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CSERIAC GATEWAY

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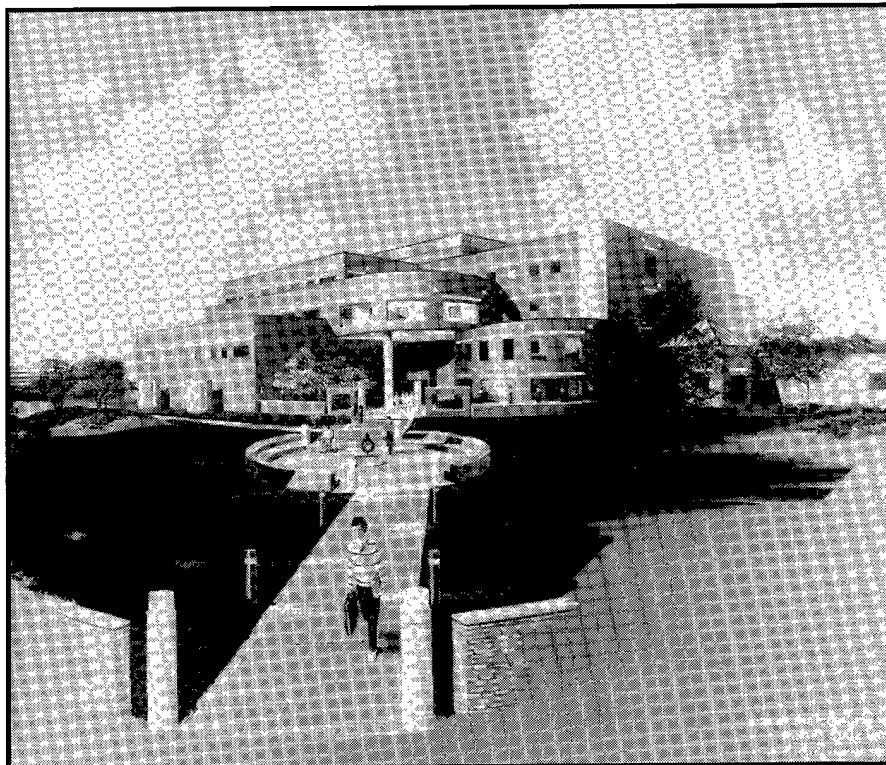


Figure 1. The Fritz and Dolores Russ Engineering Center at Wright State University

Human Factors: Quo Vadis?

Anthony Cacioppo

Reality testing may be painful. There comes a time when one must stop, introspect, and involve oneself in active problem solving. The above may read like counsel given in a clinical setting. Perhaps there is an analogy; however, my referent is the discipline of human factors, human factors engineering, ergonomics—call it what you wish.

The recent spate of articles and conference discussions dealing with the image and self-identity of human factors cannot be considered the illumination of a new issue. I recall comparable discussions as far back as the early fifties.

To ask what human factors is, asks a long question. One would prob-

ably be better advised to ask what is the role of human factors in our society. I seriously doubt that one could improve upon Dr. Chapanis's descriptions for human factors and human factors engineering provided in the Summer 1991 issue of *Gateway*. You will recall that Dr. Chapanis defines human factors "...as a body of knowledge about human abilities, human limitations, and other human characteristics that are relevant to design." Human factors engineering he defines as "...the application of human factors information to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use."

Continued on page 2

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GATEWAY

Scrutiny of both definitions reveals that the operative word is design. This lengthy introduction telegraphs the subject of this paper, human factors engineering as a design-oriented discipline.

Before I develop the above theme, my simplistic approach to issues divides human factors into two somewhat overlapping domains: research, i.e., knowledge generation; and engineering, i.e., designing and building things. Regretfully, as a number of patriarchs of our discipline have stated frequently, human factors research, more often than not, generates information with little application value to the practitioner. There is no need to belabor the issue; the gauntlet has been dropped, let us go about our business generating research that supports the needs of the practitioner.

It is not my intent to criticize the role of research. Human factors, as practiced by either the psychologist or the engineer, is dependent upon the products of research. Nor do I wish to debate the merits of being a psychology- or an engineering-trained human factors specialist. I have cast my die for the human factor specialist trained as an engineer. What I would prefer to do is share my experiences in attempting to develop a human factors undergraduate engineering program modeled within the framework of classic engineering. A number of degree-granting institutions offer the doctorate in industrial/human factors engineering (or industrial/ergonomics). The number of engineering colleges granting the B.S. in human factors engineering is limited to a few, depending on the criteria used to evaluate the curriculum.

In 1986, the Wright State University (WSU) College of Engineering's Human Factors Engineering program was moved in the direction of a classic engineering program. (The Fritz & Dolores Russ Engineering Center is shown in Fig. 1) The curriculum included a foundation built on undergraduate engineering courses which were systems oriented. Prior to 1986,

all WSU College of Engineering programs were designated "systems." Differentiation into the classic designators, such as electrical engineering and mechanical engineering, occurred in that time frame.

Differentiation of the human factors program so that it might match those "descriptors," which define engineering, started in 1986. It became apparent early in our developmental process that if we were to be an engineering discipline, we had to play by the rules of the engineering profession. Engineering focuses on the creative process of designing. The end product of our educational process is the graduation of qualified human factors engineers who can take their place within the engineering design fraternity and "hit the deck running." The human factors engineer must be able to impedance match with his engineering peers. Going for the graduate human factors engineer is mastery of the quantitative language of engineering, access to the tools provided by undergraduate mechanical and electrical engineering, as well as a facility with computers.

Mastery of the subjects common to undergraduate engineering curricula is the price of entry into the profession of engineering, including human factors engineering. An overview of the required courses is shown in Figure 2.

The foundation for engineering is advanced mathematics. The WSU undergraduate curriculum mandates four quarters of calculus and a course in differential equations. Two quarters of calculus-based applied statistics are also required. Statics, dynamics, fluid and thermodynamics are the standard mechanical engineering fare. Special attention is given to our electrical engineering base. Courses include circuits, applied electronics, linear systems, and control theory. Why the emphasis on linear and control? The techniques and mathematical tools made available to the student are invaluable in the solution of human factors engineering problems. No mention is made of the

typical courses in science taken by engineering students, such as physics and chemistry. They are assumed. Of the non-physical sciences, courses in perception and cognition are also important.

From three specialty courses in human factors engineering in 1986, the core undergraduate human factors offerings grew to eleven. At the sophomore level we start with an introductory course in engineering psychology. The junior year includes industrial ergonomics, analytic methods, human-computer interface, and a stand-alone human factors engineering laboratory sequence. The senior year provides courses in displays, systems models, application to aerospace, and the three-quarter senior sequence in design. Excepting our course in analytic methods, all courses have an increment dealing with design built into them.

The capstone course for any engineering program is senior design. Since 1986, senior design has evolved from a one-quarter to a three-quarter sequence. All students are required to engage in individual design projects. The first quarter deals with teaching the concept of human-centered design. This quarter, the deliverable is the student's engineering notebook which shows the development of the student's conceptual design. For the second quarter, concepts from systems engineering and analysis are taught. The student is also given an introduction into the systems acquisition process. The deliverable again is the engineering notebook with a detailed design, including the related engineering analysis. The final quarter permits the student to convert the design into either hardware or software. The engineering notebook and an engineering report related to the student's project are deliverables. All students are required to give oral progress reports throughout the course of the design program.

I restate my first sentence: reality testing may be painful. Throughout the development of the current hu-

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man factors engineering curriculum, we have continually tested ourselves. Are the human factors engineering courses appropriate? Will course content survive the close scrutiny of our engineering peers? Is there a market for engineering-trained human factors specialists?

Let's address the market for the undergraduate engineering-trained human factors specialist. Not only is there an industrial and commercial market for the B.S. in Human Factors Engineering, there is a demand, despite the current economy. Also

gratifying is that today the B.S. in Human Factors Engineering is offered salaries comparable to those offered others in the engineering profession. The degree is competitive.

Weaknesses in our undergraduate program? Of course! There is a major gap in the production of human factors engineering teaching materials. There are very few textbooks which qualify as engineering texts. Source materials are, in major part, soft in engineering content, which constitutes one of our major challenges: integrating the

content of human factors with engineering science.

Human factors: Quo Vadis? I personally believe that human factors engineering, as I have modeled it in terms of academics, will be the growth segment of our profession. Human factors engineering did not self-invent; it developed because it serves a need. ●

Tony Cacioppo is a Professor of Human Factors Engineering, and Chairman of the Biomedical and Human Factors Engineering Programs, Wright State University, Dayton, OH.

FRESHMAN REQUIREMENTS

(53.0 credit hours-CH; 0.0 design hours-DH)

	CH	DH	
01.	CHM	121-5.0	SUBMICROSCOPIC CHEMISTRY
02.	CHM	122-5.0	MACROSCOPIC CHEMISTRY (01)
03.	ENG	101-4.0	ENGLISH COMPOSITION
04.	ENG	102-4.0	ENGLISH COMPOSITION
05.	PHY	250-4.0	GENERAL PHYSICS (07)
06.	PHY	255-1.0	GENERAL PHYSICS LAB (05C)
07.	MTH	229-5.0	CALCULUS I
08.	MTH	230-5.0	CALCULUS II (07)
09.	MTH	231-5.0	CALCULUS III (08)
10.	PSY	105-4.0	INTRO PSYCHOLOGY
11.	PSY	110-4.0	INTRO PSYCHOLOGY
12.	CS	205-4.0	COMPUTER LITERACY
13.	SOC	200-3.0	SOCIAL LIFE

SOPHOMORE REQUIREMENTS

(50.0 credit hours-CH; 1.0 design hours-DH)

	CH	DH	
14.	HFE	306-4.0	1.0 ENGINEERING PSYCHOLOGY (MTH 130)
15.	EGR	153-4.0	FORTTRAN PROGRAMMING (07C)
16.	EC	200-3.0	ECONOMIC LIFE
17.	ME	202-4.0	ENGINEERING GRAPHICS
18.	ME	212-4.0	STATICS (09)
19.	ME	213-4.0	DYNAMICS (05, 15, 18)
20.	MTH	232-5.0	CALCULUS IV (09)
21.	MTH	233-5.0	DIFFERENTIAL EQUATIONS (09)
22.	PHY	251-4.0	GENERAL PHYSICS (05, 08, 23C)
23.	PHY	256-1.0	GENERAL PHYSICS LAB (22C)
24.	PHY	252-4.0	GENERAL PHYSICS (05,08, 24C)
25.	PHY	257-1.0	GENERAL PHYSICS LAB (24C)
26.	PLS	200-3.0	POLITICAL LIFE
27.	PSY	371-4.0	PERCEPTION (10, 11)

JUNIOR REQUIREMENTS

(50.0 credit hours-CH; 6.5 design hours-DH)

	CH	DH	
28.	HFE	307-4.0	1.0 INDUSTRIAL ERGONOMICS (14)
29.	HFE	450-4.0	HFE ANALYSIS METHODS (14)
30.	HFE	451-4.0	2.0 HFE COMPUTER SYSTEM DESIGN (15)
31.	HFE	456-2.0	1.0 HFE LABORATORY (14)
32.	EE	301-4.0	0.5 CIRCUITS (21, 22, 33C)
33.	EE	302-1.0	CIRCUITS (32C)
34.	EE	321-4.0	1.0 LINEAR SYSTEMS I (32, 22)
35.	EE	322-3.0	1.0 LINEAR SYSTEMS II (34)
36.	HST	101-3.0	HISTORY WESTERN ANCIENT
37.	HST	102-3.0	HISTORY WESTERN TRANSITION
38.	HST	103-3.0	HISTORY WESTERN MODERN
39.	PSY	321-4.0	COGNITION AND LEARNING (10, 11)
40.	STT	360-4.0	APPLIED STATISTICS I (08)
41.	STT	361-4.0	APPLIED STATISTICS II (40)
42.		-3.0	REGIONAL STUDIES ELECTIVE

SENIOR REQUIREMENTS

(48.0 credit hours-CH; 16.5 design hours-DH)

	CH	DH	
43.	BME	419-3.0	1.0 BIOMEDICAL EGR SYSTEMS I (18, 21, 56)
44.	HFE	431-4.0	2.0 HFE DISPLAYS (14)
45.	HFE	471-4.0	1.0 HFE SYSTEMS MODELS (29)
46.	HFE	472-2.0	2.0 HFE DESIGN I
47.	HFE	473-3.0	3.0 HFE DESIGN II
48.	HFE	474-2.0	2.0 HFE DESIGN III
49.	HFE	476-4.0	1.0 AEROSPACE HFE (45)
50.	EE	401-3.0	1.5 APPLIED ELECTRONICS (32, 33)
51.	EE	402-2.0	APPLIED ELECTRONICS LAB (50C)
52.	EE	413-3.0	1.0 CONTROL SYSTEMS I (19,34)
53.	EE	414-1.0	CONTROL SYSTEMS I LAB (52C)
54.	EE	415-3.0	2.0 CONTROL SYSTEMS II (35, 52, 53)
55.	EE	416-1.0	CONTROL SYSTEMS II LAB (54C)
56.	ME	315-4.0	THERMODYNAMICS (20, 22)
57.		-3.0	COMPARATIVE STUDIES ELEC
58.		-3.0	GREAT BOOKS WESTERN WORLD
59.		-3.0	FINE AND PERFORMING ARTS

Figure 2. Course requirements for the B.S. degree in Human Factors Engineering at Wright State University

The COTR Speaks

Reuben L. Hann

Welcome to the January/February issue of *Gateway*! Our feature article this time is by Dr Anthony Cacioppo of Wright State University (WSU). Tony describes the development of an undergraduate human factors program within the context of an engineering discipline.

Basic engineering courses, such as advanced mathematics and statistics, as well as standard mechanical and electrical engineering courses are typical of the requirements for the B.S. in human factors engineering at WSU. Traditional courses from psychology, such as perception and cognition, as well as more specialized human factors subjects are also required. With an emphasis on engineering and design, WSU intends to produce human factors specialists who "speak the language" of engineers and designers, thus enabling the specialist to provide the kind of ergonomics assistance most relevant to the user community.

In January the Human Engineering Division of Armstrong Laboratory, with support from CSERIAC, held the first event in its new Colloquium Series,

"The Human-Computer Interface." Our first speaker was Dr. Thomas B. Sheridan, Director of the Man-Machine Laboratory at the Massachusetts Institute of Technology. The presentation was entitled "Musings on Virtual Presence, Telepresence, and Model-Based Decision Aiding." CSERIAC staff member Dr. Ron Schopper provides a synopsis of Dr. Sheridan's talk in this *Gateway*; also, we present excerpts of an interview Ron and I conducted with our guest.

In this issue Claire Gordon, of the U.S. Army Natick Research, Development, and Engineering Center tells us about ANSUR, the U.S. Army Anthropometric Data Base. This three-year study screened over 25,000 active-duty soldiers and used 132 body dimensions to compile a general data base of anthropometric distributions for the Army.

CSERIAC staff member Mark Detroit describes the concept of "aircraft agility" and what its implications are for the human operator of such systems. As the flight dynamic capabilities of aircraft are improved, enabling them to perform

previously impossible maneuvers, the limits of pilot control are being pushed.

The article "Psyching Out Multi-Task Management," by Dr. Yvette Tenney of Bolt Beranek and Newman, provides some background and a summary of the newest CSERIAC State-of-the-Art Report (SOAR). This SOAR, available through the CSERIAC Program Office, is titled *Strategic Workload and the Cognitive Management of Advanced Multi-Task Systems*. The report deals with the unique problems of performance and workload in managing multi-task situations.

I know you will find this issue of *Gateway* interesting reading. As always, we solicit your input. This can take the form of subjects you would like to see covered, comments, criticisms, or perhaps the draft of an article you would like to submit for consideration. We are always happy to hear from you. ●

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

Calendar

March 26-27, 1992

Palmerston North, New Zealand

4th Conference on Ergonomics: Design for Usability, sponsored by the New Zealand Ergonomics Society, at the Coachman Hotel. Contact Brent Challis, Conference Organizer, Faculty of Technology, Massey University, Palmerston North, New Zealand; 64-63-505085, fax 64-63-505612.

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.

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, OH 45469-0227.

May 3-5, 1992

Monterey, CA

CHI '92, the 1992 AMC 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 18-20, 1992

Tampere, Finland

International Conference on Computer-Aided Ergonomics and Safety, organized by Tampere University of Technology and sponsored by the International Ergonomics Association, Finnish Ergonomics Society, and others. Contact Markku Mattila, Conference Chairman, Dept. of Mechanical Engineering, Tampere University of Technology, Box 527, SF-33101 Tampere, Finland; 358-31-162621; fax 358-31-162671.

May 10-14, 1992

Miami Beach, FL

Aerospace Medical Association 63rd Annual Scientific Meeting, at the Fountainbleau Hilton. Contact the Aerospace Medical Association, 329 S. Henry St., Alexandria, VA 22314-3524; (703) 739-2240.

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

Letter From The Editor

Jeffrey A. Landis

This issue of *Gateway* marks the beginning of its third year of publication. During that time, the circulation has grown from 3,900 to over 6,500 readers in 31 countries, and I receive at least one request a day for someone to be added to the list. The size has increased from 12 pages to 20 pages, in the last issue, and the number of submitted articles is steadily increasing. For these reasons, Dr. Kenneth R. Boff, Chief of the Human Engineering Division, Crew Systems Directorate, Armstrong Laboratory, and the DoD Technical Director for CSERIAC, has requested that I publish *Gateway* on a bimonthly basis, a challenge which I am happy to meet. You will notice that this issue is referred to as the "January/February" issue rather than "Winter"

and the next issue will be the "March/April" issue.

Because of the increased frequency of publication, it is extremely important that those readers who have not yet returned the card indicating their interest in continuing to receive *Gateway* please do so immediately. As before, the card is simple to complete, is mailable without an envelope (in the United States), and is stamped with proper postage. In addition, I have ordered the use of "peel-and-stick" address labels so that you can peel your address label off the newsletter and fasten it to the card, eliminating the need to write your name and address, unless it must be corrected. Please note that for foreign addresses, I was unable to obtain "peel-and-stick" labels of sufficient

size to hold five-line addresses, thus I had to use the traditional labels.

Your expedient completion and mailing of the card will enable me to print enough copies available for all interested readers, without printing and mailing unwanted copies. This cost-reduction effort will assist me in maintaining *Gateway* as a quality publication without charge to its readers. I would appreciate your response no later than 15 April 1992.

For those readers who have returned their cards, please accept my gratitude. Because of the large number of returned cards, the process of making corrections is slow and not all corrections have been made for this issue. Thus do not be alarmed if the changes you indicated on the card have not yet been made. ●

Letters to the Editor

Dear Sir:

I have recently had the pleasure of reading the last two issues of *Gateway*, and quite honestly don't want to miss them in the future. Most noteworthy are the articles by Don Norman and Al Chapanis, which I view as mandatory reading for students in our human factors program.

I am not currently on your mailing list, but would very much like to be. My understanding is that this publication is available free of charge...Thanks for your help, and congratulations on producing a publication that is truly worthwhile reading.

Sincerely,

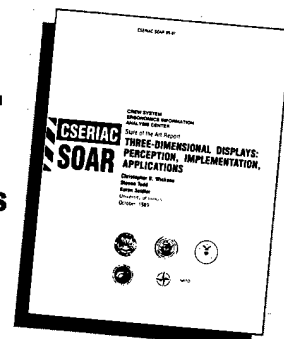
Holly R. Straub
Assistant Professor of Psychology
Human Factors Laboratory
University of South Dakota

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.

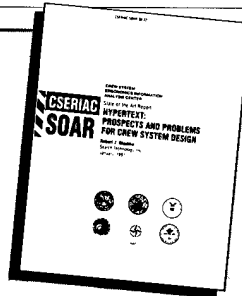
The report is 126 pages and includes 22 figures. Cost is \$35. To order, contact the CSERIAC Program Office.

GATEWAY

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 \$35. To order, contact the CSERIAC Program Office.

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.

Announcements

Anthropometry Class Offered

Did you know there is no such thing as a 95th percentile man and that it is impossible to construct a being that is 95th percentile for all measurements? Did you know that using 5th and 95th percentiles can actually fit much less than 90% of a population and can cause the design to cost more than alternative methods? Would you be interested in a class which would explain these and other pitfalls in anthropometry as well as detail methods which work better? Such a class would describe the latest in anthropometric methods as applied to the design and evaluation of cockpits (workstations), clothing and protective equipment, including the latest in topographic and volumetric scanning of the human body. If you are interested in such a class, please respond to Wes Grooms, CSERIAC Conference Administrator at (513) 255-4842 or DSN 785-4842.

Decrease in CSERIAC SOAR Charge

CSERIAC has periodically published state-of-the-art reports (SOARS) on a variety of topics relevant to the human factors community. It has been CSERIAC's intent to simply recover costs incurred for production of these SOARS. However, the high cost of contracting various experts to write these, combined with the high cost of printing, has resulted in SOARS that were priced beyond what most

ergonomists, psychologists, designers, and engineers could afford. To make the CSERIAC SOARS more readily available to professionals in the field, the CSERIAC Program Office has decreased the price from \$75 to \$35, effective immediately. This price reduction will apply to SOARS already published as well as future SOARS, until further notice.

New Journal on Teleoperator and Virtual-Environment Systems

MIT Press is pleased to announce the publication of the first scientific journal dedicated exclusively to the fields of teleoperators and virtual environments, *Presence: Teleoperators and Virtual Environments*. The complexity of the human-machine interface and associated environmental interactions affect an operator's performance, experience, and sense of presence in both teleoperator and virtual environment systems. *Presence* attempts to provide an understanding of these interfaces and interactions, as well as the underlying design. Secondary emphasis is placed on 1) the human operator's cognitive and sensorimotor system; 2) the peripheral components of the two types of systems; and 3) the impact of transformed presence.

The Editors-in-Chief are Thomas B. Sheridan, Massachusetts Institute of Technology, and Thomas A. Furness, III, University of Washington. *Presence* is published quarterly. Subscription rates are \$50 for individuals and

\$120 for institutions. Foreign subscribers should add \$14 for postage and handling, Canadian subscribers also add 7% GST. To subscribe to *Presence*, please write to MIT Press Journals, 55 Hayward St., Cambridge, MA 02142. (617) 253-2889.

DTIC CD-ROM Available

The Defense Technical Information Center (DTIC) announced the availability of its Technical Report Database on CD-ROM in October 1991. The data on the first issue covers 1970 through June 1991 and includes unclassified bibliographic citations to technical reports, patent applications, and conference papers. These citations cover scientific and technical information produced to support the management and conduct of DoD research, development, engineering, and studies program.

The annual subscription includes one complete, updated issue of the CD-ROM each quarter. Purchase of this product is limited to DTIC-registered users who are authorized access to export-controlled data.

For additional information on purchasing the CD-ROM or on becoming a registered DTIC user, call (703) 274-6434 or write to:

Defense Technical Information Center
DTIC-BCP (CD-ROM Information)
Building 5, Cameron Station
Alexandria, VA 22304-6145

Armstrong Laboratory Colloquium Series: Musings on Virtual Presence, Telepresence, and Model-Based Decision Aiding

Thomas B. Sheridan

Editor's note: Following is an abstract based on Dr. Sheridan's presentation as the first speaker in the Armstrong Laboratory Colloquium Series: The Human-Computer Interface. Dr. Aaron Schopper, CSERIAC Chief of Technical Services and Analyses, prepared this abstract.

The increasingly available and sophisticated technologies represented by high-resolution and fast computer-graphics, head-coupled displays, and instrumented "data gloves" and "body suits" are likely to have a large impact on both teleoperation (e.g., human remote control of vehicles and manipulators) and the experience of virtual environments (e.g., computer-simulated vehicles). The human interfaces inherent in such systems are characterized by terms such as "telepresence" (feeling like you are actually at the remote site of operation) and "virtual presence" (feeling like you are in the environment generated by the computer). While such systems allegedly will improve sensorimotor or cognitive performance and efficiency of training and planning, we currently have neither theories nor measures of presence (let alone telepresence or virtual presence).

In controlling actual vehicles or telerobots, where we absolutely depend on feedback, we have inadequate knowledge of how the operator's sense of presence contributes to ultimate performance. Is it critical to have displays of encoded bits of high-resolution sensory information? Is sense of "presence" simply a concomitant benign phenomenon (a distraction)? Or is the quality of "presence" the critical psychological indicator of physical stimulus sufficiency? When simulation and virtual environments are employed, what is contributed by a sense of

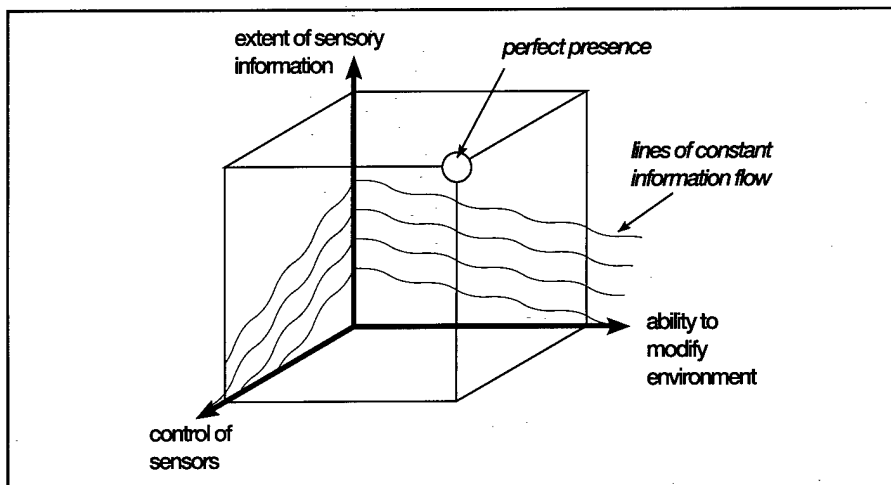
presence, per se? What design/operating principles exist to indicate how best to use the virtual and actual capabilities together?

Whereas present space limitations prevent my making a case for the following, I would like to cite the need to identify the determinants of the sense of presence. The principal determinants, as shown in the figure, appear to be (1) the extent of sensory information available, (2) the ability to control the relation of sensors to the environment, and (3) the ability to modify the physical environment (e.g., change the shape and location of objects therein). I am not suggesting that these determinants operate alone, as they are surely affected by both task difficulty and degree of automation (independent variables). The larger challenge, however, may be determining the dependent variables. There is an obvious need for measures of "presence" that are operational, reliable, useful, and robust. "Presence" is a subjective sensation, a mental manifestation. Therefore, subjective report

is the basic datum from which unidimensional or multidimensional measures can be derived—much like those associated with the mental workload models. While subjective measures are apt to be primary, there also is a need for objective measures if the work is to be accepted by the community of engineers and physical scientists. Potentially viable candidates are those with considerable face validity, e.g., unpremeditated responses to the unexpected or threat (e.g., a blink or a flinch) or highly conditioned social responses (e.g., "spontaneous," reciprocal arm and hand reactions to offers of handshakes or gifts) or utterances (e.g., cheers). The occurrence of these behaviors would lend credence to the assertion that the performers were experiencing "presence."

Causality of events in a human-machine system is commonly characterized as a closed information/control loop: the efferent, motor loop from human response to environmental state, plus the afferent, sensory loop from

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Principal determinants of sense of presence for a given task. From T.B. Sheridan, Musings on Telepresence and Virtual Presence, Presence: Teleoperators and Virtual Environments, 1992, 1 (1). Reprinted with permission of MIT Press

environmental state to human senses. Unfortunately, we have little experimental information regarding the relative effects of efferent or afferent distortions on sense of presence, training efficiency, and performance. In the case of human control loops, we are limited, to a large extent because sensation and perception tend to be characterized in very different ways from motor responses. However, in very simple continuous visual-motor tasks, the final closed-loop control usually is unaffected by whether a pure time delay is in the forward position-command loop or in the visual feedback loop. Nonetheless, enormously different closed-loop performance may result from the same resource investment, depending upon whether it is committed to improving feedback or feedforward.

There is also the question as to how the geometric mappings of body and environmental objects both within the perceived (virtual) environment and the true one, and relative to each other, contribute to sense of presence, training, and performance. Some form of spatial filtering appears necessary to account for the effects of distortions from spatial isomorphism. Control by the human operator requires such mappings. Some may demand a high degree of isomorphism, whereas in other instances it may be necessary to accommodate significant deviations due to hardware limits or constraints of the human body. At present we do not have design/operating principles for knowing what deviations are permissible, and which degrade performance. ●

Dr. Sheridan's presentation is based on the following article:

Sheridan, T.B. (1992, Winter). Musings on Telepresence and Virtual Presence. *Presence: Teleoperators and Virtual Environments*, 1 (1), pp. 120-126. Used with permission of MIT Press.

Dr. Sheridan is Professor of Engineering and Applied Psychology and Director of the Man-Machine Systems Laboratory at the Massachusetts Institute of Technology, Cambridge, MA. He is a past president of the Human Factors Society.

Scenes from the Armstrong Laboratory Colloquium Series:



Dr. Sheridan addressing a full auditorium of guests. Photo by Dan Churchill



Dr. Sheridan meeting with individuals following his lecture. Photo by Dan Churchill

Armstrong Laboratory Colloquium Series: Interview With Thomas Sheridan

Editor's note: The following is an edited transcript of a conversation with Dr. Thomas Sheridan, MIT, who had just made a presentation as the first speaker in the Armstrong Laboratory Colloquium Series: The Human-Computer Interface. The interviewers were Dr. Lew Hann, CSERIAC COIR, and Dr. Aaron Schopper, CSERIAC Chief of Technical Services and Analyses.

C **SERIAC:** Considering your position as Past President of the Human Factors Society, we would like to ask a rather global question: What do you see as the most important challenge facing the human factors community today?

Dr. Sheridan: There has been a continuing challenge of convincing the general public, the power structure, and the engineers of the importance of human factors. I believe that struggle will continue. However, I think we are gradually winning, and I'm delighted to see that there is more recognition of human factors. That's reflected by increased membership in HFS and general public awareness of what it is. It wasn't very long ago when people didn't have any idea what it even was. We have to keep working on this.

CSERIAC: Is there anything we in the human factors community can do to demonstrate or calculate the cost-effectiveness of using human factors in the design and acquisition of new systems?

Dr. Sheridan: I feel that, as systems get more complex, the problem of human factors

similarly gets more complex. We have moved historically from a kind of "knobs and dials" phase where relatively straightforward measures could be made at the interface. Now the systems are so much more complex, with a high level of automation, and you can't isolate the human component as easily as you used to. This means that measures of performance are in a sense linked to the performance of the computer systems that are working with the human operator. It becomes difficult to measure the human's contribution to the overall system performance. It's analogous to the difficulty of measuring the contribution of one individual in a group task. I think that, inevitably, as we get better at our job, our jobs will become more difficult.

CSERIAC: As you say, it's clear that our jobs will be more difficult, but the requirement to demonstrate cost-effectiveness remains.

Dr. Sheridan: You know, there's an ongoing argument about whether the human performance measures at the "local" level ever correlate with the measures of system performance at the global level, and how you can ultimately verify this. Regardless, I think we should keep trying, although at times it seems a bit like Sisyphus pushing the rock up the hill.

CSERIAC: In a recent issue of *Gateway*, Alphonse Chapanis made a plea for researchers to include a section in all their reports which states the potential rel-

evance of the research to real-world problems. What are your feelings about this?

Dr. Sheridan: I am of the opinion that somewhere there ought to be some research which is funded just because it's interesting, without any thought of relevance. I guess that is my definition of basic research. Of course, I am not saying that all, or even the majority of research should be done this way, but I think there ought to be research that is not "relevant." I agree with Dr. Chapanis insofar as the researcher has something to say about relevance. I'd be interested in hearing about it, but I don't think it should be compulsory. Of course, if the research is sponsored, and if the researcher has promised solutions to real problems, then of course, as the sponsor I would expect to see the connection between research results and the problem.

CSERIAC: I think most of us would agree that the promise of AI (artificial intelligence) applications a couple of years ago was oversold. Although AI has found its way into some isolated software applications, it has not been able to deliver on many of the promises made. It seems that applications of virtual reality might also be in danger of being oversold. Do you agree?

Dr. Sheridan: I think it is being oversold. In some ways the overselling is more rampant than with AI. In the case of AI, a large part of it was so far beyond a lot of the

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ANSUR: The US Army Anthropometric Data Base

Claire C. Gordon

Anthropometry, the quantitative study of human body size and shape, has wide application in military materiel missions including the design and sizing of uniforms, combat clothing and equipment, shelters, transportation systems, and crewstations. The US Army has been conducting systematic anthropometric surveys of its population for the past 50 years. In 1988, the US Army Natick Research, Development, & Engineering Center completed its most recent anthropometric survey (ANSUR), which includes more than 180 dimensions measured on 8,997 active-duty soldiers.

ANSUR took two years to plan and more than a year to complete. Eleven Army posts participated, and some 25,811 active-duty soldiers were screened for participation. Functional units (e.g., infantry, artillery, medical, transportation, supply) were selected for screening in proportion to their representation in the Army. Screening included answering 26 biographical questions and measurement of height and weight in running shorts and t-shirt. Subjects were then selected randomly for complete anthropometric measurement, with probability of selection varying as a function of their gender, age, and race. Figure 1 shows a subject being measured.

Each ANSUR subject was measured directly for 132 body dimensions; a palmar photograph and collimated light silhouette were taken of the right hand using a specially designed photographic device; and three-dimensional coordinates for 28 head and face landmarks were captured using an automated headboard system also specially created for the survey. The measuring process took approximately two hours, as each subject visited seven measur-

ing stations in turn. Each measuring station was equipped with a portable computer for data entry, and preliminary data editing, which included range checking and regression estimation, was done on site where questionable data values were verified before the subject left the area. Unlike previous Army surveys, which focused primarily on clothing-related dimensions, ANSUR supports a variety of human engineer-

ing applications including dress uniforms, protective clothing ensembles, workstation design, aircraft crewstation design, and mathematical man-models.

ANSUR utilized a unique sampling plan and database construction. Minority demographic groups were intentionally oversampled in the survey to support basic research goals and to provide a data pool from which working data bases can be derived and

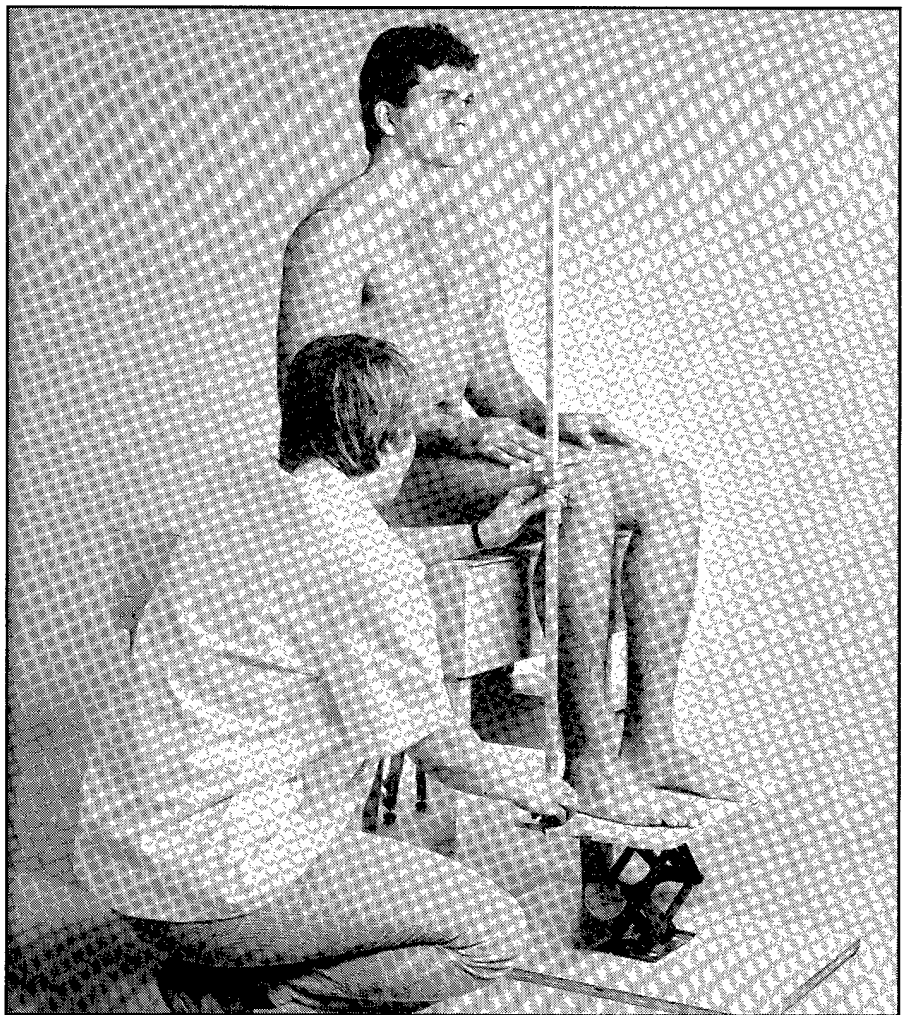


Figure 1. Knee-height measurements, sitting, being taken. These are used in determining location of instrument panels in cockpits and desk heights in office equipment. Photo by Tebby Stanley

GATEWAY

periodically reconfigured as Army demographics shift in the coming decades. Oversampling in each gender/race/age cell also facilitates the construction of demographically matched subsets that can represent special organizational units within the Army or other Armed Services, including many of our European allies.

After the ANSUR survey was completed, working data bases were formed by stratified random sampling within age and race cells utilizing relative frequencies from the contemporary active duty force. This process produced male and female working data bases that exactly matched active duty Army demographics for June of 1988. Army demographics are checked annually to determine whether reconfiguration of the working data bases is required.

In addition to working data bases that reflect general Army anthropometric distributions, pilot data bases were also created to support cockpit geometry and personal equipment applications specific to that group. The male pilot data base is composed of 487 pilots whose demographics match those of the 1988 pilot population. Because the number of female pilots is insufficient to support statistical inferences about that population, the female pilot data base (n=334) was artificially created by selecting only those women meeting current entrance criteria for flight school, and then using stratified random sampling to match age/race frequencies to the 1988 female pilot population. This method had been previously validated on male pilots by comparing an artificially created pilot data set with the actual pilot data base. In that trial, only 10 of 132 dimensions tested showed differences that were statistically significant at the .05 level, all were of extremely small magnitude, and 7 of the 10 might have been expected based on chance alone.

The methods and results of the ANSUR survey are published in a series of NATICK technical reports and journal articles. These are listed in Figure 2 and include research on

interobserver error and secular trends, as well as summary statistics such as means, standard deviations and percentiles, bivariate frequency tables, correlation matrices, and multiple regression equations. Summary statistics calculated on the general Army and pilot working data bases have also been incorporated in updates of Military Standards and Handbooks including MIL-STD-1472 and DOD-HDBK-743. Copies of the original data are available on magnetic tape from the Defense Technical Information Service. ANSUR summary statistics and measurement descriptions, along with comparative data from other military and civilian anthropometric surveys, are also available online through CARD, the Center for Anthropometric Research Data, which is one of CSERIC's many services.

Recognizing the importance of anthropometric data for Computer Aided Design of workstations and protective clothing, ANSUR data have also been incorporated into JACK, a com-

puterized man-model under development by Dr. Norman Badler at the University of Pennsylvania Computer Graphics Laboratory. Development of JACK is jointly funded through the Army Research Office by Natick, the US Army Human Engineering Laboratory, and the NASA-Ames Research Center. Since nude anthropometric data are of limited use in workstation design, ongoing anthropometric research at Natick includes clothed anthropometry and range-of-motion projects which will be used to augment JACK's nude dimensions derived from ANSUR.

For further information on the ANSUR database, contact the author at US Army Natick Research, Development, & Engineering Center, Natick, MA 01760-5020, (508) 651-5429, DSN 256-5429. ●

Dr. Claire C. Gordon is the Behavioral Sciences Division Senior Anthropologist at the US Army Natick Research, Development, and Engineering Center, Natick, MA.

TECHNICAL REPORTS:

<i>Hand Photo System</i>	Natick TR-87/044
<i>Measurer's Handbook</i>	Natick TR-88/043
<i>Data Editing Software</i>	Natick TR-88/045
<i>Automated Headboard</i>	Natick TR-88/048
<i>Descriptive Statistics</i>	Natick TR-89/027 or 044
<i>Bivariate Frequency Tables</i>	Natick TR-89/031
<i>Regression Equations</i>	Natick TR-89/035-036
<i>Correlation Coefficients</i>	Natick TR-90/032-034
<i>Secular Trends-Males</i>	Natick TR-91/006
<i>Pilot Descriptive Stats</i>	Natick TR-91/040
<i>Hand Anthropometry</i>	Natick TR-92/011

ARTICLES:

Interobserver Error	<i>American Journal of Human Biology</i> (1992)
Secular Trends	<i>American Journal of Human Biology</i> (1992)
Foot/Stature Relationships	<i>Journal of Forensic Sciences</i> (1992)

PRESENTATIONS:

<i>Quality Control</i>	Human Factors Society (1991)
<i>Secular Trend Modeling</i>	American Anthropological Association (1991)
<i>Racial Variation</i>	American Anthropological Association (1991)
<i>Sexual Dimorphism</i>	American Anthropological Association (1991)
<i>Self Reported Race/Ethnicity</i>	American Anthropological Association (1991)

Figure 2. ANSUR reports which document the methods and results of the survey

Aircraft Agility and Human Factors Integration

Mark J. Detroit

Current efforts to extend controlled flight into the post-stall regime will bring about major changes in aircraft dynamic capability. These changes will have far-reaching implications in terms of the specification, design, evaluation, and operational use of future fighter aircraft, particularly as these enhanced airframe capabilities begin to challenge pilots' limitations. Significant research continues in developing the technologies required to design and build both agile airframes and pilot-vehicle interfaces. There is a need to ensure that requirements for both are adequately represented and integrated into the specification and design process with the flight mechanics community.

The high-angle-of-attack flight regime has always been of significant interest to the aviation community. Since the earliest days of flight, researchers have sought to understand the nature of departure characteristics, as well as spin modes and recovery techniques. Revolutionary advances in flight control technology in the late 1960's and 1970's enabled designers to achieve departure resistance using control-limiting concepts which permitted relatively "carefree" maneuvering. At the "cutting edge," this type of maneuvering is limited only by pilot capability. Stability augmentation and aerodynamic design techniques improved lateral-directional stability, thus increasing the maximum usable angle of attack (maximum usable lift) and improving maneuver capability. Stability augmentation also permitted routine operation of inherently unstable airframes, allowing more agile response within the heart of the envelope.

In the late seventies, researchers

began to look at pushing controllability beyond maximum lift angle of attack (AOA) into the post-stall regime. They believed such capability would enable aircraft to perform unique maneuvers which theoretically could provide a significant advantage over conventional maneuvering performance during certain tactical situations. Many recent technological advancements—most notably thrust vectoring, improved thrust-to-weight ratios, and integrated flight/propulsion control—have made controlled post-stall flight truly feasible. As these technologies continue to advance, it becomes increasingly likely that post-stall capability will be included in next-generation tactical aircraft (as well as potential upgrades to existing aircraft). Already, the YF-22 Advanced Tactical Fighter prototype includes pitch vectoring and has demonstrated the capability to fly to angles of attack up to sixty degrees.

As aircraft capabilities continue to advance, the Air Force is faced with an increasingly difficult task. They must weigh the costs and benefits of these various capabilities and determine the proper mix to satisfy future requirements while facing tighter budget constraints. To accomplish this task, the Air Force needs to understand the utility of both increased agility and post-stall maneuvering. How are they employed? What advantages are gained? When should post-stall maneuvering be avoided? How is it limited by human factors considerations? In addition, the Air Force needs to know the cost, not only in dollars but also in terms of reductions to other capabilities. How do increased control surfaces or thrust-vectoring nozzles influence signatures? How much are weight and drag increased (thereby reducing range or

payload)? How are training requirements affected? What are the effects of human control capabilities, spatial disorientation, situation awareness, rapid onset profiles, and long-term high-g exposures? How can controls and displays improve agile performance? Conversely, how is maneuverability reduced by inherent pilot-related limitations and what is the impact of that reduction on combat effectiveness? The variations in costs and benefits for various levels of pilot/vehicle capability must be quantified. Once suitable levels of capability have been identified, there must be a means to specify requirements which are consistent with those levels and a means of evaluation to ensure that those requirements are met.

The concept of agility is a product of the Vertical/Short Take-Off and Landing (V/STOL) community. The term was used to describe acceleration, deceleration, load factor, and turning capability. These capabilities were not suitably addressed by classical performance or stability and control. They defined agility as "the combination of performance and maneuverability that determines how rapidly an aircraft can accelerate, decelerate, and turn at specified rates of climb and airspeed."

In the late 1970's, the fighter community began to recognize the need for a better means to describe maneuvering capability. With more highly maneuverable airframes and the introduction of all aspect weapons and off-boresight radar acquisition, engagement times were reduced and tactics began to evolve which incorporated the importance of nose-pointing, even at the expense of energy, to quicken the kill and reduce exposure. As enhanced agility increased

onset rates, angular rates, and multi-axis g-stress, pilot limitations became an increasingly important concern and often constituted the limiting design consideration.

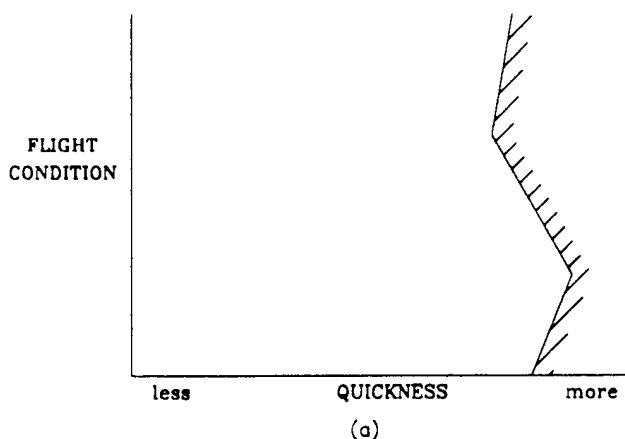
In the late 1980's, the interest in fighter agility became more widespread as workshops were held to promote work in the area, and flight test programs began to focus on agility. However, with the increasing interest in agility came increasing disparity in the proposed measures and in the meaning of the term itself. This disparity was primarily due to the emphasis on agility as a measure of combat capability rather than simply a measure of maneuver capability. Most recently, the issue has been further confused by the use of the term agility when referring to the total combat effectiveness of the weapon system (in the sense of minimum time to perform a task), including airframe, weapons, avionics, and pilot. Sometimes the expressions system agility and operational agility are used to differentiate this "total system" concept. While the importance of the combat performance of the integrated system cannot be overemphasized, agility is strictly a measure of maneuvering capability, which is solely a characteristic of the aircraft. Its relationship to combat effectiveness will be dependent upon the specific operational scenario considered, the tactics employed, and (with increasing importance) human factors limitations.

To ensure that the reader understands the author's perspective, the following definitions are proposed:

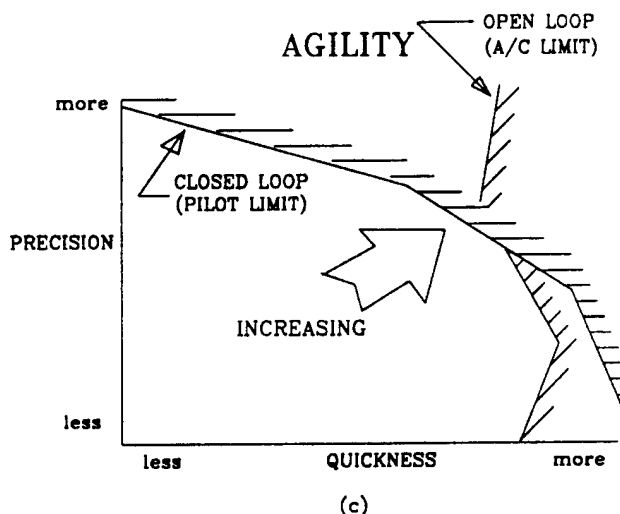
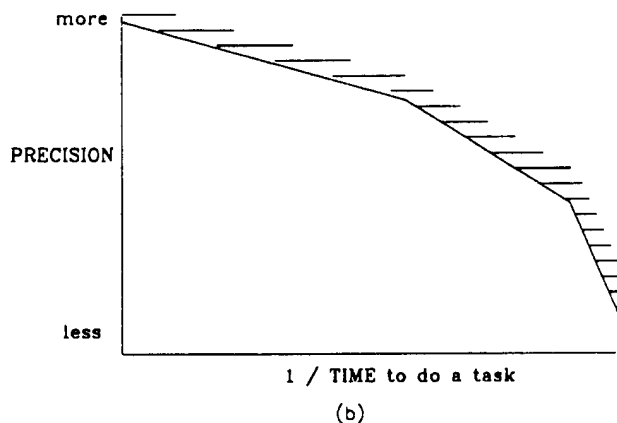
If a maneuver state is a specific set of parameters (e.g. velocity, angle of attack, load factor, attitude, rotation rates, etc.) which uniquely identify a flight condition, then maneuverability is the ability to attain, sustain, and transition between maneuver states. The third part of maneuverability definition, the ability to transition between maneuver states, is itself in need of further clarification.

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AIRCRAFT DYNAMIC CAPABILITY



FLYING QUALITIES



Relationship between (a) open-loop airframe response, (b) flying qualities, and (c) agility

tion. Transition capabilities are often addressed by maximum roll rates, maximum G onsets, and other similar quantities which fall short of adequately describing this concept and do not necessarily provide the pilot with a true sense of how his aircraft compares to that of his opponent. Transition may be the most critical capability, especially in a highly dynamic engagement where more of the time may be spent in transition. This transitioning part of maneuverability is agility, a measure of the ability to transition from one maneuver state to another in minimum time. From this definition, it can be seen that agility relates to several aspects of performance, stability, controllability, and flying qualities.

Three important points should be made regarding agility. First, agility is desired throughout the envelope and is related to high AOA and post-stall maneuvering only insofar as a certain level of agility is necessary for maneuvering at high AOA. Second, agility may play a critical role in many aspects of the mission for a variety of aircraft types. Although the emphasis has recently been on air-to-air combat for fighters, it may be equally important to a transport attempting a lateral offset during approach. And third, two separate but closely related capabilities are addressed by agility: the ability to control attitude (nose pointing) and the ability to control speed and flight path (velocity vector magnitude and direction).

As mentioned previously, system agility is the total combat effectiveness of the weapon system (in the sense of minimum time to perform a task), including airframe, weapon, avionics, and pilot. It is here that human factors concerns will have the greatest impact.

From a military perspective, the primary objective of research is to develop highly capable weapon systems which are superior to any known or projected threat, while remaining affordable. Superior means more lethal and more survivable in terms of the total force capability.

In terms of maneuverability, the

objective is then to achieve a level which is compatible with all other capabilities. This implies the need to understand (1) the effect of enhanced maneuverability on other capabilities, (2) the effect of other capabilities on maneuverability, and (3) the relationship between maneuverability and combat effectiveness. This also means maneuverability (including agility) must be quantifiable not only so that it can be related to combat effectiveness but also so that it can be specified in requirements and evaluated during design and flight test.

The pilot's ability to control the dynamics is the tie between agility and flying qualities and has become more critical as dynamic capability has increased. This relationship is shown conceptually in the figure. Part (a) shows that there is a limit to the open-loop dynamic capabilities of the aircraft. Part (b) shows that as the degree of precision demanded is increased, the time required to perform the task increases. This bound is set by closed-loop, flying qualities types of limitations. Part (c) shows how these two factors combine to set boundaries on agility. And as dynamic capability is increased, more of the bound will be determined by flying qualities and human factors limitations. Therefore, to increase agility, one must address both the open-loop airframe capability and the closed-loop pilot-vehicle capability.

The author hopes that this article helps to clarify the direction and progress of an exciting area of aircraft research. I have attempted to discuss historic and current research in agility and identify a definitive gap between flight mechanics and human factors research in this area. The agility flight environment includes many human factors concerns of which flight mechanics specialists are unaware. Communication appears to be the largest factor...let's talk. ●

Mark J. Detroit is an Aerospace Engineer for CSERIAC.

Sheridan Interview

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community that they didn't even try to get involved in it. Virtual reality is more "accessible"; an example is its appeal to portions of the art and media communities. There may also be a quicker sensitivity to the over-selling, so I think the criticism may be mounted more quickly; the action and reaction will occur on a shorter timebase than was the case with AI. Maybe there have always been fads in science, and that what we are seeing is another fad.

CSERIAC:

Within the DoD community, where do you see the greatest application of virtual reality?

Dr. Sheridan:

Certainly it has application in training, but that's where it has historically been...going back to the Link trainer. It's not new; fidelity and training simulation has been around a long time. A second application is one where the human controls external devices using virtual imagery. We already see this in various visually coupled systems, such as those under development here at Armstrong Lab. A third area is scientific visualization in design and development, where the human needs to visualize complex relationships. An example is wind tunnel phenomena... things you can measure but cannot normally experience with your senses. Virtual reality permits you to take those measurements, put them in a computer database and visualize the relationships you could not see before. Landsat photographs or measurements of complex fluid flow are similar situations. It is useful in any application where the phenomena are outside the real world as far as the human senses are concerned. You could call it "enhanced design and development." ●

Psyching Out Multi-Task Management

Yvette J. Tenney

Editor's note: Copies of Strategic Workload and the Cognitive Management of Advanced Multi-Task Systems are available through the CSERIAC Program Office for \$35.00.

Deadlines, interruptions, competing task demands, unexpected events—all contribute to the workload of operators of complex systems and vehicles. Although automation has the potential to alleviate workload problems, it has too often resulted in the opposite effect. When automation is added to the work environment in a piecemeal fashion, it may fail to take the cognitive organization and limitations of the operator into account. In particular, it may force the operator to pop in and out of tasks, without providing the cognitive support that the operator needs to make these transitions. As a result, the operator may misinterpret or overlook subtle aspects of the new situation and forget critical aspects of the interrupted task.

If designers of complex systems are to accomplish the objective of producing human-centered automation, they will need some guidelines based on an adequate theory of human performance in multiple-task situations. Such a theory would have to account for the extent and limitation of people's abilities to recover from interruptions, to prioritize tasks in terms of goals, to perceive events within a larger context, and to schedule and complete all tasks as required in the service of mission or system integrity.

In the past, research in psychology and human factors has focused on the performance of "dual tasks" in which subjects perform two tasks simultaneously. Such time-sharing tasks, though of theoretical interest, lack many of the important characteristics of real-world tasks including flexible response constraints, less rigid time constraints, a

more complex goal structure, opportunities for rescheduling, and significant demands on memory and thought. For these reasons, there is urgent need for a paradigm shift in the study of multiple-task performance. More realistic research paradigms are needed if progress is to be made in understanding how errors of oversight and misinterpretation can arise in multiple-task situations. The good news is that researchers and system developers have begun to respond to the issues raised by the advent of complex multiple-task scenarios, yielding promising steps in the areas of theory development, system design, and training.

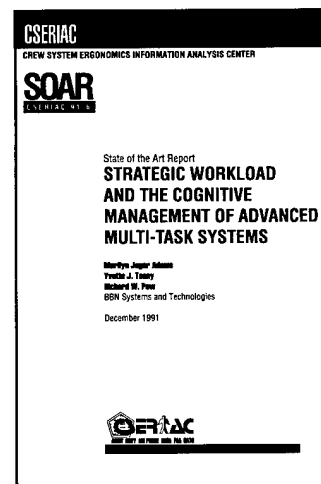
A new CSERIAC State-of-the-Art Report, entitled *Strategic Workload and the Cognitive Management of Advanced Multi-Task Systems* written by Marilyn Jager Adams, Yvette Tenney, and Richard Pew, charts the progress made in this area. The authors, following the lead of Sandy Hart, use the term "strategic workload" to refer to the operators' discretionary allocation of thought and effort in managing task loads and achieving goals in realistic multi-task situations. Their monograph raises a broad spectrum of psychological issues that go beyond those conventionally associated with divided attention or dual-task performance to include concerns about situation awareness, interruptions, prioritization and scheduling, maintenance of the queue of pending tasks, and the roles of knowledge and expertise. Their report draws from the fields of psychology, artificial intelligence, operations research, and computer science to piece together a coherent picture of the cognitive processes and stressors involved in managing multiple tasks. Building on interactive theories of perception, connectionist theories of associative knowledge structures, and schema theories of comprehension, they de-

velop a framework for raising new questions about the nature of situation awareness and the real-time management and control of multiple streams of activity.

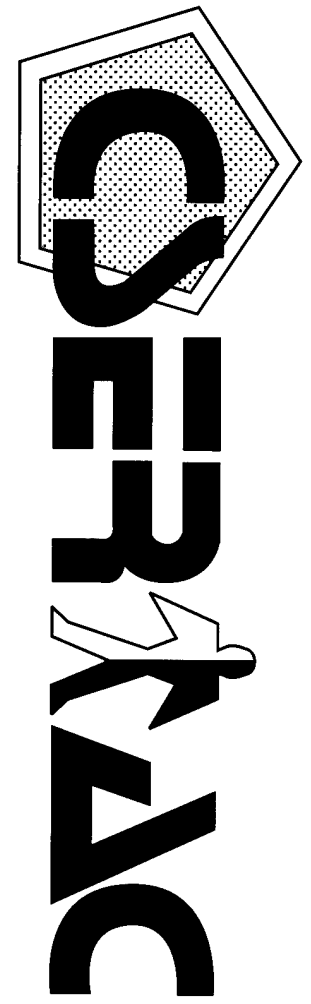
With this understanding as background, the authors explore potential solutions to the problem of reducing mental workload in multi-task situations. Examples from the recent literature are presented, suggesting personnel selection as well as training and design alternatives that are likely to promote more effective multi-task management. These alternatives are directed at improving information sampling, reducing processing complexity, making information conform to human memory characteristics, scheduling to avoid overload, and adaptive computer-aiding procedures.

Throughout the monograph, suggestions are made for research yet needed to extend the existing literature and to develop theory and application of human cognitive processing in support of the management of complex, multi-task situations. ●

Yvette J. Tenney, Ph.D., is a Scientist in the Systems & Technologies Division of Bolt Beranek and Newman, Cambridge, MA.



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- customized responses to bibliographic inquiries;
- written reviews and analyses in the form of state-of-the-art reports and technology assessments;
- reference resources such as handbooks and data books.

Within its established scope, CSERIAC also:

- organizes and conducts workshops, conferences, symposia, and short courses;
- manages the transfer of technological products between developers and users;
- performs special studies or tasks for government agencies.

Services are provided on a cost-recovery basis. An initial inquiry to determine available data can be accommodated at no charge. Special tasks require approval by the Program Manager.

To obtain further information or request services, contact:

CSERIAC Program Office
AL/CFH/CSERIAC
Wright-Patterson AFB, OH 45433-6573

Telephone (513) 255-4842
DSN 785-4842
Facsimile (513) 255-4823

Associate Director: Dr. Lawrence D. Howell; *Contracting Officer's Technical Representative:* Dr. Reuben L. Hann; *DoD Technical Director:* Dr. Kenneth R. Boff.

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