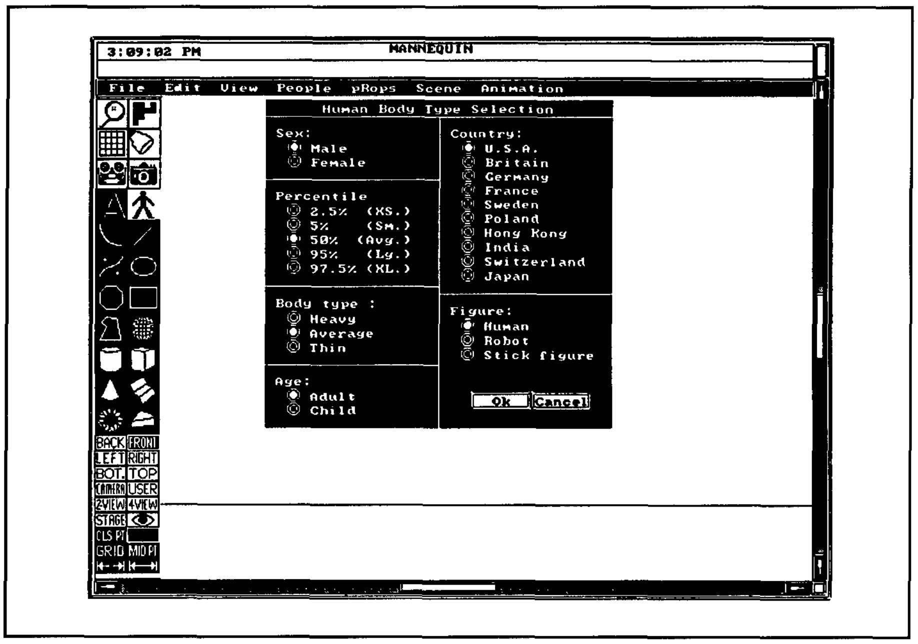


Figure 2. Accessing Mannequin program features

For manufacturing or crew station ergonomic assessments, the workplace or flight deck is the laboratory. This improves the generalizability of assessments and ergonomist productivity. The latter has become quite important in the ergonomic service business. Modern ergonomists are faced with heavy demands to complete projects quickly; to perform accurate, quantitative assessments; and to develop presentation materials for the communication of their assessments and recommendations.

Mannequin allows the user to better understand the interaction between people and products. The interface uses pull-down menus in a windows-like environment. Program features are selected from either a pull-down menu or an icon (Fig. 2). Humans are selected by pointing toward the humanoid icon.

Data Development

Mannequin data were developed in two ways. Existing anthropometric measurements were obtained from the world literature for each of ten countries. These data, however, were lacking in three-dimensional surface information. To improve the three-dimensional quality of the mannequins, particular-sized individuals were sonar digitized. From the sonar-digitized data, equations were developed for predicting surface geometry as a function of link lengths and specific circumferential measures. This approach has enabled Mannequin developers to give three-dimensional form to flat anthropometric databases. The bodies consist of more than 3,000 polygons. Joint ranges-of-motion are as specified by the American Academy of Orthope-

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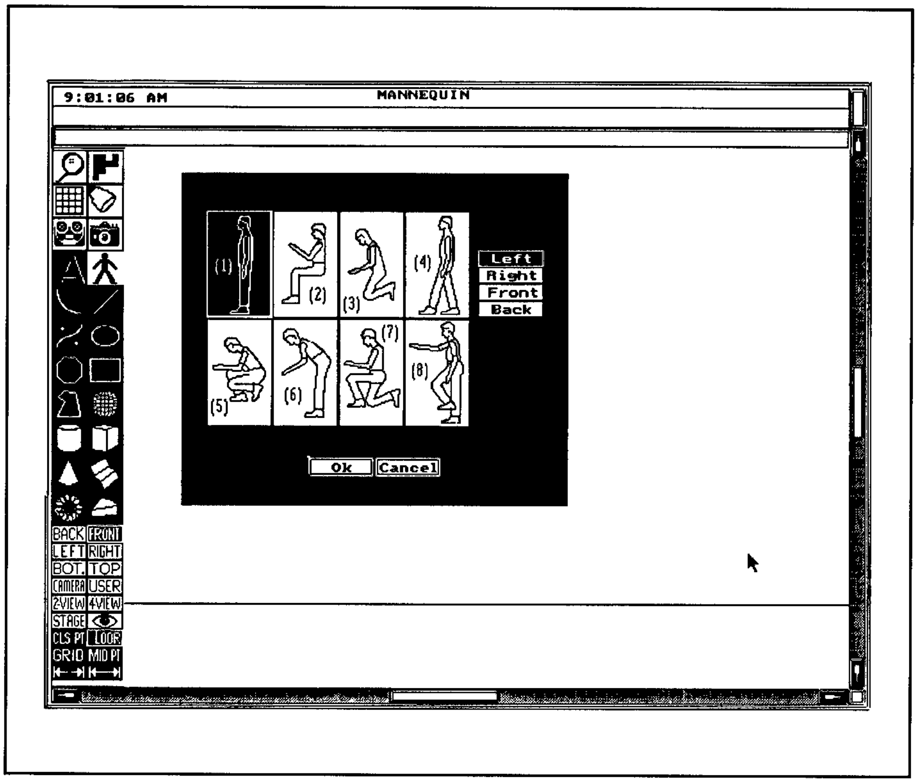

Figure 3. Mannequin body posture gallery

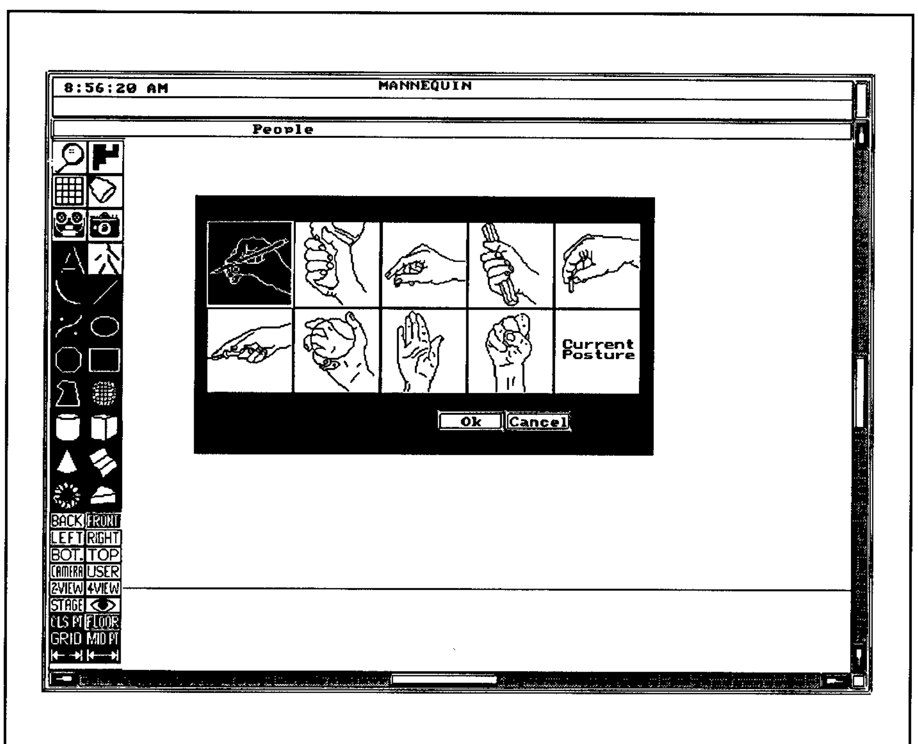

Figure 4. Mannequin hand posture gallery

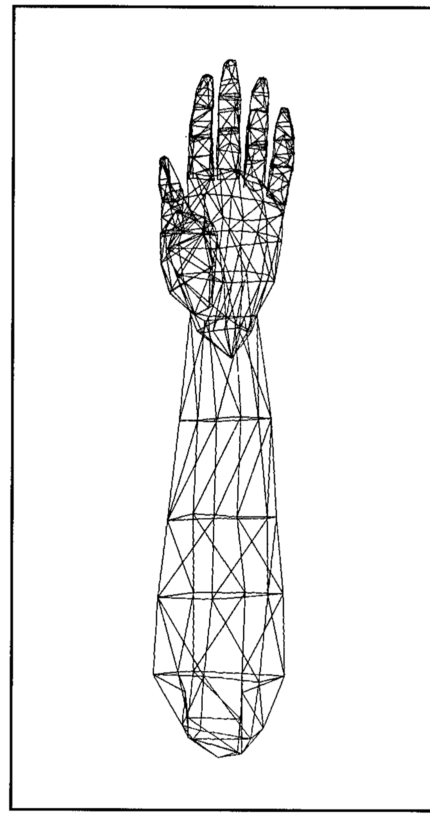

Figure 5. Hand with articulated fingers

dic Surgeons. The range-of-motion for the hands and feet is automatically calculated with a built-in function.

Body Positioning

The initial position of the body may be posed by selecting an icon from the body posture gallery (Fig. 3). Additionally, the hands may be posed through a selection from the hand posture gallery (Fig. 4). To allow the user to assume different grips, the hands are fully articulatable in three dimensions about each finger joint (Fig. 5).

Articulation

Articulating the figures is straightforward. You point with the mouse to the limb you would like to move and then you pull one of the X, Y, or Z slider bars to produce the angular motion in real-time. This easy manipulation of human-object combinations is essential for practical human computer-aided-design.

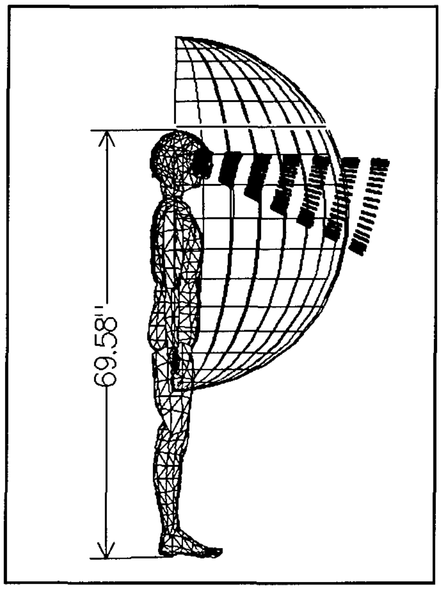

Figure 6. Vision and range of motion assessment 50th percentile U.S. male

Visual Range-of-Motion

Cones of foveal and peripheral vision may be indicated on the screen. In addition, a "human view" option is available which allows the user to look through the eyes of the mannequin. This is useful in gauging obstructions and visual clearance as it relates to specific percentile users (Fig. 6).

Torque Assessment

A built-in biomechanical torque calculator allows the user to measure torque on all measured body joints. Torque may be calculated and compared bilaterally; also comparisons may be made on body torque for one task vs. another (Fig. 7).

Grouping People with Objects

A group function is available which provides the ability to group mannequins with objects, i.e., grasping a flight control with the right hand or lifting a box. With the group function in place, objects will follow the people holding them.

Viewing

A zoom feature is provided which allows you to magnify or reduce any

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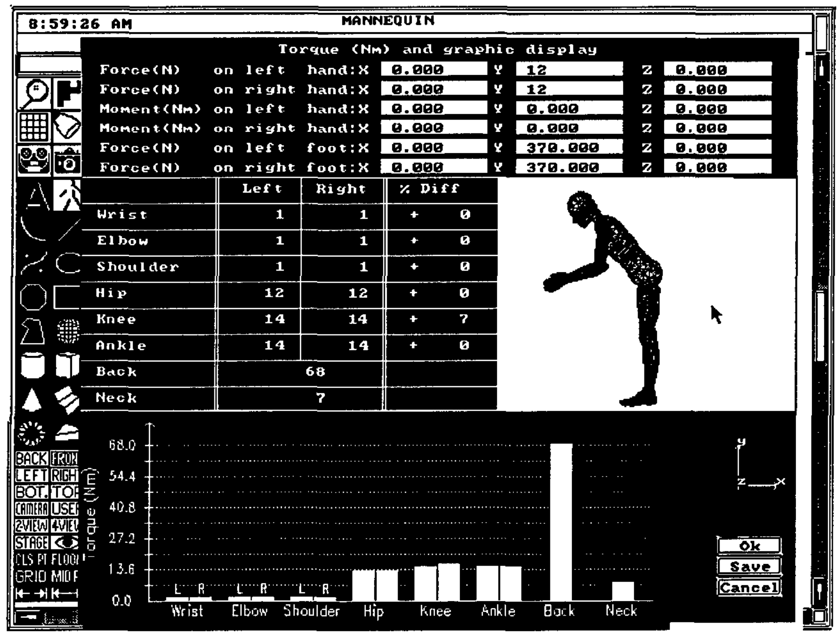

Figure 7. Torque assessment and graphic display

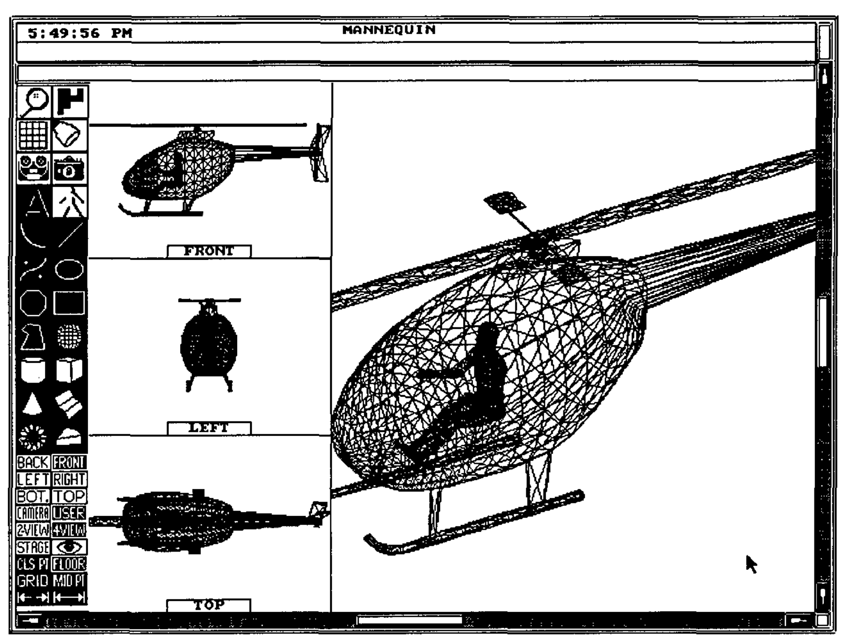

Figure 8. Multiviewing capability

part of the screen. Multiviewing capabilities provide an option of one to four views simultaneously on the screen (Fig. 8).

Other Features

A data window may be called up for any selected Mannequin to gather three-dimensional body information in metric or English units. The program contains basic three-dimensional drafting capabilities although it is not intended as a primary CAD station. These capabilities included dimensioning, shading, hidden line removal, rotation, scaling, stretching, lathing, and extruding two-dimensional objects into three-dimensional objects.

Mannequin runs freestanding, without any other CAD package. However, it can exchange files between most popular CAD and graphics programs designed for the PC. Mannequin produces simple animations through a screen-save-and-play module. Also, Mannequin may be used to create key frames for true animation packages such as Autodesk's 3D Studio and Macromind's Director.

For output, a large variety of printers and plotters are supported along with 3D DXF. Also, two-dimensional drawing formats are produced for incorporating images of these three-dimensional CAD drawings into paint, graphics, and desktop publishing packages. These file formats include AI, .CGM, .DRW, .DXF, .EPS, .PICT, .PICT2, .WMF, .BMP, .IMG, .GIF, .MAC, .PCL, .PCX, and .TIFF. Two-dimensional bit mapped images are useful for communicating the results of ergonomic assessments.

Additional screen output may be produced in wire frame or solid model formats (Figs. 9-11).

The system requirements are an IBM or compatible 286, 386, or 486, math coprocessor, hard drive, 2 Mb or more of RAM, IBM EGA or VGA Display, and a mouse.

Mannequin is available from HumanCad, 1800 Walt Whitman Road, Melville, NY 11747 (Tel: 800-437-4441, Fax: 516-752-3507). ●

Clifford M. Gross, Ph.D., is the C.E.O. of Biomechanics Corporation of America, Melville, NY.

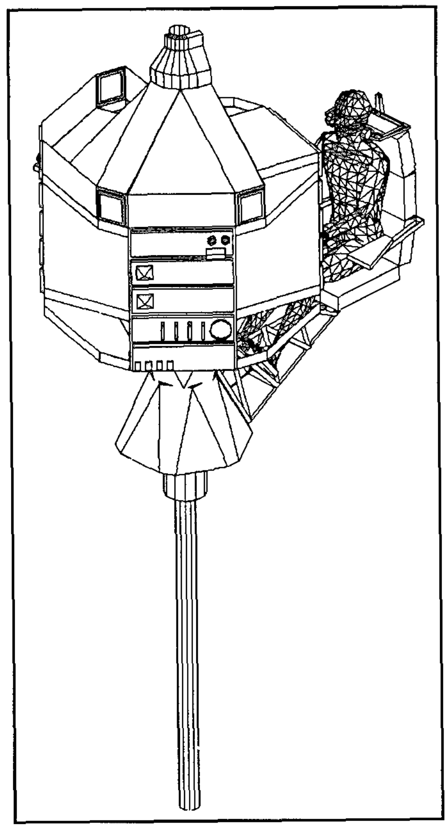

Figure 10. 3-D view of operator in instrument panel

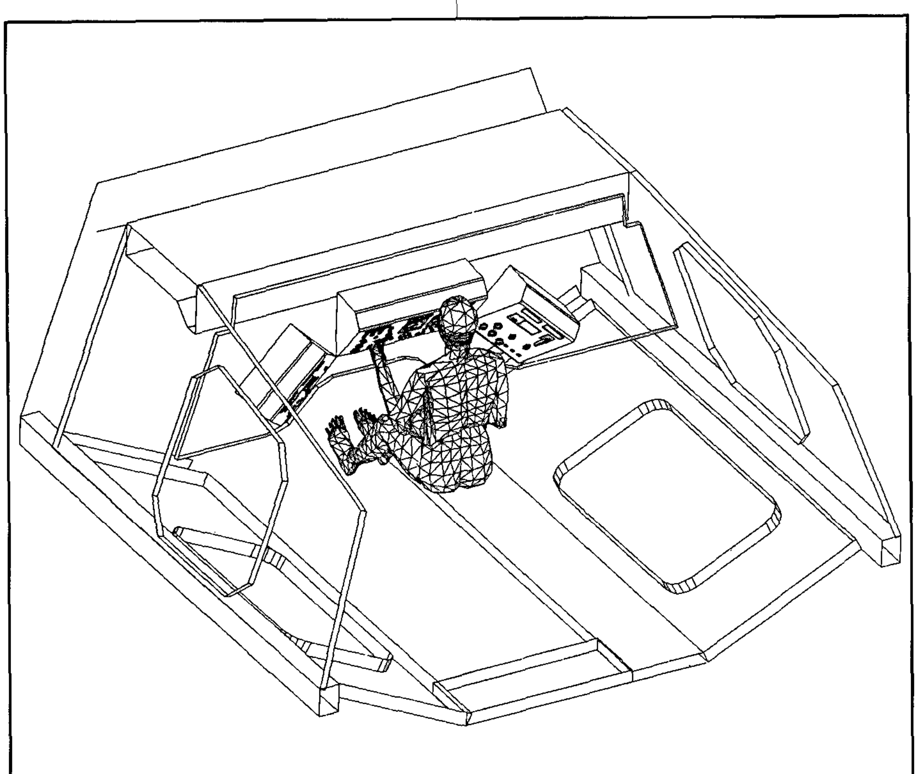

Figure 9. 3-D view of crew station with hidden line removal

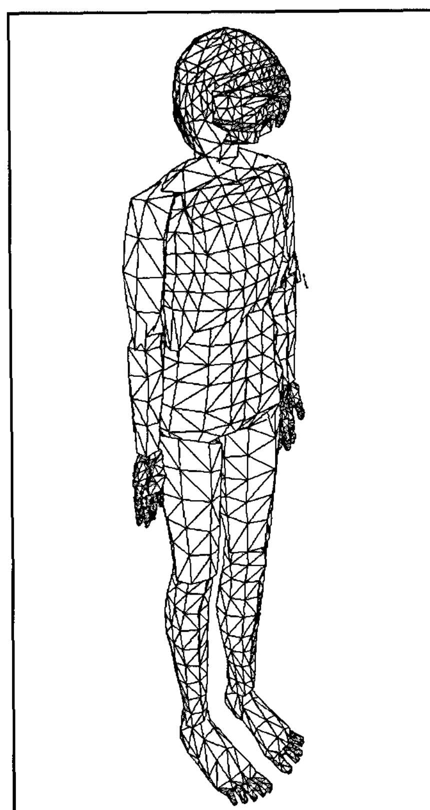

Figure 11. Mannequin with helmet

Peddling Your Wares:
CSERIAC's New Technology Transfer Program

Craig J. Dye

Since its inception, CSERIAC has strived to be a center of excellence for the analysis and dissemination of human factors information. This information has usually taken the form of critical analysis of human factors literature, but has also included certain models and databases. CSERIAC is now developing a comprehensive technology transfer (TT) program to complement the other services we provide to the human factors community. While continually upgrading our publications and technical inquiry service, CSERIAC is actively improving its capability to identify and distribute current human factors-related technologies.

Since 1980, the realization that the United States was not fully using the fruits of our collective technological achievements prompted legislative actions to correct this deficiency. Several government agencies and organizations were created at all levels to facilitate the transfer of technology within their respective domains. However, no organization has been dedicated to actively providing a comprehensive nationwide avenue for TT among the government, private, and academic centers producing and using human factors-related technologies. Ergo, many of the technologies developed within federal, academic, and private labs which would benefit human factors have not been given their due exposure, and the human factors community has been the less for it.

CSERIAC is prepared to fill this important and much-needed role. Just as CSERIAC serves as a nationwide gateway for the analysis of human factors-related information, so could it serve as a nationwide gateway for the transfer of human factors-related technology. Although CSERIAC has always been involved with TT to some extent, our new TT program adopts a more active and encompassing approach toward the identification and distribution of our technologies. We plan to identify those technologies developed at all federal labs nationwide which would be of interest to the human factors community. This includes not only DoD laboratories, but NASA, FAA, and DoT labs as well. In the future, these efforts will include academic and private labs. The technologies may be in the form of software models, databases, publications, reference works, utility programs (for data collection, reduction, and/or analysis, for example), or applicable concepts. In this way, CSERIAC will provide a more robust collection of products designed to benefit the human factors scientist.

Our goal, in short, is to effectively identify, distribute, and/or refer clients to high-quality technologies developed to expedite solutions to human factors problems. We desire to eventually be a comprehensive source, a premier gateway, if you will, for the transfer of human factors-related technologies.

Towards this end, we are currently upgrading our marketing materials to include a new general information brochure; a CSERIAC catalog describing all of our products, publications, and services; as well as a detailed brochure for each. In addition, we are contacting experts in the field of technology transfer, attending relevant technology transfer conferences, and acquiring information on the various databases and listings of potential technologies for dissemination.

Once developers permit CSERIAC to market their product/technology, marketing strategies and materials will be developed for the technology, an article will appear in *Gateway* announcing the product, the CSERIAC product catalog will be updated, the documentation (and source code, if necessary) will be reviewed for improvement, and one or more CSERIAC technical analysts will become familiar with the product to better support inquiries regarding it. Most important, the developer will be given credit for the technology at every opportunity: on internal CSERIAC product lists for use during phone-in queries; in the CSERIAC product catalog; and particularly on the detailed brochure for the product.

In the future, as we identify and screen technologies for inclusion in the CSERIAC inventory, we may develop Cooperative Research and Development Agreements (CRDAs) with the developers of the technologies to upgrade the product. Another possibility is setting up a subscription account for improving the source code and/or documentation of a program. It is also possible that a human factors technology transfer network could be established to more efficiently expose new technologies to the ergonomics community. CSERIAC workshops/symposia/conferences may be organized to further increase the awareness of designers and human factors scientists regarding available tools.

We are obviously excited about the potential for CSERIAC's TT program. Much work lies ahead, but the enormous payoffs for the human factors discipline surely justify this worthwhile effort. At this time, we are beginning to identify technologies which might be of interest to the human factors community. If you have developed, or know of, any quality technologies or concepts which have applications in the human factors arena and merit greater exposure, please contact Craig Dye at the CSERIAC Program Office. Any assistance will certainly be appreciated. ●

Craig Dye is the Technology Transfer Analyst for CSERIAC.

CSERIAC Service:

Analyses from the Biodynamics Data Bank

Trudy Abrams

Several recent *Gateway* issues have described the development of computer models that used data from the Biodynamics Data Bank (See articles titled "Modeling Human Force Response" in Vol II, Nos. 1-3), and we thought it a good time to highlight this truly unique resource. CSERIAC analysts have on-line access to this extensive collection of biodynamics experimental data and in-depth expertise on how to extract and apply the wide range of information available.

Originally conceived as the foundation for a National Biomechanics Data Bank, the BDB at this stage contains descriptive and summary information, and pointers to raw data, for impact acceleration tests and studies conducted at what is now the Escape and Impact Protection Branch of the Armstrong Laboratory's Biodynamics and Biocommunications Division (AL/CFBE). Twenty-seven experiments (studies) spanning a 15-year period and encompassing over 4,900 impact tests are currently represented in the data bank. Of these 4,900 tests, 43% involved human subjects for whom extensive anthropometry is also available. Figure 2 (shown on page 18) is a documentary photo from such a test – in this case, one done on the Horizontal Impulse Accelerator. Three other impact facilties, two of them drop towers, are also represented in the BDB. It is difficult to adequately describe the size and scope of this database. The BDB encompasses ten different interrelated record types with a total of well over a thousand fields, many of them composite lists. This means thousands of pieces of information describing each test.

Supported by a full-text database management system (BASISplus) and designed with the flexibility to accommodate changing research objectives which mean changing experimental variables, the BDB hierarchical and relational structure allows for hundreds of access points and retrieval routes for these thousands of pieces of information. Data relationships are indicated in the structure diagram shown in Figure 1. Each STUDY record contains a synopsis of the total experiment including hypothesis, results, etc. The "P" record types PTSTINDX, PTSTDATA and PTSTLOG supply "parameter" or variable names that have the potential to change from study to study. TSTINDX, TSTDATA, and TSTLOG record types, respectively, contain the actual data values that are paired with these variable names. Each of these three record types contains different types of test information. A single record called the Anthropometry Measurements Directory provides a glossary of terms and pointers to the mnemonic ("short") variable names of the anthropometry records (ANTHRO). It also allows for adding new anthro-

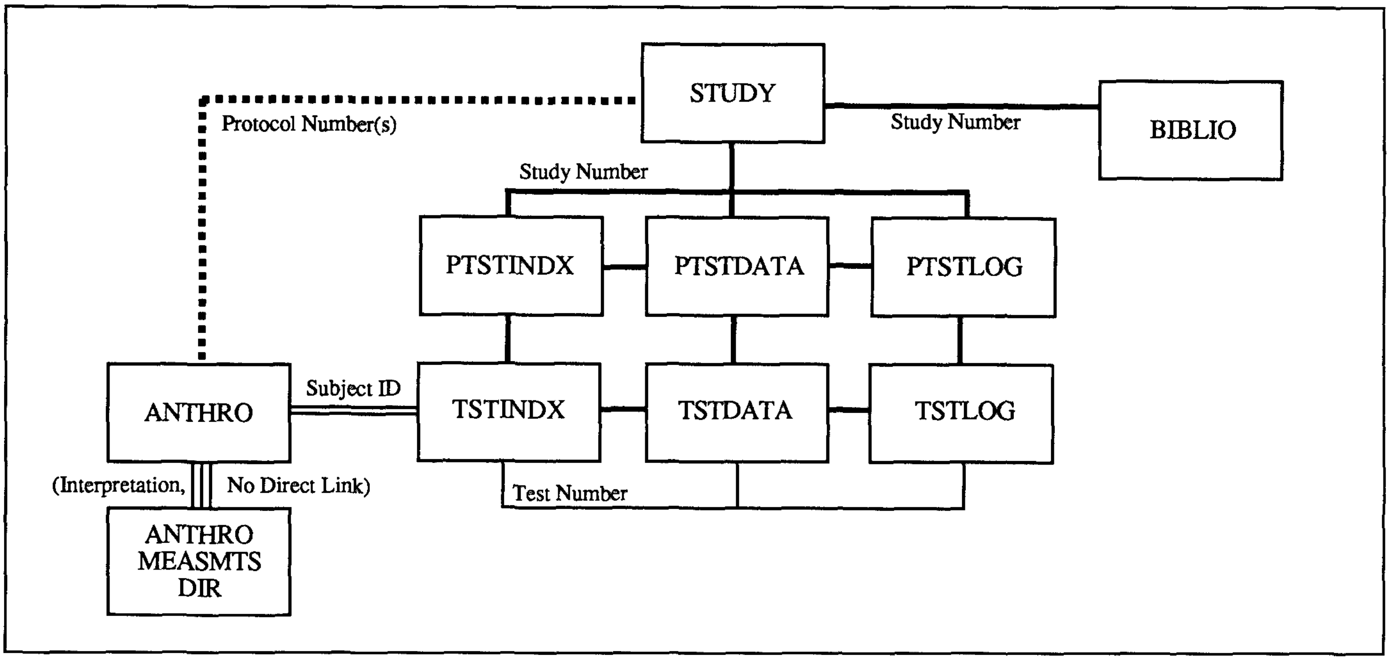

Figure 1. Logical structure of the Biodynamics Data Bank showing record relationships

pometry measurements that were previously undefined without changing the database schema. The bibliographic records (BIBLIO) represent literature or presentations based on experiments described in the BDB and other biodynamics references.

Researchers interested in a particular study or a particular hypothesis can follow routes beginning with the overview or synopsis of the study itself. Researchers interested in analyzing the responses of human subjects with particular physical attributes (or those of manikins, or animals) can begin with TSTINDX or ANTHRO records and follow routes across studies if they wish. Researchers looking for a test or a group of tests with particular input and output variables, like Norm Phillips whose articles are mentioned above, can select from the entire database according to their criteria and without concern for the study or studies that spawned those tests, if that is reasonable.

In describing the Biodynamics Data Bank and the kind of analyses CSERIAC can offer, we want to emphasize its front-end, "information-organizing," "information-descriptive," and "information-validating" functions. One of the most serious impediments to the scientific ideal of sharing data to save time, expense, and trauma to human and animal subjects is not necessarily the unavailability of data; it is the lack of descriptive information needed to *access, interpret,* and *substantiate* the data, and of the means for *relating the data* in different ways. Having access to a library of data tapes containing measurement data is, of course, a *sine qua non* if one wants to reuse data. But unless one can connect the data to all the *input* parameters, that output can not be used beyond its initial analysis. In the case of impact acceleration data, for example, voltages representing the time history for a data channel might represent raw output. But what about the electronic factors needed for equations leading to meaningful response data— the type accelerometer or load cell used, the filter frequency, sensitivity and gain of the device, etc? And what were the circumstances under which that data was gathered? Type of facility and impact direction? Coordinate system? Type and physical characteristics of the subject? Seat design and seat plane inclinations? Harnesses and preloads? Headrest? Helmet? Bracing techniques? Clothing? In other words, what are the factors that let a "secondary researcher" know that this data can be used to answer a new hypothesis, and what are the factors that could relate, in a new way, this particular set of data to other sets in the same study, or to other sets in different studies? Some examples of past BDB searches and analyses will further illustrate the value of this collection of data and of the retrieval system that supports it.

Researchers at the Workload and Ergonomics Branch of the Armstrong Laboratory, Crew Systems Directorate, Human Engineering Division (AL/CFHW), wanted to develop a correlation matrix from a dozen or more anthropometric values and a dozen or more peak values of impact acceleration test responses to determine what role, if any, anthropometry played in those responses. The preliminary tasks were to identify at least 30 impact acceleration tests with a constancy in input variables but with different subjects, and then, for the selected tests, to extract summary response data for all the data channels and anthropometric data for each of the subjects involved.

Deciding on what constituted common, or shared, input variables that would result in a sample set of at least 30, without specifics for all the variables in mind, was not a trivial task. From our knowledge of and familiarity with the collection as a whole, we zeroed in on male subjects and tests with +Gz peak acceleration between 9.5 and 10.5 G conducted on the Vertical Deceleration Tower, because we knew that would give us the largest set to look at initially, and because we knew that helmets, mostly of one type, were worn on all Vertical Deceleration Tower tests and that there were only a few variations in restraint harness for such tests. The data bank indicated that there were 281 tests meeting those criteria, and that the tests came from six different studies. Examination of the study synopses, however, raised "red flags" and led us to other criteria. Three of the studies involved modified crew seats and restraint types, and even the control cells from those studies proved incompatible with the other three studies. Another study evaluated the effect of seat cushions and seat back angle, and those (even the controls) proved unusable also. At this point we narrowed the acceptable range of peak G acceleration to between 10.25 and 10.50, because that range was more acceptable for constancy, and because that seemed to be characteristic of most of the remaining tests. We also added rise time, seat back angle, and seat pan height to our list of constancy criteria, and included the requirements of a negative g-strap and standard seat cushion.

One cell in each of the two remaining potentially compatible studies was appropriate, and that yielded a total of 35 tests. But many of the subjects had taken part in both studies and in several tests in each. To correlate anthropometry with response, we needed different subjects for each test-subject pair in our new sample set. A more recent study not yet represented in the data bank came to mind, and one cell of that study matched the input variables we had zeroed in on, giving us a total of 49 compatible tests. Participating in these 49 tests from the three different studies were 39 individual subjects, enough for a sample.

Summary response data could have come from the BDB for tests represented in the data bank, but with the test numbers and studies identified, AL/CFBE engineers were able to quickly supply these values for all three of the studies from their data files. For each of the 39 subjects, 50 to 60 anthropometric values were supplied from BDB anthropometry records. The ergonomics researchers ran their statistical

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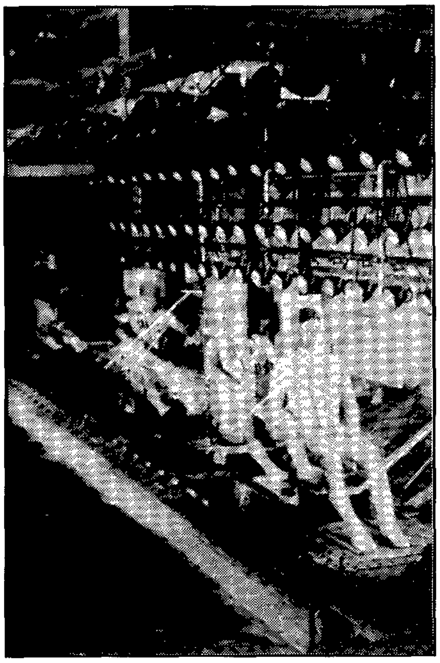

Figure 2. A sled test, typical of the type currently represented in the BDB

programs on the correlation matrix developed from these data sets and delivered their results.

As Norm Phillips' articles indicated, actual test data is crucial for developing and validating computer models. Some time ago, engineers at what is now the Vulnerability Assessment Branch of the Biodynamics and Biocommunications Division (AL/CFBV) were asked to run simulations using the Articulated Total Body Model (ATB) in support of research in C–17 survivable crashes. Several BDB sessions were necessary to locate and retrieve impact acceleration data that could validate the simulations before predictive data could be generated.

The model had to be validated using real –Gx impact response data generated in an environment similar to that of the C-17, so not only were harness types and belt configurations matched insofar as possible to those used in the C–17, but other harness characteristics such as elasticity and pre-tension were addressed as well. Initially, a 95th-percentile body size for human or manikin subjects was requested, so sitting height and weight were included as criteria. Later it was decided that human subjects would be better so that criteria for age, stature, mid-shoulder sitting height, chest circumference, buttock-knee length, head length, and knee height could also be used for test selection. Appropriate test ranges of peak G–level, maximum velocity, and impact duration were also important, and this narrowed the sample further.

Two suitable tests were identified and maximum and minimum chest accelerations, head accelerations, shoulder strap loads, and total lap loads were retrieved from the BDB for all three orthogonal axes and the resultants. The times of impact maximum and minimum for each of these measurements were also retrieved, so response data could be linked to photometric data. Exact fiducial (target) locations were supplied as well from BDB TSTLOG records. All of this information allowed the ATB experts to validate the model to C-17 Program Office objectives and then to run the predictive simulations.

While the two examples above really "put the BDB through its paces" and required considerable human-machine interaction in a continual search-and-analysis process, many times the data bank's value is demonstrated (though not always noticed) by exercises which take only a few minutes. These "duck soup" chores for the BDB can actually save anywhere from a few hours to several months of work. Some time ago biomedical researchers began an investigation of female air crew responses to acceleration impact. The BDB helped launch their investigation by determining, within minutes, that data was available for 7 different women who had participated in a total of 110 tests spanning 12 different studies and 5 different impact acceleration directions with peak inputs of 3 to 13 G. Details of the tests, the studies, and the women's anthropometry records were then provided as necessary.

Often, a "no" answer saves as much time as a "yes" answer, and "wrong" results can be profitably applied elsewhere. Recently the Army requested information on "helmeted tests" in the –Gx direction. The BDB search showed that helmets were not worn by subjects during –Gx tests, but identified 1,038 +Gz and +Gy tests (manikin and human) where the wearing of helmets was indicated. The "no" answer for the availability of –Gx helmeted tests undoubtedly disappointed the Army, but the Air Force was still saved hours and hours that would have been spent just to determine whether they could supply the data. Meanwhile, the Air Force engineer who requested the search realized that the +Gz and +Gy test information was valuable for another helmet study being conducted within his own branch and passed on the list of test numbers.

In working with the Biodynamics Data Bank, one cannot help being reminded again and again of the complexity of scientific data gathering in today's world, and what that means in terms of record keeping. The volume of data needed to describe, document, and report just a single measurement or a single test makes yesterday's "lab notebook" woefully inadequate. The counterpart and complement of today's electronic data-generating and data-gathering equipment is an electronic notebook and filing system like the Biodynamics Data Bank. The first prototype proved workable and valuable; the second "edition" is now being implemented.

Data from the original BASIS (version K) data bank, which provided the platform for the search and retrieval examples above, has been migrated to the new version L (BASISplus) format shown in the figure. Testing of the new version is currently under way and CSERIAC analysts and software engineers are hoping to support continued development and refinement of the data bank. This development is expected to be mainly in the areas of enhanced user interfaces for retrieval and display, more efficient updating procedures for incorporating AL/CFBE impact acceleration data not yet in the data bank, and the inclusion of biodynamics data from other sources.

CSERIAC is happy to answer questions on the Biodynamics Data Bank and to provide analysis services based on this unique source of information.●

Trudy Abrams is a Systems Engineer for CSERIAC.


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CSERIAC Gateway is published quarterly and distributed free of charge by the Crew System Ergonomics Information Analysis Center (CSERIAC). *Editor:* Jeffrey A. Landis; *Assistant Editor:* Christopher J. Sharbaugh; *Copy Editor:* R. Anita Cochran; *Production Advisor:* Thomas A. Hinson; *Illustrator:* Timothy J. Span; *Layout Artist:* Vicky L. Chambers.