AD 268 204

report

Third Annual

ARMY HUMAN FACTORS ENGINEERING CONFERENCE

2-4 OCT 1957

QUARTERMASTER RESEARCH & ENGINEERING COMMAND
NATICK, MASS.

SPONSORED BY:
CHIEF OF RESEARCH AND DEVELOPMENT
OFFICE OF THE CHIEF OF STAFF
DEPARTMENT OF THE ARMY

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
WASHINGTON 25, D. C.

CRD/J 28 October 1957

SUBJECT: Third Annual Army Human Factors Engineering Conference Report

TO: See Distribution

1. This report is the record of subject Conference held at the Quartermaster Research and Engineering Command, Natick, Massachusetts, on 2, 3, and 4 October 1957, and is published for the information and retention of the personnel and agencies indicated in the distribution list. The Conference was attended by the persons listed in Appendix 1 of this Report, and was sponsored by the Office of the Chief of Research and Development. Purposes of the Conference were as listed in Chapter I, Introduction, of this Report.

2. The Army now has three years of experience of these Conferences, and finds them valuable because:

a. they present a formal opportunity for the "user" agencies, e. g. USCONARC, to give guidance to developing agencies as to human factors in tactical considerations relevant to design characteristics;

b. the Conference Report presents a useful authoritative compendium of the work programs in human factors engineering of all of the Technical Services; and

c. the interchange of views and information at these Conferences has had a demonstrable effect in improving the effectiveness of human factors engineering in Army research and development.

3. As a consequence of recommendations of this Conference and its predecessors, actions are being taken in the Army General Staff to:

a. establish by Army Regulation a Human Factors Engineering Council which will be responsible for planning the annual human factors engineering conference and for guidance as to the program materials to be reported therein (See Appendices 2 and 3 of this Report); and

b. give continuing emphasis to the training of selected Army officers in human factors engineering.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

T. J. Conway
T. J. CONWAY
Brigadier General, GS
Director of Research

Distribution:
One copy to each member of the Conference
Army: DCS/MO (2); DCS/P (2); DCS/L (2); TAG (3); TSG (10); COFORD (10); COFENGRS (10); TOMG (10); COFT (2); CSIGO (10); CCMLO (10); ORO (5); HumRRO (5)
Navy: ONR (5)
Air Force: DCS/D, R&D (5)
DOD, Misc: OASD, R&D (2); AFSWP (2); NWC (2); ICAF (2), ASTIA (2); AFEB (2)

CONFERENCE REPORT

3rd ANNUAL ARMY HUMAN FACTORS ENGINEERING CONFERENCE

2, 3, 4 October 1957

QUARTERMASTER RESEARCH & ENGINEERING COMMAND
Natick, Massachusetts.

TABLE OF CONTENTS

TABLE OF CONTENTS--Cont.

THIRD ANNUAL ARMY HUMAN FACTORS ENGINEERING CONFERENCE

QM R&E COMMAND

Natick, Massachusetts

2, 3, and 4 October 1957

I. AGENDA OF THE CONFERENCE

2 Oct 57 MORNING SESSION: Dr. Lynn E. Baker, OCR&D, Chairman.

0930-1030 Registration

1030-1100 Opening of the Conference:
Announcements: Dr. Lynn E. Baker, General Conference Chairman
Welcome: Brig. Gen. C. G. Calloway, Commanding General, Hq QM R&E Command, Natick

1100-1130 Introduction of Keynote Address: Brig. Gen. T. J. Conway, Director of Research, OCR&D
Keynote address: Dr. James B. Edson, Assistant to the Director of Research and Development, OSA. "Man: The Ultimate Weapon"

AFTERNOON SESSION: Dr. Austin Henschel, Environmental Protection Research Division, QM R&E Command, Session Chairman.

1300-1400 USCONARC Presentations
Col. H. V. Middleworth, HQ USCONARC, Combat Developments Section: "New Organizations and Tactics"
Lt. Col. E. A. Fossum: "Impact of New Tactical Concepts on Materiel Objectives"

1415-1445 QM Presentation: Dr. E. Ralph Dusek, Psychology Branch, EPRD: "Manual Performance in the Cold"

1445-1630 QM R&E Center facilities tour.

3 Oct 57 MORNING SESSION: Dr. Henry F. Gaydos, Psychology Branch, EPRD, QM R&E Cmd, Session Chairman.

0830-0900 TSG Presentations
Col. Charles W. Hill, MSC, Research and Development Division, OTSG: "Selected Significant Results of Recent Unpublished Research Within the Research and Development Division of the Office of The Surgeon General."

Dr. Lee S. Caldwell, U. S. Army Medical Research Laboratory: "The Effect of the Spatial Position of a Control on the Strength of Six Linear Hand Movements"

Capt. John L. Fletcher, MSC: "Noise Exposure and Hearing Loss: A Military Problem"

0900-0945 USCONARC Presentation
Maj. Nelson A. Mahone, Jr., Avn Bd, and Capt. John J. Sullivan, Arm Bd.
"Examples of the Practical Influence of Human Factors Data on Army Equipment Design"

1000-1130 Concurrent, separately assembled, Working Group Sessions
Group A, Room R302, Col. E. A. Fossum, Chairman:
"Utilization of Available User Experience Information During Engineer Design Stage of New Equipment Design"

Group B, Room R120, Dr. Henry Gaydos, Chairman:
"Training of Engineers in Application of Human Factors Data, and Optimum Utilization of Engineering Psychologists in the Technical Services"

Group C, Room R106, Dr. John Kobrick, Chairman:
"Establishment of an NRC Committee to Select and Arrange for English Translations of the Best Foreign Literature in Human Factors Engineering"

Group D, Room R109, Col. Charles W. Hill, MSC, Chairman
"Human Factors Contributions to Equipment Design for Night Operations"

Group E, Room D200, Mr. Henryk J. Bukowski, Chairman
"Human Factors in Design for Ease of Maintenance of Army Materiel"

AFTERNOON SESSION: Dr. E. Ralph Dusek, Psychology Branch, EPRD, QM R&E Cmd, Session Chairman

1300-1330 OrdC Presentation
Dr. John D. Weisz, Ordnance Human Engineering Laboratory, APG: "System Evaluation of Ordnance Materiel"
Mr. Thomas Goldsmith, Human Engineering Unit, Picatinny Arsenal: "Specification of Brightness and Readability for Self-Luminous Control Panel Elements."

1330-1400 CmlC Presentation & Film
Dr. Earl Davey, Army Chemical Center, Md.: "Human Factors Engineering Aspects of the Design of Field Protective Masks"

1400-1430 TC Presentation
Dr. John W. Bailey, Transportation Corps Research and Engineering Command: "Human Factors Engineering in the Transportation Corps"

1430-1500 TSG Special Presentation
Col. Maurice Fletcher, MSC, Army Prosthetics Research Laboratory: "Some Human Factors Engineering Implications from Design of Prosthetics."

1515-1700 Concurrent, separately assembled, Working Group Sessions (Continued in Rooms as indicated for morning session, same date)

1700-1830 Social Hour

4 Oct 57 MORNING SESSION: Dr. John M. McGinnis, Psychology Branch, EPRD, QM R&E Cmd, Session Chairman

0830-0900 CofEngr Presentations
Mr. Alonzo J. Vrooman, Mechanical Engineering Department, USAERDL: "Industry's Acceptance of Ease of Maintenance Features in Design"
Mr. Benjamin Goldberg, Electrical Engineering Department, USAERDL: "Effect of Flicker on Humans"
Mr. Henryk J. Bukowski, Provisioning Division, Engineer Maintenence Center, Columbus, Ohio: "The Human Engineering Factor in Equipment Specifications"

0900-0930 SigC Presentation
Mr. Paul E. Griffith, Office of Engineering Operations, USASEL: "Selected Significant Results of Recent Signal Corps Research, and Major Future Studies Planned"

0930-1130 Reports of the Conference Working Groups

AFTERNOON SESSION: Dr. Lynn E. Baker, OCR&D. Chairman

1300-1400 Invited Paper
Dr. Alphonse Chapanis, Johns Hopkins University: "Human Factors in Systems Engineering"

1415-1430 General Chairman's Summary of the Conference.

1500 Conference Adjourns.

II. INTRODUCTION

References and Background of the Conference, and Summary of Opening Remarks of Dr. Lynn E. Baker, General Chairman of the Conference, and of Brigadier General C. G. Calloway, Commanding General, Hq QM R&E Command, Natick, Mass.

1. SPONSORSHIP OF THE CONFERENCE: The Annual Army Human Factors Engineering Conference is sponsored by the Chief of Research and Development, Department of the Army. Two previous such Conferences have been held and their reports are as follows:

a. "Army Human Engineering Conference," The Pentagon, 14-15 December 1955.

b. "Second Annual Army Engineering Psychology Conference," 7-9 November 1956, Army Medical Research Laboratory, Ft Knox, Ky.

2. PURPOSES OF THE CONFERENCE: The purposes of the Conference are to:

a. Provide direct interchange of information on human factors engineering among personnel of Army development and user agencies and other related qualified individuals;

b. Provide recommendations for Army follow-up to assure exploitation of all opportunities for improving man-machine compatibility in the design of Army materiel.

c. Provide a Conference Report which gives a useful and complete single annual reference summary of all Army human factors engineering R&D activities.

3. WORK OF THE CONFERENCE: a. Preparation of Conferees. Appendix 2 of this Report was distributed as Conference "Homework" material for advance study. These materials summarize, for each Army Agency having a human factors engineering R&D program: I. Vitae of Professional Personnel; II. Current Projects; III. Bibliography of Published Reports.

b. Presentations: Presentations assume familiarity with the above materials and cover selected recent unpublished R&D results and major future plans. In addition, the "keynote" address and distinguished invited paper are presented in Chapters III and VII of this Report.

c. Working Groups: Groups were assembled at or in advance of the Conference on selected topics, with specific terms of reference, to present recommendations to the Conference for Army follow-up action, or to initiate continuing study for report and recommendation at a subsequent Conference. The Working Group Reports are presented as Chapter VII of this Report.

4. Welcome to the Quartermaster Research and Engineering Command at Natick was extended by Brigadier General C. G. Calloway, Commanding General.

5. Appreciation for the excellent facilities and arrangements provided for the Conference by its host, Brigadier General Calloway, was expressed by the Conference Chairman, who then introduced Brigadier General T. J. Conway, Director of Research, OCR&D.

III. MAN: THE ULTIMATE WEAPON

INTRODUCTION OF KEYNOTE ADDRESS

Brigadier General T. J. Conway

Mr. Chairman, Distinguished Guests, Ladies and Gentlemen:

Lt General Gavin, Army's Chief of Research and Development, and Maj General Wood, his Deputy, wish me to bring you their best wishes for an interesting and productive Human Factors Engineering Conference. Both General Gavin and General Wood would have liked to be here. Both fully understand and endorse the values of this Conference in improving human factors engineering of Army equipments. Both, however, are presently occupied on other important matters of equally great concern to the well-being of your programs and all of Army R&D, notably the Army Budget. They therefore must send you their greetings and best wishes while they carry forward these other pressing matters.

News from the Pentagon at this time surely, as you know, must give a central role to budgets and funding. We are having an unusually long "budget season" this year. We have always practiced strict economy in the Army and will continue to do so in future. Beyond strict economy, however, I believe that you already know that substantive cuts may also be necessary this year in many Army R&D programs.

In the face of the probable necessity for such cuts, you will be pleased to know that, as a matter of R&D policy, the Army recognizes that the man is uniquely central to accomplishment of the Army's mission. Accordingly it has already been determined that, insofar as possible, the Army's small but important Human Factors research program will be spared the brunt of budget reductions. This does not mean, of course, that it will be possible to avoid some reductions in this program. It does mean that, as you individually may face curtailed funding, you may take some grim comfort from the realization that "it could have been worse."

Dr. Rollefson, who last year addressed this Conference as Army Chief Scientist, has now returned to his position as Chairman of the Department of Physics at the University of Wisconsin. Dr. Richard A. Weiss has been designated Acting Chief Scientist. As further "news from the Pentagon," you may also have heard that the Human Factors Research Division of the Office of the Chief of Research and Development has now moved to Ft. Belvoir. At Ft. Belvoir we have established an "OCR&D Field Office" which remains an integral part of the Office of the Chief of R&D yet takes advantage of the benefits of space and detachment afforded by a field location outside the Pentagon. As a companion-piece to this improvement of their office facilities you should also be aware that your General Chairman, Dr. Baker, has in the past few months been elevated to be the Army Chief Psychologist and General Gavin's principal scientific advisor on matters affecting human factors in Army R&D.

I indicated earlier that the Army recognizes that the man, the soldier, is central to accomplishment of the Army's mission in war. Those of you who are not Psychologists may wonder what possible connection could prompt us to ask an astronomer and astrophysicist to be the "keynote speaker" for a conference focused on human factors. For those of you who are Psychologists, such a choice will seem singularly appropriate. You Psychologists will recall that it was the English Astronomer, Maskelyne who, in 1796, dismissed his assistant because of a large and increasing error which was somehow creeping into the Greenwich observations of the times of stellar transits. These observations of Maskelyne on his unlucky assistant were further analyzed and experimented with by the German astronomer Bessel at Koenigsberg, who found that there were certain constant differences among observers. In 1822 Bessel published the results of these studies attributing these constant differences, which you now study as "reaction time," to something he called "the personal equation."

In the Army Ordnance Corps, and more recently in his new post as assistant to Dr. Martin, the Army's Director of Research and Development, our astronomer-keynoter has had numerous opportunities to observe and reflect upon "the personal equation" in connection with the Army's mission. He has reached some conclusions on this matter which I know you will want to hear. I am therefore pleased to introduce to this Conference Dr. James Edson, whose address bears the significant title "Man: The Ultimate Weapon."

Ladies and gentlemen, Dr. Edson.

"MAN, THE ULTIMATE WEAPON"

Dr. James B. Edson,
Assistant to the Director of Research and Development
U. S. Department of the Army

I bring to you Dr. Martin's heartiest greetings. He has emphasized to me the importance that he attaches to your field of human factors work. He reviewed for me his address to you at your conference two years ago, in which he recounted his own human factors studies in connection with the creation of the modern telephone.

Dr. Martin confidently expects you further to extend the application of measurement and quantitative theory to broad human problems, an activity to which biologists, psychologists, and engineers have already so notably contributed. He urges you to make increasing use of operations research; this in the interest both of effectiveness and economy. He counsels you to become ever more familiar with the special problems and requirements of the soldier, in order more effectively to discharge your key role as transducers between the scientific and the military communities. Finally, Dr. Martin reminds you of what you already know--that the Army keenly appreciates and supports your work.

General Conway has referred to the battle of the budget. I would like personally to testify to the energy, endurance, wisdom, and gallantry with which General Conway and the whole Army staff team conduct that unending campaign. It remains a fact, however, that, in these days of tight budgets, the Army's appreciation of your work and of your aspirations may not always find full expression in dollars. Indeed, perhaps our efforts should not be so measured. Rather, the true measure of accomplishment may well be taken by each of us for himself. You have, I am sure, shared my experience of those small but repeated incidents that remind us of the innocent and almost terrible trust reposed in every one of us by our neighbors and fellow citizens. They must, and do, depend on us to outmatch and to overawe the powers that threaten them. They give us not only of their trust, but also generously of their substance. They carry us on their shoulders, that we may see further than they. So, as you present your work here, you might imagine that your Russian colleagues are sitting out there in the empty rows. I hope that, as you go on, you may sense a proper awe and respect in that phantom audience. I hope that you may never hear, as I have once or twice, the ghostly echo of their scornful laughter.

But enough of these occult manifestations. With so many psychologists in the audience I'd better get away from parapsychology and back to the safe realm of astronomy. As General Conway pointed out, Bessel's analysis of the personal equation certainly lies close to the beginnings of quantitative psychophysiology. Astronomers have encountered some other interesting human factors problems that are directly connected with work to be reported at this conference. Astronomical studies of atmospheric shimmer began with the invention of the telescope. The original telescope tracking problem was to keep a camera aimed precisely at a star field during many hours of exposure. Controversies over observation of support "markings" on Venus, which are not real, and the "canals" of Mars, which are real, were essentially signal-to-noise problems of an era long before electronics. And the blink microscope, as used in planetary search work, is the ancestor of all moving target indicators.

In each of these astronomical problems, man, with his native sensory, mental, and manipulative equipment, played the decisive role. The same is true of fighting. We hear much talk today of "ultimate weapons" with one gadget or another nominated for that imposing role. This performance reminds me of the annual beauty queen contests. We get a new "ultimate weapon," if not annually, at least every few years. These titanic gadgets have just one thing in common. Their ultimate purpose is always to control or destroy that truly ultimate weapon--man himself. And when all of the gadgetary uproar subsides, what crawls out of the shattered landscape to settle the argument? What else but that incredibly tough and deadly weapon, the thing of which Armies are made--the Man!! Our central problem and unique Army responsibility is the preparation, equipping, support, and tactics for that ultimate weapon.

I was much interested in the cover on your last year's conference report. Starting out with the brute in the raw, your artist proceeds to equip him with items that augment his native deadliness while protecting his frailties. Let's carry this process to its logical extreme--Let us imagine the ultimate soldier: the super-trooper. He has three properties. He appears instantly when and where required. He moves among his enemies immune to their attacks. He secures their consent to our national will without damage to his opponents or to the surroundings. If one measures the "efficiency" of a weapon as the ratio of wanted to unwanted effects, then the "efficiency" of the super-trooper is infinite. This is to be contrasted with the same parameter for large "strategic" bombs, which have an "efficiency" of practically zero. Your aim, then, may be described as the development of the man and his equipment together into an optimal tactical agent whose capabilities approach the ideal.

Of course, at the moment we have no "super-troopers"--probably we never will. But we just might, by taking a new look at the possibilities, make some unexpected progress. Take, for instance, the requirement that the super-trooper move immune among his enemies. Is armor the answer? Well, not by itself, anyway. You psychologists, biologists, engineers--can you imagine a novel approach? The fact is, I am sure, that if we break away from mental fixation on the usual solution, we can think of several new ones. We may hope within a decade to make our soldier substantially immune to small arms and to high explosive fragments. We can perhaps in the same time frame provide him with a technological watch-bird that sits on his helmet or shoulder and looks around while our soldier proceeds on his business. When the watch-bird sees something suspicious it may either tell the soldier who then takes a look to see what goes on--or in a slightly more sophisticated model--the watch-bird may, in a time very short compared to human reactions, perform an identification of friend or foe and train and fire on any hostile manifestation. If the soldier were not otherwise occupied he could then look around and satisfy his curiosity as to what his enemy had been. The soldier's hand weapons, if he still needs any, can be of a smart and eager type which needs only to be pointed in the general direction of the target. As soon as it sees the target for itself, it locks on and only when on target does it fire. All the soldier has to do is to swing the weapon into general alignment by way of target designation and pull the trigger. Or perhaps he desires only to neutralize--not to kill--his weapon can have a "persuader" instead of a kill capability. What devices will secure consent without damage? The rude concept of persuasion through slaughter has reached its absurd extreme in present weapons. What novel design principles should go into a firm but gentle "persuader" for our future soldier? Or what likely fields of research might yield such principles?

By way of auxiliary equipment our persuader teams might be provided with a type of vehicle which for reason soon to be obvious, I will call a "skunk." The skunk would have a tactical atomic explosive weapon carried aboard and equipped to be fired by any hostile molestation. Such a vehicle suddenly disclosed in hostile territory might well invite respectful or even courteous treatment by the enemy. The operators of such a vehicle would require considerable nerve but they might accomplish results otherwise impossible. There remain, of course, numerous and sundry problems of clothing, food, fuel, communications and tactics for such groups, but the outlined pattern of capabilities seems, indeed, almost within the capacity of present science.

The powers of the "super-trooper," dramatic as they are, may lie perhaps not so far beyond the present boundaries of the art. In reading the reports of your impressive progress over the past few years, I am inspired to believe that you have occupied the present territory of human engineering in a very workmanlike manner. My own classification and countup of your activities as reported at last year's conference totalled about 40 applied and 70 supporting research projects. This is my own count and not connected with any official or budgetary tally. In the same way, I found about 30 projects that appeared to be basic research. It now seems to me that the Army's need and your own capabilities summon you to cross the frontiers, and to present our rivals with a jolting technological surprise in the form of new and unheard-of Army human factors capabilities. I feel confident that, with a determined, creative, and disciplined effort you can succeed in this. My confidence is based on the observation that, due partly to fixations and tabus, partly to plain neglect, the application of truly modern science and technology to the human factors field has not been fully exploited.

For example, one might make a contact lens with a little rod that works a pair of potentiometers. The wearer looks into the eyepiece of a tracking instrument and simply follows the target with his eye. The potentiometers drive a servo in the tracking mount which follows the eye motions. And here's one case where I'll bet the eye is quicker than the hand.

Let's try one more. I see by your work that simultaneous use of a variety of sensory channels helps a man to span more information or to be more confident in his responses. I read about buzzers on the skin--a fine idea. But how about that third "eye," the tongue? With it, you can build up a magnified and detailed picture of your teeth, including all the little corners, cavities, and textures. Now, the topography of a man's teeth is usually a dismal and monotonous view. How about installing a more lively scene, like a radar or infrared image, or maybe an instrument panel, for presentation to the tongue? The transducer might be either electrical or tactile, and could be built and arranged for insertion behind the lower teeth in such a way as not seriously to interfere with speech.

I am only a layman,--you experts must have better ideas by the hundreds. I would like to point out, however, two of the very concrete examples of work across the frontiers that you will see at this conference. One is the presentation by the Army prosthesticists later on this program. It seems to me only a step from their work to the actual physical modification of man for the optimal performance of special tasks. And just beyond that I foresee a device I have wanted all my life--a "wisher." The "wisher" would plug directly into the human system, whereupon one would merely have to wish and his equipment would respond like part of his own body.

I would like to bring you a second example of Army work across a frontier and in a field potentially related to your own. The physiologists have long been intrigued by the capability of muscle to do efficient work. When to this efficiency one adds an almost ambient temperature and absolute silence, the military potentialities of muscle as a source of power are obvious. The Frankford Arsenal has for some years been working on a basic scientific approach to the understanding and control of muscle-like energy transducers. Believing that you would find their work interesting, and encouraging to your own off-the-beaten track ideas, I have prevailed upon them to demonstrate it here today. My companion here on the platform has been quite impatiently waiting to address you--I shall therefore defer the remainder of my remarks and introduce him at this point. Ladies and gentlemen, I give you that true pioneer and muscular fellow from Frankford Arsenal--Captain Pitman!!

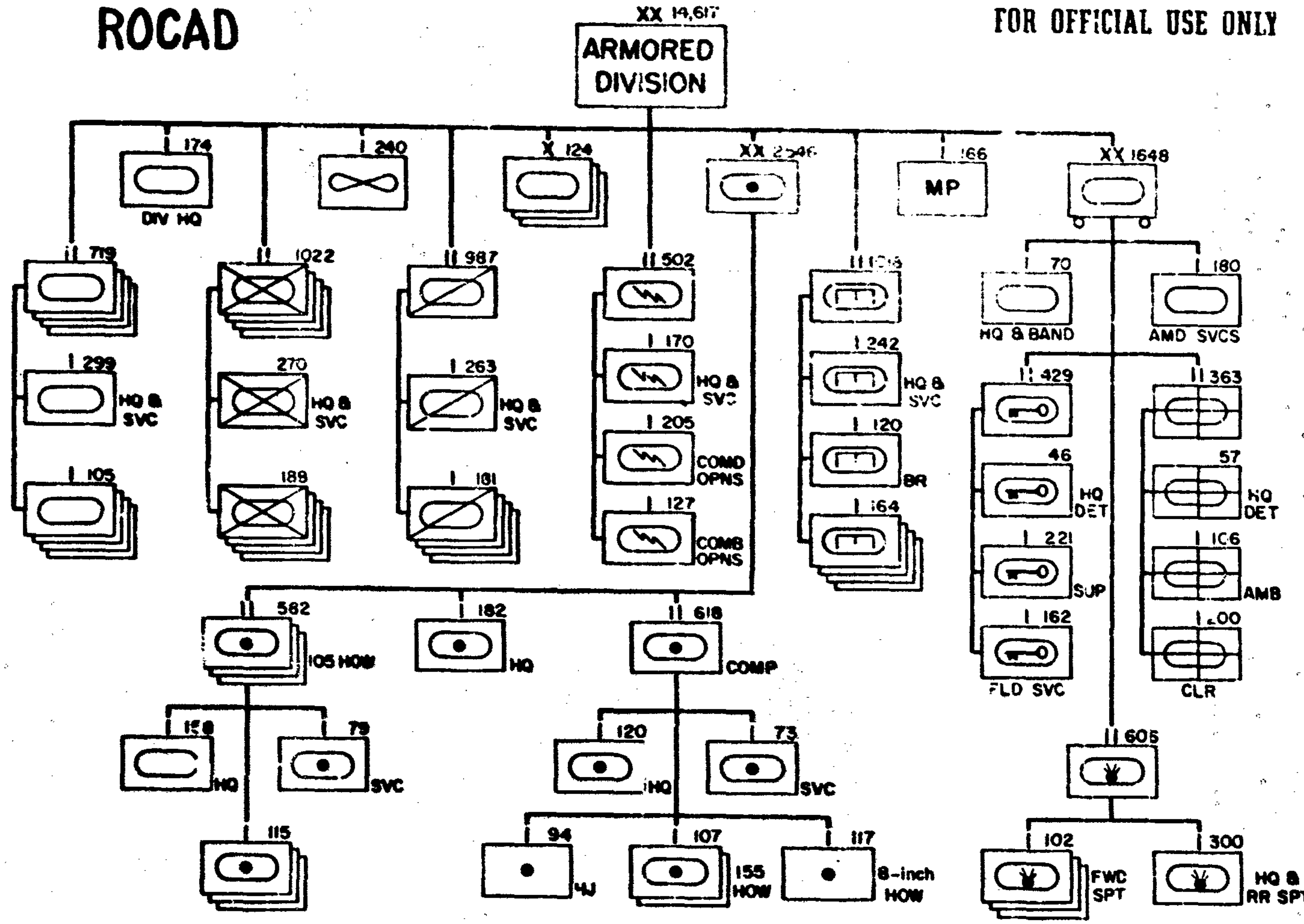
(Demonstration of Robot powered by artificial "muscle engine")

Thank you Captain Pitman. May your speed, strength, and dexterity increase mightily over the coming years!!! Now, may I present Captain Pitman's mentor, one of the world's pioneers in military robotics--Mr. James M. Mikula. We are indebted to Mr. Mikula, Mr. C. D. Fisher, Mr. E. Rechel and their colleagues at Pitman-Dunn Laboratories for this demonstration and for the imaginative pioneering research that made it possible.

Gentlemen, in the last few minutes I have brought you the assurance that the Army knows your value and needs your work. I have pointed out that the Army's appreciation cannot and must not always be measured in terms of budget and I have spoken about the truer measure that we all know: for each--the measure of his own effort in terms of the trust we have accepted. I know you will share with me a very lively pride in your Army accomplishments and growth over the past few years, as reflected in the proceedings of these meetings and in the respect which you have won among your colleagues throughout the country. I think you also share with me the realization that our obligation demands much more of us for the future than we have achieved in the past. We must lay our paths into new fields--we must work beyond the frontiers to provide the men of our Army with decisively superior capabilities. We must provide our opponents at the same time with a jolting surprise to the effect that there are things not dreamed in their primitive and often brutal philosophy of human factors. I have tried to point out my own all too hazy glimpses of where lie the frontiers and how we may drive across them. Now, may you gain new vision as you confer together here. May you find, in the months ahead, strength, and inspiration to match your unique responsibility for Man--the ultimate weapon.

FOR OFFICIAL USE ONLY

ROCAD



FOR OFFICIAL USE ONLY

Figure 1: Reorganized Current Armored Division

IV. USCONARC PRESENTATIONS TO THE CONFERENCE

NEW ORGANIZATIONS AND TACTICS

Col. H. V. Middleworth, Hq. USCONARC

Introduction

Gentlemen: I shall briefly describe the new divisional organizations of the Army and indicate how they came about. Additionally, I will endeavor to describe some of the tactical concepts applicable to one of these new organizations, the Reorganized Infantry Division. Subsequently, Col Fossum, also of USCONARC, will indicate the impact of these new organizations and their tactics on our materiel objectives.

ROCAD

Figure 1 shows the newly Reorganized Current Armored Division (ROCAD). A cursory glance at the ROCAD organizational chart gives the first impression that there have been few if any changes from the previous organizations. While it is true that there are many remarkable similarities, there are many evolutionary, but nevertheless basic, changes expressed within the general ROCAD framework.

The number and internal structure of the major combat elements of ROCAD, i.e., the tank and armored infantry battalions and division artillery, bear a striking resemblance to former organizations. This is especially true with respect to the command structure, the number of subordinate elements, and their equipment. The characteristics of mobility, armor protected firepower, and a highly efficient control and communications system, which are prerequisites to the conduct of warfare on the nuclear battlefield, have also always received a high order of emphasis in Armor's prenuclear doctrine, organization, and equipment. Current and future emphasis on development in these fields is aimed at enhancing Armor's already considerable capabilities to control mobile formations of the combined arms in the presence of friendly or enemy nuclear weapons.

The most significant differences from previous organizations appear in the division artillery, the reconnaissance battalion, the signal battalion and the combat aviation company.

While direct artillery support and liaison is provided by a rather conventional direct support artillery organization, the firepower capability at and above the general support level has been vastly increased by the inclusion of nuclear delivery means in a composite battalion. These changes in organization will require modification in the doctrine of employment of fire support. A minimum requirement will be that, proximity of friendly troops permitting, the division commander will have "permissive" authority to utilize nuclear weapons with "veto" authority retained by the higher commander.

An anticipated increase in the antiaircraft capabilities in the form of certain missile units to provide an "umbrella" defense for the field Army and corps area of combat operations has permitted the withdrawal of the small caliber AA forward weapons battalion and their concentration under AA control for the most efficient defense of the combat zone. AA doctrine will probably provide for attachment of, or direct support by, forward area units when the mission of the ROCAD division visualizes it moving out from under the effective protection of this umbrella defense. Again, this change is a reflection of the relative effectiveness of conventional AA weapons vis a vis modern high performance aircraft, the necessity to conserve manpower, and at the same time marshall the necessary skills and advanced devices into an effective AA defense. Perhaps as these newer AA weapons become more plentiful, less complex, and more adaptable to highly mobile units, they will again be integrated into the Armored Division.

To provide for increased control and coordination and a better reconnaissance capability to locate nuclear targets and to cover the voids which will exist on a dispersed battlefield, both the reconnaissance battalion and the signal unit have been increased substantially in strength and capabilities. The former now has integrated companies rather than integrated platoons, as well as an embryo reconnaissance and surveillance element equipped with electronic detection devices. The full realization of the potentialities of this reconnaissance and surveillance unit and its airborne and ground devices must await the production and delivery of improved materiel. This is one area in which subsequent revisions of the TOE will probably reflect the greatest changes--dependent upon the exact

INFANTRY DIVISION (ROCID)

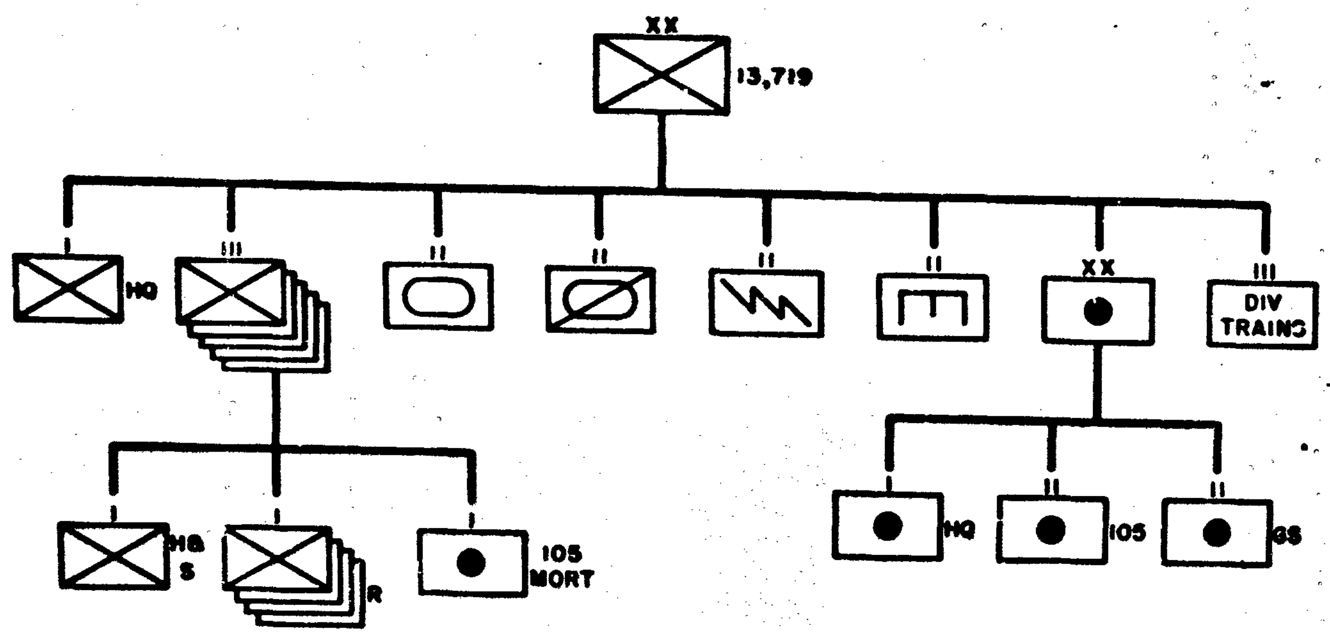


Figure 2: Reorganized Current Infantry Division

capabilities and limitations of the final production models of materiel. Again, changes in materiel will cause changes in organization and doctrine.

The exact timing and control required in coordinating an attack with an atomic strike, the dispersal of units, and a requirement for better and more timely intelligence are all reflected in the organization and equipment of the signal battalion (formerly company). The precise accuracy and message control which can be achieved through radio teletype are required for such purposes as coordinating atomic fires, where no misunderstanding can be tolerated. Moreover, this means is less susceptible to enemy intercept and analysis through straight voice FM traffic, which brings an added measure of security against enemy atomic attack. For these reasons the capabilities of the signal battalion have been expanded both by additional personnel and additional equipment, principally in the radio teletype (RTT) field.

The ROCAD combat aviation company does not add a new capability to the division. It is merely an organizational device which concentrates all Army aviation into one unit, in order that more effective maintenance and supply procedures, and pilot rotation, will insure the best aviation support of the overall division mission. Its doctrine of employment visualizes assignment of support of all combat elements of the division on an "as required" basis. Certain elements of the company will be earmarked for habitual employment in support of the same units. This is especially true of support for the reconnaissance battalion and division artillery. If maintenance difficulties or other unforeseen difficulties render certain aircraft inoperable, support can be quickly reallocated so as to be applied to the most remunerative area of effort. This type organization has permitted almost doubling the aircraft in the division without jeopardizing their effective employment through organizational fragmentation and the resultant maintenance difficulties.

The principal differences in the supply and service echelons of the division are the addition of tank trucks and replacement of certain $2\frac{1}{2}$ ton by 5 ton trucks in both the unit and division trains. Since the mobility of the division is ultimately based on the energy equation of petroleum fuel, the increased consumption factors and powered equipment density demanded a more efficient supply system. The number of cargo trucks and consequently their POL consumption has been held to an absolute minimum, while at the same time the specialized gasoline tankers will permit moving a certain amount of POL forward in bulk which is also more economical, both from the standpoint of manpower and the ton-mile fuel consumption ratio.

ROCID

Briefly I have described the characteristics and some of the employment techniques of the new Armored Division; now I will turn to the Reorganized Current Infantry Division which we call ROCID. I am going to stress this new organization in somewhat greater detail for it represents a more radical change from the Infantry Division of WWII and Korea.

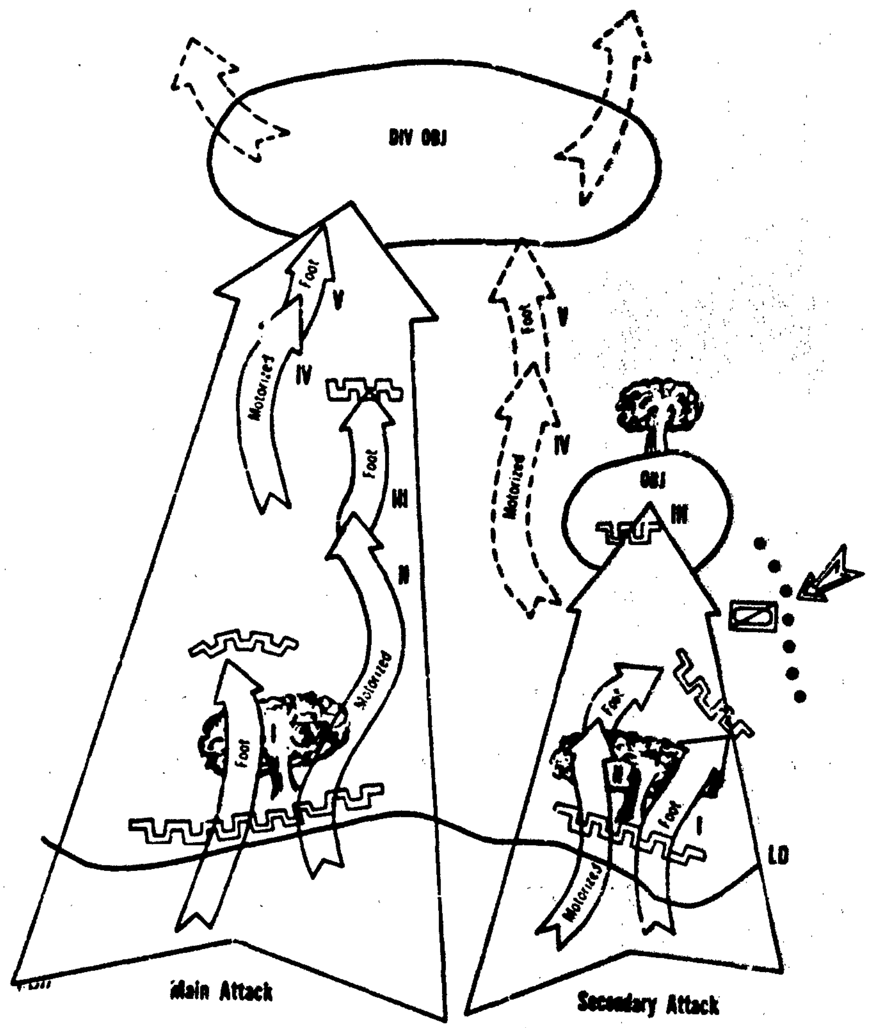
In developing the basic structure of the new infantry division (figure 2), we have attempted to anticipate future trends to the greatest possible extent. Consequently, it was designed to meet certain criteria. These criteria are:

1. To be suitable for employment in the foreseeable future.
2. To be capable of integrating new weapons and equipment as they become available.
3. To facilitate the early incorporation of future operational and organizational concepts in training literature and service school instruction.
4. To facilitate early training of commanders and staff officers in warfare of the future.

In addition, a basic aim was to build an infantry division around a preponderantly strong infantry component, supported by only those minimum balanced elements of the other arms and services habitually needed to support the infantry component regardless of theater of employment. As a result, the basic structure is lean. At the same time, the design is sufficiently flexible to permit the ready attachment of units to reinforce the division for employment anywhere in the world.

In comparison with our division of WWII and Korea, ROCID is smaller, more mobile, and more flexible. One echelon of command has been eliminated, leaving the infantry battle group as the only echelon of command between the rifle company and the division. We consider that this reduction in layers of command will assist in speeding up the reaction time required to meet the demands of the atomic battlefield. At the same time the assistant division commander has been provided with a staff which will enable him to command a task force when and as required.

A comparison, in terms of organization and strength, between the old and the new divisions and their infantry components will show that even though the infantry strength is some 3400 less, there are nevertheless 80 rifle platoons as compared with 81 in the old division. Note also that the new division has more riflemen--2640--as opposed to 2187 in the old division. This has been made possible by utilizing a larger squad, containing 11 men instead of 9.



Roman numerals indicate a probable sequence of action for each attack.

Figure 3: ROCID In Attack

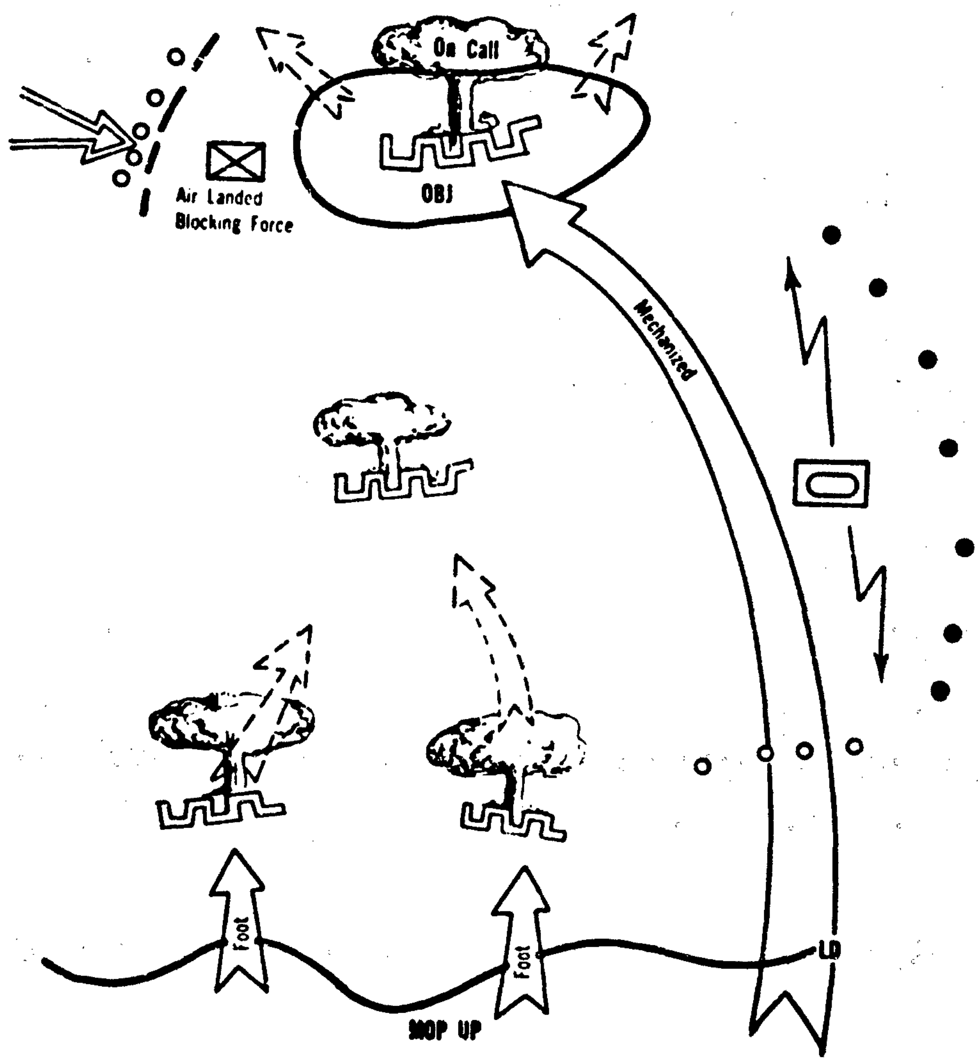


Figure 4: RJCID in Attack by Mechanized Envelopment

Now let's take a look at the components of the ROCID division shown in Figure 2. The organization of major supporting elements of the division is tailored to facilitate support of the five battle groups:

1. The division tank battalion has five companies of 17 tanks each.

2. The division artillery has only two battalions, however, the light battalion has five firing batteries, each having six 105-mm howitzers. A committed battle group may expect to be reinforced by a minimum of one of these batteries. The general support battalion has two batteries of six 155-mm howitzers each. Its two other firing batteries both have an atomic capability. One battery has four 8-inch howitzers. The other battery has two "HONEST JOHN" launchers.

3. The engineer battalion is organized with five companies to permit one company to be attached to, or placed in support of each battle group.

4. The reconnaissance company of the old division has been replaced with a reconnaissance battalion containing three armored cavalry companies. In addition, the battalion headquarters company has both aerial and ground surveillance equipment for atomic target acquisition.

5. A signal battalion replaced the former signal company. It is organized to provide adequate communications and control means under conditions of increased dispersion and atomic destruction. This communications system, known as the area or grid system, provides for multiple communications centers to insure uninterrupted communications during atomic warfare.

6. The division trains command contains not only the usual technical and administrative services and a pool of cargo trucks or lorries, but also an aviation company and two armored personnel carrier companies.

7. The aviation company is located in the trains command to facilitate maintenance.

8. The two armored personnel carrier companies contain sufficient APC's to lift a battle group and a half. This carrier lift, together with his tanks, gives the division commander the means quickly to constitute mechanized, mobile forces in many possible combinations for a variety of missions. In other words by adding these APC's to the division, we have built in a tremendously augmented mobility and flexibility potential. The new APC now being developed will be air-transportable and capable of swimming across inland waterways.

9. The administrative services company incorporates the special staff agencies--AG, Finance, and the like--also the former replacement company.

10. In the new Infantry Battle Group, the headquarters company contains three combat elements, a reconnaissance platoon, an engineer platoon and an AT platoon. We expect to equip this latter platoon with DART when it becomes available. In the interim, the current 90-mm gun tank will probably be the primary armament.

11. The four identical rifle companies each contain five platoons, four rifle platoons and a weapons platoon. The rifle squads or sections of eleven men are organized into two fire teams of five men each and a squad leader. Each fire team contains an automatic rifleman. Each rifle platoon has a weapons squad of two light machine guns and two 3.5 inch rocket launchers. A 90-mm recoilless rifle is under development which will replace the 3.5-inch rocket launcher and give a greater antitank capability. There are three 81-mm mortars and two 106 mm recoilless rifles in the weapons platoon. Overall we consider that this is a large and potent rifle company. With its heavier caliber weapons, we can expect it to produce a much greater value of fire than its predecessor. The main heavy fire support for the rifle companies of the battle group will be provided by the artillery mortar battery which contains eight 4.2 inch mortars. These may be replaced.

The new division, with a little more "foxhole" strength than its predecessor, is more mobile and more flexible and utilizes span of control more efficiently to reduce overhead. We believe that its five infantry battle groups are powerful enough to survive as effective fighting forces under operational conditions which emphasize wide intervals and distances between them in the battle area. It is organized to integrate new weapons and equipment as they become available. The inclusion of an organic atomic capability within the division is of particular significance. In addition, this division can quickly field powerful mechanized, mobile task forces. We believe that it will be able to dominate a goodly share of the battle area.

Let us now consider how this unit will function on the atomic battlefield--or the non-atomic battlefield. In the latter case, conventional weapons would provide the necessary fire support. First we shall consider the division in the attack and then turn our attention to the defense.

ATTACK

The conduct of the attack will vary in form depending upon terrain, the enemy situation, the number and type of atomic weapons available, tactical air support, and the degree of air and ground mobility attainable. All attacks will have one thing in common--they will be characterized by rapid movement to assault positions, vigorous assaults and rapid exploitation.

We visualize the attack (figure 3) as a continuous flow or movement of forces to the division objective. By this means, combat power is applied continuously throughout the duration of the attack. Action is initiated by one or more battle groups reinforced with tanks and engineers attacking relatively close-in objectives on foot in conjunction with atomic and other supporting fires. Reserve elements consist of one or more battle groups with attached ranks. These units are mounted in available transport, including APC's. Throughout the advance, attacking elements heavily engaged are rapidly bypassed by mounted reserve units, or reinforced by these reserve units and/or atomic fires, if required. Armored personnel carriers are ideally suited for transporting this reserve. The APC's will deliver the reserve units as close to their objectives as possible. At this point they dismount and attack on foot. The transportation withdraws to be used to lift additional or reconstituted reserves for similar future employment. Momentum and mutual support are maintained by the rapid phasing of these mechanized reserves into the attack. A measure of security from enemy atomic fires is afforded by rapid movement of these forces not closely engaged, and by dispersion of reserves. In this form of attack, when given adequate atomic weapons of suitable size, it is quite conceivable that attacking units will not themselves become heavily engaged. Rather they will locate and determine the extent of enemy dispositions, than annihilate or neutralize him with atomic fires.

Another variation of the division attack is a mechanized envelopment (figure 4). This maneuver consists of a rapid exploitation of atomic fires by mechanized elements of the division to seize the division objective. The division may employ this form of attack in situations where initial enemy resistance can be neutralized by atomic weapons employed in conjunction with secondary attacks. Other factors favoring this maneuver are relatively weak or over-extended enemy defenses, and terrain which is suitable for mechanized operations. For his secondary attacks on initial objectives, the commander will employ minimum forces on foot in conjunction with low-yield atomic strikes. In this example, perhaps a single Battle Group reinforcement of tanks, engineers and artillery would be allocated to the secondary attack. For his main attack, the commander may employ a task force under command of the assistant division commander. Typically, this task force would be built around a strong infantry nucleus--one or more battle groups--mounted in APC's and heavily reinforced with tanks, reconnaissance units, engineers, and artillery, together with on-call atomic weapons. Additional reconnaissance elements will usually be assigned the mission of protecting one or both flanks of the task force. Note also that a small airlanded force is employed in a blocking role near the division objective. To insure success, the main attack must be characterized by speed and violence in order to deny the enemy time to react effectively.

DEFENSE

By way of illustration, figure 5 shows an example of one way in which the division might conduct the mobile defense. Well forward of the defensive area, reconnaissance aviation and a covering force provided by higher headquarters furnish security and give early warning of attack. Between the covering force and the forward edge of the battle area, the division commander establishes his own reconnaissance and security forces. The Reconnaissance and Security Line is located about 3 to 4 miles in front of the main battle position. It will usually be manned by forces provided by the forward battle groups, augmented as required by the attachment of other divisional units, particularly reconnaissance elements from the Divisional Reconnaissance Battalion. The security elements establish a series of lateral outposts, road blocks and observation posts. Reconnaissance detachments probe to the front to maintain contact with the covering force, locate possible atomic targets, and thus extend the security to the front. These forces have the mission of warning of enemy approach, covering the withdrawal of the corps covering force, and screening the main battle area by delaying, deceiving, and disorganizing the enemy. This mission emphasizes locating suitable atomic targets.

In our concept of the mobile defense, the commander employes the minimum forces to occupy forward defensive positions. The mission of the forces employed in the forward defensive area is to warn of impending attack, canalize the enemy into terrain favorable for the defender, and block or impede the attacking force. Note that the two forward battle groups are disposed in a series of organized positions extending across the forward defensive area. These organized positions are of varied size and the forces occupying them are prepared for all-round defense. Coupled with these positions, a series of observation posts is also employed across the forward area. To provide depth, additional blocking and switch positions are prepared in rear of the forward positions in accordance with the division commander's overall defensive plan. When the forward positions come under attack, the division commander may authorize certain units to withdraw immediately to occupy switch or blocking positions while other units may be ordered to hold.

In the mobile defense, principal reliance is placed on bold and vigorous offensive

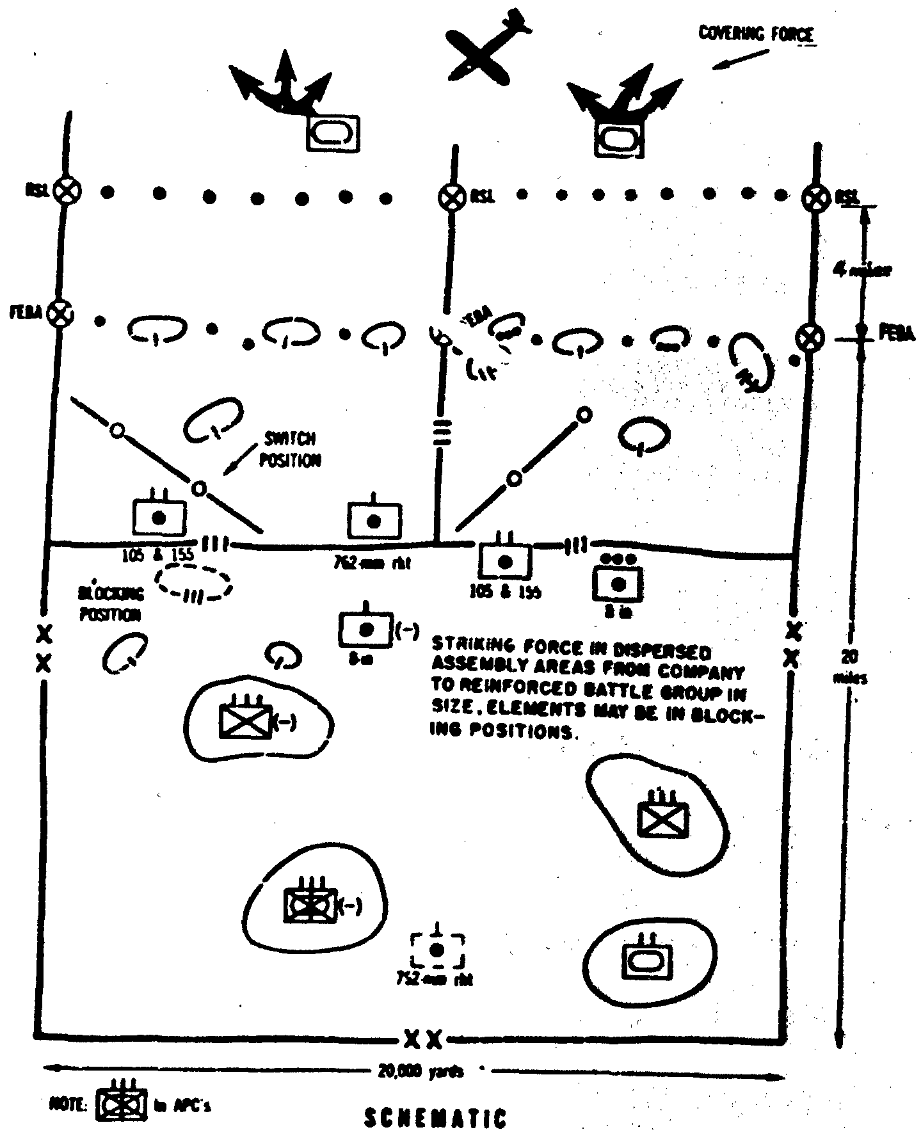


Figure 5: ROCID in Mobile Defense

action to destroy the enemy in the selected tactical locality most favorable to the defender. Thus the commander in this example has retained the major portion of his combat power in dispersed areas well in rear of the forward defensive positions. This force consists of the divisional tank battalion and three battle groups, one of which is mounted in APC's. These elements constitute the striking force whose mission is to destroy the enemy force at a time and place of the commander's choosing. All or part of the striking force may be employed offensively, as required by the situation. In some cases a part of the force may occupy blocking positions while the remainder executes the counterattack. In any case, plans for employment of the striking force will include maximum support by atomic and other fires. As in the attack, the division commander may employ his assistant division commander to command either the striking force or the forces in the forward defensive area.

ROTAD

Many of the tactics I have described are applicable not only to the ROCID Division but to our new Reorganization of the Airborne Division (ROTAD) shown in figure 6. However, the latter is more often employed in an airhead type of operation where all around protection is required. As a consequence, each of the airborne division's battle groups contains five infantry companies rather than four.

A glance at figure 6 will convey the similarity between ROCID and the new airborne division. For your purposes it would be well to note that this division is 100% air-transportable and its personnel are trained parachutists. There are differences in the logistical support structure, the airborne division has a support commander with subordinate functional elements. The support command is responsible for all logistics support in an airborne airhead. The reconnaissance element is smaller and lighter and the artillery of the division does not have the relatively heave 8" howitzers.

Employment Principles:

1. Firepower.--From the description of these organizations and their methods of doing business it should be obvious that greater reliance is placed on firepower--both conventional and atomic--than ever before. Delivery systems designed to apply this firepower from the small arms to the guided missile must be rugged and relatively simple to operate. They will be subjected not only to the rigors of ground combat of the past but also to the threat of--or actual effects of--enemy atomic weapons. (In this regard, a convenient eye shield to prevent flash blindness is an example of a rather obvious requirement.)

2. Mobility.--You should be impressed by the mobile tactics that the new divisions will employ. To achieve the requisite mobility every effort must be made to make individual equipment as light, as compact, and as convenient as possible. Although there is a comparatively greater degree of mechanization, the foot elements of ROCID and ROTAD are ever present. They should not be dependent upon vehicles to discharge their missions, and as a consequence their weapons and equipment must be capable of being broken down to man-portable loads. For example, a great advantage of the 106mm recoilless rifle over its predecessor the 105mm RR is that it may be dismounted from its jeep-type weapons carrier and man transported in several loads when required. The 105mm RR was only as mobile as its weapons carrier.

3. Dispersion.--Wider frontages and greater depths, on a battlefield threatened by hostile employment of atomic weapons, dictate that combat units achieve greater dispersion. Often there will be gaps between front line combat elements which will be covered by reconnaissance, by fire, or both. Under such conditions maintenance and other required support from the rear will be difficult. Again, as far as individual and organizational equipment are concerned, simplicity of operation and maintenance becomes extremely important. Whenever possible, repairs to organizational and individual equipment should be accomplished on a unit exchange basis as opposed to minute individual spare parts which require unit breakdown and reassembly.

4. Control and Communications.--The new organizations and the tactics they employ place a premium on communications and control. Although wire will be used where possible, great reliance must be placed on radio. With radio, communications security, adequate readability, and sufficient power sources are always problems. Of course armored vehicles provide excellent power sources for radio equipment, however, portable radio equipment for foot elements must include the power source--batteries. Operators of portable radios should be able to operate them with their hands unencumbered, particularly so they may use their personal weapons.

5. Vulnerability to Detection.--Another employment principle that may be inferred from the discussion of organization tactics I shall call vulnerability to detection. In the past, we have given a degree of lip service to camouflage and concealment, but some commanders took the problem lightly. On the atomic battlefield, however, such passive measures may be the most effective defense against hostile atomic weapons. All Army forces must therefore be provided with optimum equipment to accomplish the task and

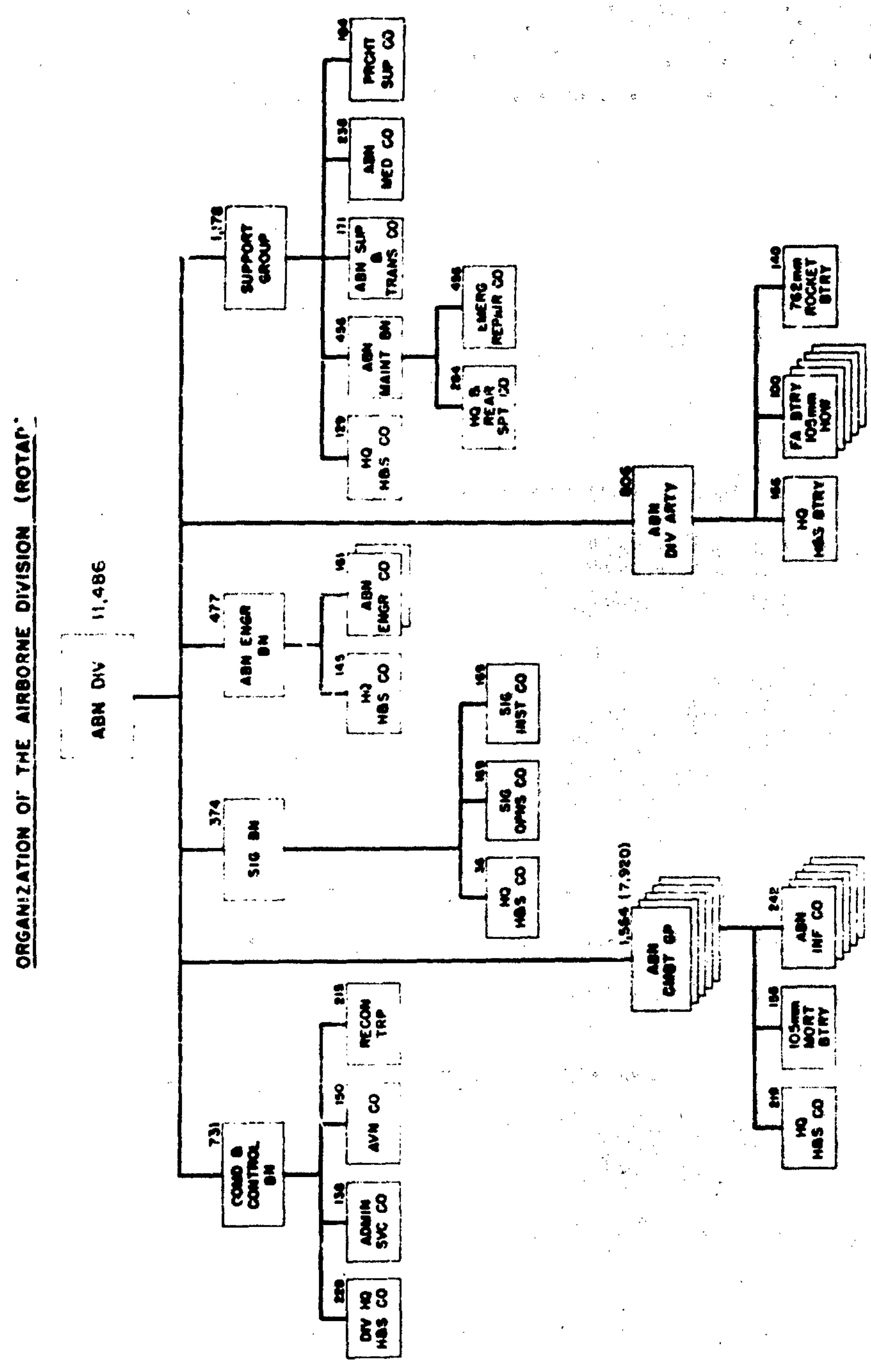


Figure 6: Reorganization of the Airborne Division

be trained and indoctrinated in its use. The problem, of course, is even more complicated when the mobile tactics of the new organizations are considered. Perhaps in your work you can help us find answers.

6. Serviceability.--It goes without saying that materiel for these units must be serviceable. I believe that in discussing the other employment principles I have stressed the point sufficiently.

7. Staying Power.--The new infantry and armored divisions are designed for sustained operations; they have the requisite staying power for such operations. Sustained operations infer replacement not only of materiel but also personnel. Replacement personnel must be trained in the SOPs and techniques of the unit. This may well have a decided impact on our materiel designs. Again it may be seen that simplicity and convenience are absolutely required.

CONCLUSION

I have described our new organizations and some of their tactics. Modern tactics could well be described by one word--mobility. I have briefly discussed what I choose to call employment principles to include: firepower, mobility, dispersion, control and communications, vulnerability to detection, serviceability, and staying power. I hope that I have stimulated your thinking and provided a platform for Col Fossum to discuss the impact of these new tactics and organizations on materiel objectives.

Thank you.

IMPACT OF NEW TACTICAL CONCEPTS ON MATERIEL OBJECTIVES

Lt. Col. E. A. Fossum, Hq., USCONARC

Gentlemen:

Col Middleworth has told you how our new tactical concepts and organizations are based upon certain employment principles. I will now attempt to describe, in a rather general sense, the impact of some of these principles on our objectives in the development of new materiel, and some of the human factors which are involved.

First, it has been said that we will place greater reliance on firepower. That means that existing weapons must be replaced with new weapons which will give us greater lethality, longer effective ranges and faster rates of fire. In other words, we must be able to distribute more destructive energy over a wider area in a given period of time than at present. Unquestionably this can be done but there are many limiting and restrictive factors which stand in the way of this developmental objective, and one of the most important of these is the human factor.

Let's consider some of these limiting factors in regard to one of our more common and simpler weapons, the machine gun, which is familiar to all of us.

Existing American machine guns are antipersonnel weapons, firing a .30 caliber or 7.62mm bullet, which has plenty of punch to knock out an unprotected man. But if the man is in an armored carrier or a concrete pill box, or even in a foxhole, he doesn't have to worry much about the terminal destructive effects of that .30 caliber slug. The destructive power of this bullet could of course be beefed up, primarily by increasing the weight and size of the ammunition and proportionately increasing the weight and size of the weapon. But you can't increase the weight or bulk of either very much without going beyond the physical capability of the crew to transport the weapon and its ammunition. And if you make it big and heavy enough to require vehicular transport, you may have increased the destructive capacity of your weapon, but you probably won't be able to put the fire down on the place you want it.

Let's look at ranges for a moment. Existing machine guns have effective ranges up to about 2000 yards. If you increase this range, you will have to make a bigger and heavier cartridge to hold more propellant, and a heavier weapon to withstand the increased pressures. And since existing weapons are effective about as far as a man can see and sight on his target, any increase in range will probably impose a need for additional sighting and target acquisition devices. And now we are back on the same old side of the same old circle. Additional equipment means more weight, and more weight means less flexibility of employment of the weapon.

Now consider rates of fire. If you want the bullets to come out of a machine gun faster than they do at present, you must increase its stability. Otherwise the bullets will spray all over, particularly up in the air, rather than on the intended target. Increased stability means increased weight, particularly in the mount. And as I have said a couple of times already, the heavier the weapon, the more difficult it is to get it to the proper implacement; and in this instance, increased rate of fire isn't worth much anyway. Present machine guns fire faster than a gunner can shift from one target to another, and there isn't much pay-off in shooting faster at a single target, because that is just pumping more bullets into a target that's already destroyed.

So, while we need more effective firepower, it must be provided without increasing the burden on the individual soldier in the case of infantry weapons, and without substantial increase in the overall logistical burdens in the case of large supporting weapons.

This leads into consideration of mobility, another of the employment principles.

Elements of our new Army must be shifted rapidly over comparatively great distances for two basic reasons. One, in order to concentrate our offensive power to exploit the effects of modern weapons. And secondly, there will be times when they must be shifted quickly out of potential target areas.

All of this means that our soldiers must be ready at all times to load up and move out on any and all means of transport--armored carriers, trucks, airplanes, and helicopters. They must be able to unload ready to fight, or possibly already fighting. This requirement for loading, riding, and unloading from the confining space of any type of transport--ground or air--has a strong impact on our objectives in developing all types of individual weapons and equipment. Any of you who have ever witnessed American soldiers, under the stress of combat, stumbling about with full field packs on their backs and tripping over M-1 rifles and BAR's while they attempt to debark from the comparatively roomy 2 1/2-ton truck, can well imagine the confusion which would exist at a similar debarkation from a more confining armored personnel carrier or helicopter. This concept of frequently or habitually transporting troops over the battlefield in ground or air carriers makes it imperative that we materially reduce the weight and bulk of all individual equipment and hand-carried weapons. When the soldier had plenty of unoccupied space around him, weight was the most important factor in this type of materiel. But now overall bulk and compactness have become increasingly important.

However, don't take what has just been said to mean that weight loses its importance. True battlefield mobility is not achieved solely by putting wheels and tracks under the troups or wings and rotor blades over them. The soldier will still be called upon to move and fight on foot, and his personal load must be reduced to where he can expend more of his energy on the fighting job and less on merely packing around his personal accoutrements.

Dispersion is another of the employment principles which have a decided impact on our materiel development objectives. A battlefield of wide frontages and great depth with many unoccupied gaps and pockets means that even greater effort must be made to develop materiel which is characterized by simplicity of operation and ease of maintenance. No longer can we be assured that there will be fully equipped maintenance outfits with trained mechanics and technicians and large stocks of spare parts right behind the combat units, prepared to keep the fighting gear in operating condition. The maintenance support units are going to be out of reach when the going gets toughest. The combat equipment must be simple and rugged, and maintenance when it is needed most will frequently be limited to the immediate action and on-the-spot first echelon work that can be performed by the combat soldier on the battle position. The equipment must be rugged and without complex frills and gadgets to start with. And major repairs will probably have to be accomplished by simply replacing the broken and damaged part with a new assemblage which can be quickly snapped, bolted, or screwed into place.

None of these things I have mentioned are new. We have always been striving for increased firepower, reduction in weight and bulk of equipment, simplicity in operation, and ease of maintenance. You can examine the military characteristics for most any type of equipment--from a guided missile to a hand grenade--and you will find that these are features which we as users have always asked for. The impact of our new tactical concepts on these developmental objectives intensifies this need.

We have always wanted more firepower. Now with wider frontages and unoccupied gaps in the battle position, we must have more effective weapons.

Since Caesar's legions stormed across Gaul, the soldier's load has been too big and heavy. But now that he must be transported in confining carriers, as well as move faster than ever before when on foot, the load must be reduced.

Breakdown of equipment during the conduct of a battle is obviously undesirable. Without close and constant maintenance support it becomes intolerable.

Our new tactics haven't changed our developmental objectives. They merely make the attainment of these objectives more important than ever before, lifting them out of the category of being desired and making them imperative.

As in the "Old Army," man is still the basic component part of the "Army of the Future."

Men will continue to implace our weapons and other equipment, driving it in carriers and aircraft to the proper place of employment in some cases, and packing it on their backs in others.

Men will continue to operate the weapons and equipment, even though some of the "trigger fingers" may be replaced with a push button type.

Above all, as we rely more upon complicated mechanical and electronic equipment, we must remember that men will be required to keep it operating on the battlefield.

Our new tactical concepts merely point up more strongly than ever that military materiel must be designed to fit the capabilities, both physical and mental, of the men who will wear the uniform of the United States Army.

US ARMY ARMOR BOARD PRESENTATION

Capt. John J. Sullivan, Arm Bd., Ft. Knox, Ky.

In an opening address delivered by Dr. Rollefson at the 1956 Human Factors Engineering Conference, he described the aims of your work as three:

1. To insure that the man and machine are compatible.

2. To insure that there is a proper division of work between the man and the machine.

3. To obtain optimum efficiency and capability of the combination man and machine.

These three aims can be considered as they pertain to tank development and tanks in existence today. At the Armor Board the tests conducted usually apply in some way to aim number one; are the man and machine compatible? We come up with such things as (quoting from recent tests): "the driver's knee strikes the odometer when he applies the brakes suddenly"; or, "when the gunner tries to elevate manually he hits his knuckles on the (you name it)"; or, "insufficient room is available for a mechanic to perform his tasks." These are examples of user experience which can be used by the technical services to improve equipment design, and consider the influence of the human factor on this equipment.

The tank we have and its ability to fight is a combination of man, machine, and training. It is hard to draw the line where one stops and the other takes over. They are interwoven. At Fort Knox the mission of the US Army Armor Human Research Unit, working under CONARC headquarters and George Washington University, is to discover the best way to train our tankers on the equipment we have today. They not only want to train them to learn how to use it but they want them to retain what they learn. As a result of their work they come up with many suggestions which point to the design of materiel as being one of the factors contributing highly to the problem of training our men to use the equipment available. Right now they are interested, among other things, in track maintenance of our tanks. How do we teach a man to maintain his track? What type of inspection is used; how frequent is the inspection; what results do we get? Are we perhaps over-maintaining? Their work is directed closely to aim number 3--obtaining the optimum of efficiency and capability in the combination man and machine.

A thought on aim number 2, the division of work between man and machine, is offered with the knowledge that more work by men in your field is necessary. Let's look at a simple tank fire control system, consisting primarily of a coaxially mounted telescope. The tank commander estimates the range to the target, gives a fire command to the gunner, and the gunner takes over. He fires his first round; let's say it is a miss. Then he uses the "burst-on-target" method of adjustment, the gunner moving the strike so that the second round would be more likely to be a hit. In this adjustment the gunner notes on his sight reticle the point at which the tracer passed the target, and moves this portion of his reticle to the target center.

What we have on our tanks today is an attempt to increase the probability of a hit with the first round. Recall, in the instance mentioned, we said we probably had a hit on the second round. By studying the ability of human beings to estimate range, it has been discovered that there is a certain average error. If we eliminate this error we increase our probability of a first round hit by so much. For this we added a range-finder to our tanks. Thus on an M48 tank, the range-finder, periscope, gun, and computer are connected together by mechanical linkages. Our tank commander uses the range-finder to range on the target; automatically range data are fed into the computer, which considers the ammunition and moves the periscope line of sight by the proper amount of superelevation (the elevation required to reach the round to the target), so that as the gunner lays his cross on the target the gun is elevated for that range. We have eliminated the human requirement to estimate range and substituted the human requirement to use the range-finder.

However, experience has shown that some of the men in our tank crews can't use the stereoscopic range finder; for those who can, the problem of training and maintaining a proper level of proficiency is a major one. Today, development is therefore pointed to a full-field, superimposed, coincidence type of range finder; and it is expected that such equipment will better fit the man.

To get a still higher theoretical probability of a first round hit, it was found necessary to include such items as drift correctors, cant correctors, and so forth. In fact, there is presently under development an electronic computer which has the capability of correcting for such additional factors as wind, gun droop, vertical and horizontal jump, and geometrical parallax. It must be admitted that if we are to get a high probability of first round hit, this may be the only way to do it; to reduce our known errors, some of which are human. But, the question is raised: by adding all this gadgetry, what have we done to the human being in that tank who is trying to use all of this. Today, when a soldier enters a tank, the first reaction is one of amazement at the amount and complexity of the equipment. The transmission of data is done electrically in some tanks, requiring all sorts of electronic units; in some tanks, cant correctors must be leveled by hand; other cant correctors now coming out will be automatic.

Don't misunderstand. The Armor Board is not against automation. If we could push a button and thereby destroy an enemy tank we would be all for it. However, there is evidence that our soldiers today are not using this costly equipment properly, and, in some cases, not at all. Is it the men? The equipment? The training? Studies such as yours should assist in pointing to areas most in need of improvement.

Some refinements added in an attempt to satisfy user requirements may introduce additional errors. One example of this is in fire control linkages: it has been found that temperature changes, caused even by the crew turning on the heater in the tank, are enough to move the line of sight of the periscope. As a result a temperature compensated linkage has been developed. Also, in the 120-mm gun, under certain firing conditions the obscuration of the target (the inability to observe the tracer due to smoke, dust, or blast) prevents application of burst-on-target adjustment. This, in effect, makes each round a first round. If you have fired a carbine you recall that at one time there were two range settings on the rear sight. Some firing courses required firing at three different ranges. In order to hit the bullseye the individual had to adjust his sight picture; he either took a little black or allowed a little white. He was adjusting to fit the firing characteristics of his gun and fire control system. On tanks, gunners can do the same. They can adjust to such things as the AP hitting low and right and the HE going high and to the left. The gunner knows the first round of the day is going to be a wild one, so gets it off quickly and out of the way. But when we add our refinements we have eliminated much of the human element and we have also decreased the capability of the human being to influence the projectile strike. In the simple system, if the gun were hitting a little low, the gunner would aim a little high. Today, with the many items utilizing in the fire control system to place the shot into the target, and with possible variations in the information fed by these items, the gun might conceivably fire low now and high one hour later. The human element being reduced, his ability to correct is also reduced.

Before leaving the subject of fire control, a single simple example of how user experience influences the design of equipment should be cited. The coaxial telescope over the years has had one major drawback. The eyepiece moves vertically with elevation and depression of the main armament, forcing the gunner to crouch way down in his seat at maximum elevation and stretch or actually raise himself off the seat at full depression--and the arc of travel kept getting longer as guns got bigger. The solution to this problem was quite simple. The telescope was articulated so that large movements of the forepart of the telescope tube produced only a small movement of the eyepiece. The T172 telescope mounted in the T43E2 tank is of this type. Other developmental tanks will have similar coaxial telescopes.

In the case of the general purpose wheeled vehicles considerable progress has been made in a general way in the matters of instrument design and location for easy reading, lessening the number of instruments which need be read, etc., and in the improved design and location of controls. The greatest problem however, yet confronts us. That problem concerns the ride quality for the operator, and its most difficult aspect concerns the vibration to which the operator is subjected. Such vibration can be detrimental to health, is obviously fatiguing, and impairs safety by making machine control more difficult. At the present time we find in many types of off-road operations that the top limit to speed of movement is not dictated by the capabilities nor ruggedness of the machine, but rather by the abuse to which the driver is subject by vibration with its attendant loss of machine control by the operator.

The Armor Board is currently testing suspension type seats for use in wheeled vehicles. For certain applications the seats appear promising, but the use of such seats creates a new problem: the perfect suspension seat would completely isolate the operator from his machine; the operator would travel in pure, uniform, one-directional translation subjected to no lateral or elevating displacements whatsoever, regardless of what vibrational gymnastics the vehicle might be undergoing at the time. Such a seat would unquestionably eliminate those physiological impairments or injuries which are caused by vibration, but the problem of control would still remain if the controls were rigidly fastened to the "bucking bronco" vehicle.

The Armor Board suggests that the entire operator's station, to include both seat and controls, must be isolated from the vibration of the vehicle if the ideal is to be achieved. An alternative of course would be the design of a vehicular suspension system so effective that the driver, his controls, and the vehicle itself, less its running gear, would travel in pure vibration-free translation. This is not believed to be a proper and realistic goal because of the problems of mechanical complexity which would arise. Much of the complexity and weight of today's trucks is caused by the necessity for a suspension system, which in turn makes necessary the use of an articulating power train replete with universal joints, extensible shafts, etc., all in great numbers.

There appears to be one other relatively unexplored approach to the problem. That is the position which the operator is required to assume in his vehicle. At the present time we "plunk" him in his vehicle on the end of his tail bone and in such a way that he is denied any good opportunity to cushion shock by use of his own bones, muscles, and joints. It is as though we eliminated the stirrups from the saddle so that the cavalry trooper could not post at the trot. Possibly we should seat the truck driver as though he were operating a motorcycle and permit him to take better advantage of his God-given shock absorbing characteristics.

The Armor Board considers human engineering as a fertile field and its applications in the development of combat vehicles to be of prime importance, and re-emphasizes its comment of last year, "Human factors must be taken into account from the beginning of the earliest design phases."

THE INFLUENCE OF USER EXPERIENCE CONCERNING HUMAN FACTORS ON EQUIPMENT DESIGN

Maj. Nelson A. Mahone, Jr., Avn Bd., Ft. Rucker, Ala.

The United States Army Aviation Board has the mission of conducting user tests on Army aircraft and allied equipment. In conducting these tests initial Army user experience is obtained, and deficiencies found are reported for corrective action through the research and development agencies. We can consider the Army Aviation Board as the primary feed-back circuit to the research and development system for Army aircraft. Influence of these tests is exerted through the medium of military characteristics, test reports and unsatisfactory equipment reports.

Although we tend to associate user testing with the test of a major item of equipment, much of the Aviation Board's testing is concerned with component testing oriented directly at the human factors aspects of the design. Much of the testing has the single purpose of determining how and to what extent the item matches the physical capabilities of the aviator who is to be the user. I am in no position to provide a complete analysis of the influence of Board projects on human factors engineering, but I shall attempt to present pertinent ideas and considerations in the application of such engineering as regards the design and testing of Army aircraft and allied equipment.

Although man may be considered a variable in many respects, he is not, in general, as adaptable to broad physical changes as is the design of a machine. Therefore, when I speak of human factors engineering in this paper; I mean, essentially, the engineering required or appropriate to fit the machine to the capabilities and limitations of the man rather than fitting the man to the machine.

User experience has exerted an influence on what we now refer to as human factors engineering since the dawn of civilization. Numerous examples may be found in every period. Today many of these influences have evolved into what are now accepted as merely common sense or practical design practices. For instance, today we would probably not even consider incorporating muzzle loading features into a new Army rifle. A vast array of user experience has taught us the many undesirable human factors characteristics inherent in the muzzle loader. We have the user on one hand, constantly searching for an item which will perform more efficiently, yet require less training of fewer operating and maintenance personnel. On the other we have the designer who is constantly striving to fulfill the user's demands. Since each of these requirements is a direct reflection of human factors engineering, it is not difficult to see that every item being designed today will evolve as a result of some human factors as influenced by the user.

As an example, consider a relatively new item requirement of jet airplanes. Runway length requirements for landing purposes are affected to a large extent by landing speed. With the highly wing loaded airplanes of today a landing speed differential of five knots can make a considerable difference in landing "Roll out." Therefore, the lowest safe speed for landing should normally be used. However, the high rate of fuel consumption of the modern jet airplane can change this safe speed by as much as 30-40 knots between the conditions of full fuel load and low fuel load. The pilot is required to note his fuel status and mentally compute what his approach and landing speed should be. Now if for any reason the pilot is unable to land and has to go around for a second attempt, the high fuel consumption may lead to a different approach speed being required for his next approach. Furthermore, this additional mental stress is occurring at a critical period of the flight when many other operations, such as activation of landing gear, speed brakes, flaps, power adjustments, etc., must be remembered in a designated sequence and within a very short period of time. To relieve the pilot of this additional mental manipulation during a critical period, an angle of attack indicator has been installed on some of the new airplanes. When used properly this item deletes the requirement to remember and compute approach speeds.

What are the criteria by which we judge or rate human factors engineering considerations? Recently I heard stated eight specific objectives in the design of man-machine systems. These were:

1. Speed and/or quantity output.
2. Quality of output.
3. Reliability and maintainability.
4. Minimum personnel sub-system demands.
5. Performance under stress.
6. Safety and Habitability.
7. User acceptance.
8. Adaptability to future improvements.

These are in fact the pay-off criteria in design. They tend also to describe the various subsections of our military characteristics.

User tests are conducted by the USCONARC Boards for the purpose of determining the adequacy and suitability of the item when operated under field conditions and as reflected in the military characteristics. From this we might infer that user testing is directed toward determination of the adequacy and suitability of the human engineering practices involved, and to a large extent this is true. Any user test that does not include consideration of compatibility between the operator and the machine may be considered incomplete and invalid. However the degree of success achieved by human engineering must be evaluated not only in terms of such direct measures of man-machine performance as efficiency, operability and reliability, but also by reference to: the training and man-power requirements imposed by new equipment; the possibility of providing adequate safety and habitability; and the feasibility of supporting and maintaining such equipment in the field.

Deficiencies in design caused by either failure to consider the man and/or failure to consider the environment in which the system will operate can be and usually are discovered during user test. Correction of these deficiencies at so late a stage in the development cycle is costly, time consuming, and often results in interaction with other design features, thus setting off a form of chain reaction. The primary effect is usually first noticed in a new or replacement type of equipment of similar design. The Aviation Board contributes to this effect by including those desirable characteristics of human engineering nature in new military characteristics as they are prepared. These characteristics, however, are subject to various interpretations throughout the development cycle and require close coordination of user agencies with all development agencies concerned. This is necessary to provide for the correct interpretation of the military characteristics and to insure that lessons learned previously do not go unheeded. As the development item goes through the mockup and prototype stages, user personnel must stay alert to point out those features which will adversely affect the system when operated under field conditions. The fact must be kept constantly in mind, that the equipment must be designed for operation under field conditions where the operating environment is somewhat less than ideal and opportunity for input of human error increases rapidly with complexity and stress level imposed by conditions.

As an example, in the field of aircraft controls there are at least six types of error which have a high rate of occurrence, and each is affected by environment and status of operation. These errors are: substituting one control for another; adjusting the control improperly; forgetting to activate the control; moving the control in the wrong direction; unintentionally activating the control; and not being able to reach the control. These errors have been known for some time and much has already been accomplished to alleviate these error-sources by standard color and shape coding, specifying standard sizes and location of the controls, and specifying a standard direction of movement of the control. These specifications and standards are kept up to date by a joint Army, Navy, Air Force panel, and much progress can be noticed in the newer aircraft with regard to compliance with the standards. The user, however, must remain alert to the possibility of error sources overlooked during development.

As a further example, we can look at the problem of aircraft instruments. At present a sizable portion of the Board's effort is directed toward the test and determination of the most suitable available instrument presentation and display. In the past, four types of instrument design have been found to contribute to the largest percentage of errors. These include: multi-revolution instruments, in which the primary indicator makes more than one revolution of the dial; two or more pointers on the same instrument; certain designs which aggravate the possibility of reversal of reading; and instruments requiring the viewer to exercise a memory function. We would, of course, like to have a system that did not require memory, transition of thought, or interpretation, thus deleting the sources of error. In the absence of such a system at present, we are considering instruments which operate in a "natural" manner, so as to minimize transition and interpretation and thereby reduce the demands on the pilot.

In order to consider the influence of user experience as it concerns the Army Aviation Board, let's take a closer look at the manner in which the user evaluates and influences human factors in equipment design.

When an item is received for test, it is examined and checked in detail, and a short period is spent becoming familiar with the operating procedures and gaining proficiency in the use of the equipment. Invariably deficient design features are discovered even at this early stage and, if of a major nature, immediately "fedback" into the development system by means of the unsatisfactory equipment report and/or consultation with the manufacturer. At the end of this period, when the project officer is thoroughly familiar with the item, the actual field testing is started. Flight tests are conducted under day, night, and instrument conditions to determine the performance quality, reliability, maintainability, safety and habitability. Consideration is given to growth potential if applicable. If the item tested is an aircraft, it will be operated from the areas and under the various load and weight conditions expected under actual operating conditions. Long hours in the air may indicate that a pilot fatigue problem exists. This could be the result of poor seat design, instrument arrangement, cockpit lighting, control locations or any combination of these or other things. Recent tests conducted on one helicopter design showed that the pilot's and copilot's seat design in this aircraft was unsatisfactory for one particular regime of flight: the location of the control sticks prevent the pilot from taking advantage of the support provided by the seat back while he is manipulating the controls. A change has been recommended to correct this situation. At times the standard instrument or control arrangement may require changes in order to meet all the operating conditions. Thus the ideal design may have to be compromised. As a result of testing under the operating conditions expected for the aircraft, such condition was found to exist with this same helicopter. Location of the flight and engine instruments appeared satisfactory when operating from large open areas with external loads. However, when taking the same load out of a confined area and over obstacles, the division of attention between outside the cockpit and the engine instruments inside the cockpit was too demanding on the pilot to allow safe efficient operations. Accordingly a completely new arrangement of instruments has been recommended. In another case pilots found that after several hours of flying at night, excessive eye strain was encountered and the instruments appeared to blur and displace, creating vertigo or disorientation of the pilot. The primary cause of this phenomenon was traced to the cockpit and instrument lighting. The results of this test brought about a satisfactory lighting system in future models.

Another phase of test is designated the transition training phase, and is conducted for both aviators and mechanics to determine the relative complexity of the item when considered in conjunction with the human element. Other aspects of a human engineering nature are considered to determine what level of training the man will require to more efficiently operate the overall system. Throughout all phases of these and other tests, the maintainability and reliability of the system is subjected to repeated review and testing. In order to adequately cover each of the eight objectives delineated earlier, approximately 300 flight test hours are accumulated on the equipment. In addition, maintenance time of from 1 to 12 hours per flight hour is required, depending upon the individual design and to what extent human engineering factors have been considered by the designer.

No immediate or apparent results are noticed in most cases. However, the influence is felt in the education and thinking of research and development personnel, and eventually brings about a change in the unsatisfactory feature. Through the years certain items or design features have been determined to be desirable and others to be undesirable. For instance one airplane procured for the Army was provided with the pilot's seat adjustable fore and aft but sliding on an inclined plane. As the seat moves forward it also rises. On the surface this appeared to be a good feature. In actual use it became apparent that the design was undesirable. The short aviator found himself in an unnatural and uncomfortable position which made it difficult to use the rudder pedals without activating the brakes. As a result of this, two-way adjustable seats are now specified in most of the newer military characteristics for aircraft.

Airborne communication equipment has been changed considerably also as a result of user experience. Three or four years ago, all Army airplanes were equipped with separate headsets and microphones. Through user test it was determined that safer and more efficient operation was obtained when the microphone button was located on the throttle or control stick and used in conjunction with a combination headset and microphone. This leaves the pilot's hands free to handle the controls. This was recommended and at present the headset with microphone attached is becoming standard in all Army aircraft.

The most marked indication of the influence exerted by the user is in the maintenance field, however. Operation in the field has indicated a necessity for rapid disassembly and assembly for inspection and repair services. Previously this meant many hours of laborious disconnecting and connecting fittings. Due to requirements levied by the user, quick disconnects have been designed and are being employed for everything from fuel and hydraulic lines to control cables. These features are usually implied in the military characteristics and specified in type specifications.

Another point of emphasis from the users viewpoint is that of giving due consideration to "Murphy's Law." Paraphrased, this law states that if an item can be assembled or a job can be accomplished in a manner other than correctly, it will be. This one thing alone is the clue to many fatal aircraft accidents.

There is a case on record which indicates that a pilot entered the traffic pattern and put his landing gear control in the down position. To his consternation, the landing gear failed to extend and upon checking his instruments he found that his flaps indicated down. By experimenting he discovered that his flap control actually controlled his landing position. After determining the situation the pilot extended his gear and executed a safe landing. The mechanic had to force the connections, but he had managed to connect the flap hydraulic lines to the gear and the gear lines to the flaps. It sounds incongruous but I can assure you it did happen. We recommend that the "go, no-go" principle be applied wherever possible as a direct result of such incidents.

In all instances the safety aspects of human engineering must be considered. It was originally thought that a helicopter pilot would have his hands too busy to activate an emergency external load release manually. Therefore in initial designs, the release was placed on the cockpit floor where it could be foot operated. Experience later proved this reasoning erroneous. We are now including in the new helicopter military characteristics a stipulation that the emergency manual release be hand operated.

In other respects we have failed to consider the complete man-machine system in sufficient detail to determine all the necessary features prior to test. Apparently not much thought was given to the static electrical potential of a helicopter as long as it was in the air. It was only by user experience that we found a problem does exist. When picking up external loads, a ground crewman is presently required to manually prepare and hook up the load. In doing so he establishes a ground contact. Sufficient electrical potential to knock this man down has been encountered in several instances. A solution for this problem is presently being investigated and if successful, will be retrofitted to existing helicopters and included on all new ones procured.

I think you can see that in considering the pilot as merely the control in the man-machine system, everything possible must be done to provide this control with accurate data, simply displayed without need for interpretation, if efficient operations are to be accomplished. If through lack of consideration of the human element the control is over-loaded, receives erroneous information, or is unable to activate the necessary sub-systems, the entire system fails either wholly or in part in its capability to perform the mission.

In summary let me emphasize the point that user testing by the U.S. Army Aviation Board can be considered to a large extent a test of the degree of human engineering designed into the equipment. Thus, the military characteristics, many of the unsatisfactory equipment reports, and the recommendations provided to HQ US CONARC by this Board will exert a high degree of influence on equipment design through user experience.

V. TECHNICAL SERVICE PRESENTATIONS TO THE CONFERENCE

1. MANUAL PERFORMANCE IN THE COLD

Dr. E. Ralph Dusek, Chief, Psychology Branch,
Environmental Protection Research Division, QM R&E Center

A soldier's hands are indispensable for the carrying out of his many military duties. Moreover in modern armies the demands made on the hands have increased tremendously as a result of increased complexity of equipment, as well as a result of the greater range of environments in which armies must be prepared to fight. To meet these increased demands particular attention must be given to the effects of cold environments on manual performance.

Previous experimenters and observers have repeatedly emphasized that exposure of the hands to cold temperatures reduces the level of manual performance; however, in general the reports are based on performance of very complex unstandardized tasks under highly variable ambient temperature conditions. In addition, finger skin temperatures and performance were never recorded simultaneously and related to one another. Thus, reduced hand efficiency may or may not be strongly related to cold hands. To correct these inadequacies, a series of studies have been conducted in an attempt to relate different performance factors or dexterities to finger skin temperatures and to physical variables such as ambient temperature, windchill, and handwear design. The information derived from these studies should have practical value for designers of handwear and manually operated equipment.

An initial study was conducted to evaluate the effects of air temperature, windchill, and physical exercise on body and skin temperatures and on hand performance. A total of 580 soldiers were exposed to 12 different conditions involving two temperatures (-15° and -35° F) combined with five wind speeds (5, 10, 15, 20 and 30 mph). Two control groups were exposed to 60°F with 5 mph wind while dressed in shorts and fatigue uniforms respectively. The men in the experimental groups wore the Army arctic uniform. The experimental procedure consisted of 25 minutes of cooling followed by 15 trials on a hand performance test, then 10 minutes of sitting followed by three minutes of running in place (exercise) and five more trials on the test. Groups exposed to the lower temperature (-35°F) took consistently longer to perform the tasks than groups exposed to -15° F. Body and digital skin temperature decreased systematically with increased windchill. Furthermore, performance time on the manual task was essentially a linear increasing function of windchill over the range studied. Using performance of the control groups as a reference, the approximate loss of performance for the low and high windchill groups (800 and 2200 $KgCal/m^2/hr$) was 12 and 32 percent, respectively.

Correlations between mean skin temperature and performance time were negligible as were those between digital skin temperature and performance time. However, the results show that windchill has a systematic effect on both mean skin temperature and digital skin temperature. The relationship between these two dependent variables and performance is not clear, although it appeared that neither was highly related to performance.

Since the above experiment did not require fine finger manipulation, another study was performed to relate this aspect of manual performance to lowered skin and ambient temperatures. Eighteen subjects served under each of four different ambient temperature conditions (35°, 45°, 55° and 75°F). They wore the Army wet-cold uniform except for having their hands bare. During the experiment the subjects' hands cooled for thirty minutes following which they performed on three tests known to measure at least two different hand performance factors, fine finger dexterity and gross hand dexterity. Finger skin temperatures were recorded continuously.

The results showed a systematic deterioration in performance on each test as ambient temperature decreased. Moreover there was a systematic increase in the variability of the scores on all tests as ambient temperature decreased. The amount of impairment relative to performance at 75° F varied among the tests, suggesting that the cold was affecting the factors measured by the tests in different ways. Thus the greatest impairment appeared on the test involving fine finger dexterity and the least on the test measuring gross hand dexterity. For the 35° F condition the impairment was approximately 45 and 20 percent, respectively. Thus in the first study discussed the estimated loss in manual performance as a function of windchill is conservative since the test used was weighted for gross hand dexterity. A further breakdown of the fine finger dexterity test revealed that the tasks requiring the use of both hands were affected most and that left hand was affected more than right hand performance.

In order to evaluate the relationship between performance on a test and index finger temperature, correlations were calculated between these measures, but none were significant.

In both of the previous studies manual performance and finger skin temperature were dependent variables and the correlations between these variables were negligible. In a subsequent study another experimental design was used in an effort to evaluate the relationship between these two variables without resorting to correlational techniques. The purpose of this study was to determine the extent to which local hand temperature affected performance when the ambient temperature surrounding the rest of the body was controlled. The design involved close monitoring of finger temperatures, and administering performance tests at certain predetermined temperature levels. Sixteen soldiers were used in this experiment, which was conducted under two conditions. One condition involved working in an ambient temperature of +15° F. The other condition involved exposing the hands to +5° F while the rest of the body was surrounded by a 75° F ambient temperature. Manual performance tests were given immediately on entering the controlled temperature room or on placing the hands in the cooling box, and again when the fifth digit on the left hand reached 65° and 50° F, respectively.

Differences in performance attributable to the two conditions of cold exposure were negligible; however, lower performance levels were associated with lower hand skin temperatures. Relative to performance upon first entering the cold, performance at a skin temperature of 65° F had decreased by 5 and 9 percent on the two tests, and at 50° F the respective decreases were 27 and 23 percent. From these results it was concluded that finger skin temperature is related to manual performance, and that the ambient temperature surrounding body areas other than the hands and wrists had little effect.

In still another study an attempt was made to determine whether impairment in performance on a complex task in a cold environment could be prevented by maintaining the hands at normal temperatures even though the rest of the body was cooled to subnormal temperatures. Twelve soldiers dressed in shorts performed in a controlled temperature room maintained at 45° F. The experimental group kept their hands in a warming box with a temperature between 90° and 100° F in order to keep the finger skin temperature above 80° F. The subject performed on entering the room and on two subsequent occasions when the mean body skin temperature dropped to 82° F., and to 79° F. The control group placed their hands in the box which was at the room temperature (45° F). The temperature of the fifth digit of the left hand was monitored and the tests were administered when the subject entered the room, and again when fingertip temperature dropped to 65° F and 55° F, respectively.

Performance on the two tests was not affected when the body cooled, but the hands were kept warm; however, when both hands and body were cooled simultaneously performance dropped off as in the previous experiment. Thus maintaining hand warmth by applying heat locally appears to facilitate hand performance when the individual experiences cold stress.

Future research will involve further study of the hand temperature and hand performance relationships. The next experiment planned will study specifically the effects of different rates and degrees of hand rewarming on recovery of manual efficiency. This work will have direct application on design of protective devices and on training in operational techniques to be used in arctic environments.

The effect of handwear design on manual performance and skin temperature has been evaluated in two human engineering studies. In one study the "Chinese Sleeve," a type of muff extension on the Parka sleeve, was found to have superior thermal protection characteristics without impairing manual functioning any more than the standard arctic mitten. In the other study which is still in progress the number of movable fingers available in handwear was systematically varied. Preliminary analysis indicates that efficiency of performance on a number of tests is positively related to number of movable fingers. Hand cooling associated with these designs is currently being studied.

The combination of psychophysiological and human engineering research offers a dual approach to problems of environmental protection. The psychophysiological research provides information on the capabilities of individuals under cold stress and techniques for reducing the effects of this stress. Human engineering research attacks the problem of loss of hand efficiency imposed by handwear design and other protective devices. Both the handwear designer and the design engineer may use the knowledge of the differential effects of cold on various dexterities to advantage. The increased variability of performance found with decreased ambient temperature suggests that individuals react differently to environmental stress, and raises a further question as to whether, through selection procedures or training, such variability could be reduced.

2. Selected Significant Results of Recent Unpublished Research Within the Research and Development Division of the Office of The Surgeon General

Colonel Charles W. Hill, MSC
Chief, Human Resources Research Branch,
Research and Development Division, OTSG

The principal responsibility of the Office of The Surgeon General in regard to Human Factors Engineering lies in the scientific area of psychophysiology, or physiological psychology. Research results are sought in this area which will contribute to the development of new or improved human engineering principles for application by each technical service, including ourselves, to the design of its specific pieces of equipment. Thus, the laboratories of The Surgeon General are focussing their attention upon basic questions in vision, hearing, motor coordination, etc., in order to identify and quantify the performance characteristics of the soldier in terms of his capabilities and limitations.

Although we accept this responsibility for providing basic data on the human body, unfortunately we have neither the funds nor the facilities to work on all the problems crying for attention in this area. Selective digging down into the more fundamental levels must therefore be conducted by all the technical services whenever their human engineering applications are impaired through lack of knowledge. Such a procedure should insure steady, optimal, overall progress, with integration maintained and duplication controlled through timely notification of needs and intentions to The Surgeon General followed by continuous mutual exchange of information.

With this brief introduction to our general situation, let me now turn to the specific topics which have been selected on the basis of currency and interest for presentation to you today. Two fairly discrete research studies will be described --both from the Psychology Department of our Medical Research Laboratory at Fort Knox, Kentucky. The first, pertaining to the problem of control and coordination, will be presented by Dr. Lee S. Caldwell, Control Coordination Section, Experimental Psychology Department, U. S. Army Medical Research Laboratory. Dr. Caldwell will describe for you his investigations of the force-spaces for the more common hand movements, and their implications for the location of hand controls. The second, describing current efforts in regard to noise exposure and hearing loss, will be presented by Captain John L. Fletcher, Sound Section, Experimental Psychology Department, U. S. Army Medical Research Laboratory. Captain Fletcher will discuss the ever-growing serious problem of environmental noise, together with several related efforts directed at analysis of noise and measurement of hearing loss. I am sure that both of these papers will illustrate clearly the typical supporting relationships of psychophysiology to human engineering and give some indication of what contributions you may expect to receive in the next few years.

3. The Effect of the Spatial Position of a Control on the Strength of Six Linear Hand Movements

Dr. Lee S. Caldwell
Army Medical Research Laboratory
Ft. Knox, Ky.

The present study is the first of a series of investigations to measure the forces that can be applied within the work-space of the hand, and from this to determine the "force-spaces" for the more common hand movements. The specific object of this first study is to isolate the spatial factors which influence the force with which 6 linear hand movements can be made along the 3 orthogonal axes of an isometric control.

Measurements were made of the maximum-exertable force that could be applied to a dynamometer handle by each of 6 linear hand movements (up, down, right, left, push, pull). The maximum strength of each of the 6 movements was measured at 5 handle distances (12, 16, 20, 24, and 28 in.), 4 angular elevations (60, 90, 120, and 150 deg.), and 4 lateral positions (0, 30, 60, and 90 deg.) of the control.

The results for each of the six movements were analyzed separately by an analysis of variance. The results were as follows:

1. The handle distance was the factor which most influenced the strength of the movements. This source of variation was statistically significant in each analysis. The strength of the Up, Down, Left, and Right movements progressively decreased with increasing handle distance.

2. The lateral position of the control significantly affected the strength of only the Down and Right movements. The 30 deg. lateral position (30 deg. to the right of the saggital plane of the shoulder) was best for the Down movement. The 0 deg. lateral position was best for the Right movement.

3. The Left and Pull movements were most affected by the angular elevation of the handle. The 60 deg. elevation (30 deg. below the horizontal plane of the shoulder) was best for the Left movement, and 60 deg. elevations were best for the Pull movement.

4. Noise Exposure and Hearing Loss: A Military Problem

John L. Fletcher, Captain, MSC
Army Medical Research Laboratory
Ft. Knox, Ky.

The noise level of military work environments increases as more powerful engines and weapons are developed. This has, with little question, increased the frequency of noise-induced hearing loss in the service and has resulted in considerable monetary compensation.

The mission of the Sound Section, USAMRL, includes measurement and analysis of noise levels, and relating such noise levels to the probability of hearing loss in personnel exposed to such noises. To facilitate our mission a mobile sound laboratory has been built to permit testing of hearing in the field.

Relating noise exposure of range operators to hearing loss is part of our long range program. Pre-exposure audiograms are made, and subsequent hearing loss is related to several variables such as amount of exposure, hearing conservation practices, family history, and other relevant factors.

Effort is being made to find a test to differentiate those susceptible to noise-induced hearing loss from those who are not susceptible. One promising test, the aural overload test, is now being studied. Initial audiograms and aural overload thresholds of 106 Reserve Forces Act trainees at Fort Knox for 6 months will be compared with termination audiograms and aural overload thresholds to determine whether the aural overload point is indicative of subsequent hearing loss.

5. Some Human Factors Engineering Implications from Design of Prosthetics

Colonel Maurice I. Fletcher, MSC
Army Prosthetics Research Laboratory

I have read with great interest past papers and reports on the meetings of the Human Factors Engineering Conference and, of course, am stimulated with the tantalizing possibilities and never-ending problems presented.

It occurs to me that the situation regarding the man-machine combinations is following somewhat the pattern that has its parallel in the projectile - armor plate problem, namely, the armor is developed to resist the projectile, and then the projectile is developed to penetrate the armor, ad infinitum.

In the development of artificial limbs, the problem becomes more intimate and complex. A part of the human body is missing, together with its functional possibilities, at least part of its motive forces, and its proprioceptive senses so important in our manner of living.

In the design and development of the artificial limb, and particularly in the upper extremity prosthetic restoration where a wide range of motion is necessary, many studies have been made to provide as much function utilizing the remaining limb stump as possible.

If a hand and part of the forearm are amputated, over 25 muscle groups have been destroyed. To restore the action of all of these groups would not only be a complex job, but would be so complicated in its operation as to frustrate or discourage the amputee. Furthermore, there are not enough remaining harnessable sources of power to effectively operate so many motions.

The prosthetic designer is faced with many problems; the location and use of all available sources of power, the most efficient transmittal of that power, the use of control separation so that one source of power can be used for several operations, the stability of the entire unit or units, and, if possible, a kinesthetic feedback cue as to position, grasp force, or touch.

In the more general human factors engineering problem where the entire body is available for operation of external devices, several techniques developed for artificial limbs have possibilities in the modification of the man to operation of complex equipment.

Most intriguing of the anatomical sources of power is the use of muscle loops, or tunnels, installed through the surgical technique known as cineplasty. This operation is performed by cutting skin over a muscle, forming it into a tube and re-inserting this tube through an orifice expanded in the muscle body, and then covering the exterior with a skin graft. Muscles available on each side of the parasagittal or vertical center plane of the body include the pectoralis, latissimus, biceps, triceps, and the forearm flexor and extensor muscles. Highest forces and greatest excursion possibilities, with good force-work range, can be obtained from the pectoralis major and biceps muscles.

In the amputee the distal portion of the muscle tendon is detached to provide greater excursion. Such muscle loops in the non-amputee could be of small size and used only to "trigger off" a source of external power electrically, pneumatically, or hydraulically. Reaction points to the pull of the tunnel could be established on the body, and very efficient, silent, cable transmission systems are already a part of the prosthetic armamentarium.

In addition to muscle tunnels or slips, the muscle bulges themselves may be utilized externally to provide servo-motor controls. In this respect, the reflex muscle actions of the body might be synchronized with respect to the mechanical response desired. For example, when the equilibrium of the body is upset there is a reflex muscle response tending to right the body, and the tension in the muscles attendant to this response may be utilized externally, through a sensitive valve or micro-switch, to produce a parallel righting or correction of a machine. Such a correlation of muscle-machine movement would not be too difficult. This system has been used in the control of knee locks on artificial legs.

In the purely mechanical application of man to machine through external power, the scapular and other natural motions of the body can be harnessed to multiple valves or switches with mechanical over-rides, and many external remote controls can be thus actuated with one movement.

Any of the mechanical motions can be utilized with existent mechanical force multipliers, so that repeated operation of the source of power can be transmitted as in an automobile jack to obtain any ultimate force desired. This is, of course, dependent on the time factor required.

Many devices exist, or are being developed within the prosthetic research program, which can be utilized in the control systems between man and machine. These include: force multipliers; locking devices for elbows, hands, and hooks; velocity and inertial locks; clutches; separation of control mechanisms; anti-backlash and front lash locking systems; load controlled unlocking mechanisms; and many other items useful in adapting a machine to the man.

A study of the force potentials of various muscles and body motions discloses a vast number of useful sources of power for obtaining external motion or control. A study of the data compiled on time and motion studies, already available through the Prosthetics Research Board of the National Research Council, will, I am sure, uncover other possibilities of increasing the work potential existent in the human body.

As to the future, every possible lead is being pursued to increase the efficiency of the man-machine combination so necessary in the restoration of a lost human limb. It is impossible to tell you in the time allotted of the hundreds of devices developed for prosthetic replacement of a lost portion of the human body or of the numerous studies that have been, and are now being conducted on the subject, but I can assure you that such studies are continuing and never ending.

I would like to close with a few "germs" for thought which are now being explored and which might become a useful possibility for application of the man to a particular machine in the future. First, the extension of our myoelectrical studies, wherein electrical potentials set up by the nerves activating the muscles may provide a sense of touch and a source of nerve stimulation which may be harnessed electrically to trigger external sources of power correlated to such tasks as are needed; Secondly, through the imbedding of secondary antenna or even transistor transmittors internally, and adjacent to a nerve or nerve center to signal to an external receiver as usable impulse. Also studies of the nerve-electrical system adjacent to the spine may provide a clue for further development of impulse-controlled external utility motors which are "mind-controlled" or regulated.

All of the modifications of the human body sketchily described above offer the possibility of modifying the man until the machine can be perfected to accomplish the task, and then until more complex objectives are required of the machine, at which time the man can again be modified until the ultimate of each has been reached and man has become so complex that his only vacation will be a bottle of tranquilizers.

Bibliography

Technical Adequacy and Practical Application of the Heidelberg Pneumatic Prosthesis, Marquardt, E, and Haefner, O., Published by the International Society for the Welfare of Cripples, 701 First Ave., N. Y., N. Y. 1956

Human Limbs and their Substitutes, McGraw-Hill Book Co., Inc., 1954

Artificial Limbs, Published three times annually by National Research Council, National Academy of Sciences, Washington, 25, D. C.

Catranis Report, National Research Council, 1950.

I.B.M. Report, National Research Council, 30 June 1947.

6. System Evaluation of Ordnance Materiel

Dr. John D. Weisz, Director
Ordnance Human Engineering Laboratory
Aberdeen Proving Ground, Md.

The U. S. Army Ordnance Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, conducts three types of research activities: (1) background or fundamental research in noise, blast, optical, radar, and display control relationship problems common to a number of weapon systems; (2) user-opinion or problem survey studies conducted by field liaison teams of military engineers and psychologists who interview user personnel on problems connected with the operation of standard Ordnance materiel; (3) systems evaluations.

Currently, fundamental research is continuing, and user-opinion surveys have been completed on the M48 Tank, permanent NIKE installations, the HONEST JOHN system, and Personnel Carrier M59, the CORPORAL systems, the 280 mm cannon, and the M76 and M59 vehicles under arctic conditions. Surveys are now being conducted on the Personnel Carriers T113 and T117, and the Atomic Warhead Checkout Equipment. This paper, however, is devoted exclusively to a discussion of the system evaluation program.

Since the Laboratory has been doing system evaluation research for approximately 2-1/2 years, methods have been developed which may be of considerable interest to USCONARC and to the Technical Services. A general method of procedure has been developed which is followed on all systems under study, with minor variations as required.

The procedural phases are described as discrete events, but in reality they usually overlap each other considerably. Systems currently under investigation are LACROSSE, DART, HAWK, TALOS, VIGILANTE, REDSTONE and SERGEANT.

Obviously, every attempt is made to enter into the design picture as early as possible so that the maximum benefit can be realized. In several instances the Laboratory has been given the opportunity to review and submit comments on the military characteristics of specific weapon systems. In such a situation the Laboratory can predict the major human factor problems and can recommend specific design considerations. The military characteristics are considered as the final criteria and constitute the parameters within which the Laboratory will make its ultimate system evaluation. Project personnel must thus become thoroughly familiar with the military characteristics, as well as the results of any design feasibility studies which may have been conducted prior to the initiation of any development work.

Every attempt is made to assign several personnel with training and experience in engineering and psychology to a system evaluational project as soon as the Laboratory is requested to enter into the project. They remain with the project until it is completed. Usually one person is designated as the project director, primarily for administrative and coordination purposes.

A close consulting relationship is next established with the arsenal designers and design engineers from the prime contractor in order effectively to monitor the human factors design efforts, and to provide human factors design data as needed throughout the developmental phases of weapon system development. If such design data are not found in the literature available to the project personnel in the Laboratory library, specific field or laboratory research studies are initiated to derive such information. An example of such research would be the determination of the optimum level of magnification to use in an optical sighting system for an anti-aircraft system. Such a study was recently conducted by the Laboratory at Yuma Test Station, Yuma, Arizona, and the resulting data are currently being utilized in the design of the item. This working relationship with the prime contractor has to be constantly maintained throughout the developmental phases to insure that an optimum weapon system is developed. Research efforts are directed towards the evaluation of design layouts, bread-board concepts, and mock-ups of both system components and the complete weapon system as it emerges.

Every attempt is made to visualize the use of the weapon under all types of environments by the typical user personnel for which the weapon is being designed. The maintenance requirements have to be determined early in the developmental phase in terms of ease of maintenance, procedures, and the type of test and checkout equipment to be used in the field once the weapon system becomes a standard item. In guided missile systems currently under development considerable attention is being given to providing adequate work space in the vans and on associated equipment. The space is evaluated in terms of traffic flow patterns, the number of operators involved, and the proper layout of the equipment in order to obtain an optimum working environment. Other factors considered are: the communication systems involved, heating and ventilating requirements, interior color, and lighting schemes.

Once the design of most components becomes fixed, project personnel begin to write detailed test operating procedures for every crew member who will operate the weapon system. Since this task is so essential to the entire evaluation, it has to be a joint effort of the prime contractor, USCONARC, and the Laboratory. Any major changes made in the design of the weapon at this point will obviously result in changes in operating procedures. Thus, every attempt is made to write the procedures around the latest modifications possible. Since tactical considerations are very important assistance is sought from USCONARC regarding the weapon's ultimate use under various terrain and environmental conditions. Concurrence is obtained from all agencies (USCONARC, the contractor and arsenal designers) on the final version of the operating procedures prior to their use in a field evaluation of the weapon system.

Project personnel then develop, in detail, the program which will be followed in the field test phase. An attempt is made to set up a valid test plan which will allow the Laboratory to examine the weapon system in tactical field situations similar to those in which the item will eventually be utilized by troops. This plan may include both day- and night-time conditions, and operations under environmental extremes. The field test plan not only tries to check likely errors, but also tries to determine the time requirements needed to emplace and check out the weapon and all of its supporting equipment.

The field test is then conducted as specified in the test plan, using as operators a sample of military personnel obtained from the specific user population for which the weapon is being designed. The personnel are divided into crews, and trained to operate the actual prototype equipment to a specified stable level of proficiency prior to the test.

During the test a team of observers from the Laboratory records time and error scores for every operation made by the crew members as they emplace and check out the weapon prior to actual firing. Motion pictures are taken to be used for later analysis and evaluation.

Once the data have been gathered they are analyzed and evaluated, and a final report which includes redesign recommendations of deficient components is written. If sufficient time is available, some of the critical components may be redesigned in mock-up form and evaluated again prior to submitting specific recommendations to the arsenal and contractor designers.

Every systems evaluation project constitutes an extensive research program as essential to the development of a weapon system as any other design research and development effort. Through such a program the critical human factors areas can be isolated, and the resulting design problems resolved, prior to the time that the weapon is mass-produced and becomes a standard field item for troop use.

7. Specification of Brightness and Readability for Self-Luminous Control Panel Elements

Mr. Thomas Goldsmith and Mr. Joseph L. Seminara
Human Engineering Unit, Picatinny Arsenal

a. Introduction: Mr. Thomas Goldsmith

Picatinny Arsenal's Human Engineering Unit, being organized as a service organization for hardware development groups, must be concerned primarily with the immediate problems of equipment design. Usually the handbooks and psychological literature are checked for information needed for application. When the information does not exist, our personnel are sometimes able to undertake supporting research, as necessary, and thus function as Engineering Psychologists or Human Factors Research Specialists.

Mr. Seminara will describe some significant research which was prompted by a specific design problem--How can troops make settings on a control panel at night with no electrical power and no flashlight available?

b. Report: Mr. Joseph L. Seminara

The Human Engineering Unit of Picatinny Arsenal was called upon to make recommendations concerning the illumination of certain rocket control panels. The engineering and military limitations imposed on the situation were as follows:

1. No conventional power source would be made available specifically for illumination of the control panel
2. The source of illumination chosen would be required to stand up under extremes of climate and
3. The illumination provided should be such that the control panel would be adequately illuminated and at the same time should render the rocket launching site minimally detectable to possible enemy patrols in the area.

After surveying available methods of illumination it was decided to utilize radioactive self-luminous sources. These sources basically consist of a radioactive substance in combination with a particular phosphor. The radioactive substance emits alpha and beta particles which strike the phosphors resulting in the emmission of visible light.

In addition to meeting the military and engineering requirements just stated, these sources have the following advantages:

1. They take up a minimal amount of equipment space since no batteries, wires, switches or bulbs are needed.
2. They require no maintenance effort since these sources have a useful luminosity life measured in terms of years.
3. The cost of incorporating this form of illumination into many equipments is not prohibitive when we consider the savings resulting from the just-mentioned factors.

Great progress has been made in the field of radioactive illumination in the past few years. Much research has gone into finding the right combinations of radioactive sources and phosphors to produce light of sufficient brightness and length of life. A concomitant problem has been the development of shielding techniques to prevent harmful radiation from striking the human body.

The first successfully used radioactive substance was radium. Everyone is familiar with the greenish-blue light seen in the dark on the markings of watches and clocks.

However, radium excited phosphors did not prove widely applicable for two main reasons:

1. radium emits extremely dangerous radiations making this substance hard to handle, and
2. radium alpha-particles destroy the phosphor crystals too rapidly, causing too rapid a loss in brightness of emitted light.

Since the early use of radium, a number of artificially produced radioisotopes have been employed in attempting to overcome the limitations of radium. Among these have been Strontium, Krypton, Thallium, Prometrium and Tritium. The last-mentioned, tritium, has shown the greatest promise in avoiding the radiological hazard. This radioisotope requires very little shielding. By encasing the self-luminous Tritium substance in a plastic envelope one-hundreth of an inch in thickness, this material is rendered harmless. The most promising development to date has been a commercial product named "Safeglow." This is a "paint" consisting of the Tritium radioisotope in combination with a phosphor and special plastic solvents and adhesives. This "paint" requires no shielding at all. At present, brightness values of up to 50 microlamberts can be obtained according to the manufacturer's claims. It is anticipated that in this future brightness values of from 75 to 100 microlamberts will be achieved with this new substance.

In order to make specific recommendations concerning the utilization of radioactive illuminants, two investigations were performed. The first study dealt with the detection thresholds for radioactive self-luminous stimuli at night. The stimulus materials used were five strontium -90, one inch diameter discs supplied by the U. S. Radium Corporation on a thirty-day loan basis. There were 2 green one blue and 2 yellow discs ranging in brightness from 10.8 to 28.6 effective microlamberts. Detection thresholds were obtained by the method of limits. Under varying conditions of darkness, the detectability of the radioactive light sources varied from an average of 89 to 245 feet. A small simulated control panel containing five four letter words with letters $\frac{1}{4}$ inch in height was seen at a mean distance of 60 ft away. On the basis of this study it was recommended that self-luminous sources would be used to backlight rocket control panels with little or no chance of detection by the enemy beyond 1000 feet.

The purpose of the second study was to determine the required brightness level and best color of illumination for readability of letters and numbers of varying sizes. The stimuli used were common four letter words such as FUZE, nonsense syllables, and two or three digit numbers. Letter sizes varied from 0.116 to 0.235 inches in height. The radioactive sources used to backlight these stimuli were the same as those used in the night detection study.

Of the colors used, yellow proved best for acuity and blue proved least effective. On the basis of the results of this study we were able to make recommendations to design engineers concerning the required brightness levels of illumination for numbers and letters of varying sizes at a reading distance of 28 inches.

In specifying the initially required characteristics of self-luminous source for a specific equipment application, a number of factors must be considered. These are:

1. The color of illumination desired.

2. The optimal brightness level for readability at a panel reading distance of twenty-eight inches.

3. The shelf life of the equipment or the anticipated useful life of the item to be illuminated.

4. The rate of decrease in luminosity in time for the particular radioisotope used.

A formula has been devised which takes account of these four factors and yields the required initial brightness level for the self-luminous sources.

The research that has been performed at Picatinny Arsenal has been preliminary in nature. Further research is currently underway with a wider range of colors and brightness levels. It is hoped that in the near future we will be able to specify with a greater degree of precision the required dimensions for this form of illumination.

At present, self-luminous sources are being utilized by the military in illuminating scales, level vials, and reticles for mortar sights and gunners' quadrants. The Navy has made use of these sources for deck markers. Another use that is being considered is in the form of personnel markers for night field situations. An "atomic flashlight" for map reading and other night activities is also in existence. To cite a commercial application, the railroad companies are testing the use of these sources as warning lamps. The use of "atomic lamps" will represent tremendous savings in many thousands of feet of expensive cable and will greatly reduce the maintenance costs required to keep up present types of electric lamps.

We have only scratched the surface of potential applications for this form of illumination. With such new developments as "Safeglow" in which the threat of harmful radiation is eliminated we can anticipate that the use of self-luminous sources will be widely expanded in the years to come.

8. Some Human Engineering Aspects of the E13R9 Field Protective Mask

Dr. E. Davy
U. S. Army Chemical Warfare Laboratories

About three and one half months ago, a number of American newspapers carried a United Press release which was headlined: "Army developes new atomic age face protector". An alternate version of this headline from another newspaper was: "Mask protects GI against radioactivity", etc. These press releases and accompanying articles referred to the current experimental or E13R9 Mask, Protective, Field, commonly called the E13R9 Gas Mask.

The E13R9 mask was developed by the Chemical Warfare Laboratories of the Army Chemical Corps, working in conjunction with the Mine Safety Appliances Company of Pittsburgh, Pennsylvania.

The small print of the article, which followed the eye-catching headlines I have mentioned, diminished to some extent the spectacular impact in that there was an admission, presumably in the interest of reporting accuracy, that the mask, although preventing the wearer from breathing air-borne radioactive fallout particles, did not afford protection against direct radiation.

Before continuing this discussion of the E13R9 mask, I should like to point out that I am not an authority on protective masks and, although I may often be seen carrying a brief case, I am not even an expert. The study which I am about to relate was not designed by the Army Chemical Corps Psychology and Human Engineering Branch. Our part in this study was purely on what might be called a consulting basis. Actually, I was invited to observe field tests on the mask and saw an opportunity to obtain data on the reactions of troops to this mask.

Prior to, and during, the time that these field tests were being conducted, a series of laboratory tests were being conducted at the Directorate of Medical Research at the Army Chemical Center. These laboratory tests included determinations of the actual resistance of the mask filter elements, tests for leakage around the edges of the mask as it was being worn by active personnel, endurance measures of personnel executing strenuous tasks while wearing the mask, etc.

Insofar as human engineering evaluation was applied to this item, the question of primary importance concerned the satisfactoriness of the interaction of the item and its user. The importance of this question becomes apparent if we note that upon its answer depends the answer to two related questions; namely, "Will the item be used (rather than ignored or discarded)?" and "What will be the effect of using the item upon the proficiency of the user, both in terms of consequent morale changes and in terms of physiological limitations, which the item may impose?" Extreme physiological effects upon the user, such as exhaustion and excessive fatigue, may be determined by direct observation or by measurements of body temperature, oxygen consumption, heart rate, etc. The concern of our part of the study was with more subtle physiological manifestations which are only in evidence if they are reported by the individual, and especially with the subjective attitudes of the individual toward the item.

Characteristically, these sorts of reactions are determined by the use of form questionnaires. The widespread use of prepared questionnaires for the purpose of determining subjective reactions of large groups to equipment may be readily understood if one considers the advantages of this method. For one thing, the prepared questionnaire may be administered to large groups in a short time by a very small complement of personnel. For another, the questionnaire is a fair guarantee that a large amount of data will be forthcoming. Because of the nature of the typical questionnaire; i.e., because it usually asks for brief and previously constructed answers, these data may be easily tabulated in a form which readily lends itself to statistical analysis. However, it is also obvious that this sort of questionnaire has some very definite limitations. It is always possible that some very important reaction, observation, or feeling on the part of the subject user will not have been anticipated by the person who has constructed the questionnaire. Of course many questionnaires end with the open ended type question such as "Any further comments?" However, the formal structure of the greater part of the questionnaire usually tends to limit the informal comments which the subject will make. In addition, as these comments are written and as they are often read after the subject is no longer available for questioning, their meaning may be obscured, misinterpreted, or completely lost. Still another important disadvantage is the fact that a questionnaire may be a more effective determinant of the subject's responses than his experience with the item we are investigating. In other words, it may, through suggestion, draw upon his imagination rather than his memory.

The Chemical Corps gas mask of current standard issue is designated as the M9. This mask has, on one side of the face piece, a canister for the purpose of removing toxic material from the atmosphere before that atmosphere reaches the oral-nasal tract of the wearer. During the past two years, the U. S. Army Chemical Warfare Laboratories at the Army Chemical Center has developed a new mask now known as the E13. In this mask, the side canister has been replaced by two charcoal filter elements one on either side of the facepiece.

The M9 mask offers a rather high resistance to breathing upon inhalation, thus resulting in user fatigue beyond the extent which would normally result from participation in any given activity. In the E13 mask, this resistance has been cut approximately in half. To overcome the interference with speech and the resulting lack of intelligible communication caused by the design of the M9, a "voicemitter" has been included in the facepiece of the E13. Other innovations incorporated in the E13 include an eyepiece construction which affords wider angle visibility than that of the standard mask. Last June, during the time that the new mask was being tested for leakage, durability, usability in cold environments, etc., field tests were being conducted to determine the extent of direct interference of the mask with the execution of typical military tasks such as rifle firing, rocket launching, etc. For these tests, fifty masks of each type (M9 and E13) were taken to the U. S. Army Chemical Corps Proving Ground near Salt Lake City, Utah. The proving ground covers a rather large area in the western part of the state and the terrain includes desert and salt flats as well as some rugged areas of the Wasatch range. Before the tests, fifty troops were selected and fitted with one of each type of mask. Each man was shown and allowed to practice the proper method of wearing and carrying both masks. Tests included marching over hill and desert terrain, competitive softball and volleyball, resting in recreation areas, use of weapons, donning mask on signal during a simulated Chemical Warfare attack, etc. Wherever possible, half of the subjects wore one mask and half wore the other during the tests. Halfway through the tests, each subject changed the mask he was wearing. Wherever applicable, the proficiency of task performance, in terms of proper and rapid completion, accuracy, etc., was objectively evaluated by expert military observers.

Having outlined the context of our particular problem, we return to the question of determining subjective reactions and attitudes of the troops. It seemed that the most useful information, that is the information most likely to reflect the true attitudes toward the mask, would be the spontaneous reports of the subjects during a time immediately following a test trial. To state it this way is to be almost redundant with the initial formulation of the problem. It is almost as though one were to state that the feelings of the subjects were the best indicators of their attitudes. However, the collection of this kind of information, unaltered by the method of collection, presented a need for techniques which we had not previously used in this type of situation. Of course clinical practitioners have, for some time, been developing and utilizing methods and skills which have proven successful in obtaining information from a source somewhat deeper than the level of consciousness at which we were interested in working. But, as is true in the instance of most field studies of military equipment, personnel with experience or training in interviewing techniques were not available, especially not in large numbers. Instead, we were able to obtain a staff of ten Army enlisted personnel, none of whom had any previous research experience and who, at the outset, understood nothing of the mysteries of psychic probing. Naturally it would not have been possible to make competent clinical technicians out of these men in the few days used in preparation for the test. However, it was believed that enough insight into the basic concepts underlying the unstructured interview could be transmitted and that enough skill could be acquired by this staff, of presumably average intelligence, in a period of three days of training and practice, to enable them to complete the task demanded by this particular problem. During the first day the research design, the masks, and some very elementary Rogerian principles were explained and discussed. On the second day, each man practiced interviewing several others who were instructed to behave as they imagined subjects might during the interviews. Only one practice interview occurred at a time. This was always in the presence of the other interviewers and under the supervision of the instructor. Thus, it was possible for the entire staff to profit by each criticism and by each repetition of the principles involved. In general, the men seemed not to find this activity unpleasant and were making very serious efforts to become skilled in their jobs. Wherever possible, of course, a trainee was highly complimented for his handling of a situation. Criticism was introduced by the instructor in the form of additional instruction or nuance of technique. Trainees were encouraged to criticize each other and to comment on specific situations which developed. This kind of participation contributed a great deal toward the holding of their interest. By the third day, each of the men seemed to have sufficiently "mastered" the necessary art. It should be noted that a sort of "model interview" (conceived by the instructor prior to the training period) was "developed" by the group during the training period. This model interview consisted of simple, short, interrogative phrases which were to be used successively in event a subject did not show sufficient spontaneity in expressing his attitudes. These phrases were nonspecific to the equipment; e.g., "How did it go?" and referred to the equipment only if the subject stopped talking or wandered too far from the information sought. The "information sought" was, incidentally, defined for the interviewing team as consisting of special or outstanding comments about the mask including recurrent complaints. Explanations were requested in instances where subjects' comments could not be understood. Interviewers were instructed to terminate all interviews after a five minute period had passed. In practice however, it was found that less time than this was typically required to determine all that a subject had to say. Recording a subject's responses, after they had been successfully elicited, would have been rather difficult if a verbatim account had been attempted. For this reason, a list of the kind of comments in which we were most interested was made up. Previous studies of gas masks and the typical responses of troops; that is, the typical criticisms made by troops wearing these masks; knowledge of design characteristics upon which the designers of the new mask had concentrated, such as the voicemitter, the decreased breathing resistance, etc., particularly those specific attempts at improvement of the standard M9 mask which were expected to elicit comparison comments, enabled us to make up this list. Thus, a part of the list had been developed prior to the training situation and the rest was added at that time. Additions were for the most part, made up from the suggestions of the interviewing team. This list consisted of one to three word phrases which were found to be capable of summarizing most all of the comments made by the interviewers acting as subjects. In other words, a man might talk for several minutes about how hard it was to breath, how he felt suffocated, couldn't get enough air, etc., or about how he kept tripping over objects because he couldn't see them, etc., but the notations written by the interviewer would consist only of the phrases: "breathing difficult" and "poor vision". Thus, after having memorized the list, interviewers were able to record subjects' statements with a minimum of notation. When a very unusual comment which seemed important was made, this was recorded as stated. It is in this one instance that we were forced to rely upon the judgments of the interviewing team. This method of recording the subjects' responses made codifying and tabulating the data far easier than it would otherwise have been.

Our observation of the members of the team indicated that our training method was successful. That is, it appeared on the basis of a spot check of the interviews, that the interviewing team was actually able to utilize "nondirective" interviewing techniques to the extent required by this study without introducing bias into the responses of the subjects.

To return to the actual test situation....The gas mask, that is, the experimental mask was worn by the subjects under a variety of field circumstances. In each instance, the standard mask was worn under comparable or identical circumstances in order to compare the reactions of the troops to the two masks. It should be noted that the test conditions in which the subjects wore the masks were selected for several purposes. Tests such as road marches over rough terrain, volleyball and softball, etc., were introduced primarily to determine such factors as the increased heat load imposed upon a man by the mask, the extent of fatigue resulting from the wearing of one mask as compared with the fatigue resulting from the wearing of the other, etc. In addition, a great deal could be learned about the degree to which the new mask was able to afford a visual field commensurate with the requirements of these tasks. A second type of test is exemplified by the leisure studies; that is, studies during which no specific task was assigned but during which the men were required to wear the mask over an extended period of time. A third type of test required the utilization of specialized and highly developed skills, such as rifle firing.

I have a short film which will show some of the actual tests during which the masks were worn. I should like to emphasize at this time that these are examples of developmental testing only; in no instance is a user test of an end item a part of this study.

AT THIS TIME, A 10 MINUTE FILM WAS SHOWN. THIS FILM SHOWED THE TYPES OF FIELD TESTS ON WHICH THIS STUDY WAS BASED. THESE INCLUDED AN OBSTACLE COURSE, A ROAD MARCH, A SOFTBALL GAME, A SHOT OF AN ARCTIC CHAMBER, AND ACTIVITY ON A FIRING RANGE.

The results of the interviews indicated that the troops were of the opinion that the E13R9 was more easily withdrawn from its carrier than the standard M9. This is an obvious advantage in combat when gas alarms are sounded. Timed tests have confirmed this subjective finding. The E13R9 is considered to fit better and to remain in place better than the M9. In addition, the E13R9 causes less irritation to the face and head.

Most all subjects stated that breathing was easier with the E13R9 mask, that lens fogging was less, and that wearing the E13R9 was less tiring than wearing the M9. The latter point is interesting to note in view of the fact that, when men on treadmills were told to run until too tried to continue, those men wearing the experimental mask ran no longer than those wearing the standard mask. Thus, it appears that the apparent advantage, with respect to fatigue of the new mask, though possibly important, is purely subjective. Most subjects believed that they were cooler while wearing the new mask. Again, laboratory evidence indicates that there is no difference between the heat load of the new and that of the standard mask.

In rifle firing tests there was a slight but not significant preference for the standard mask. Scoring totals however, showed little or no difference. It should be noted that the test subjects were very inexpert as riflemen. For this reason, it is probable that the variability of their scores was sufficiently great to mask any difference that might have been due to the respective designs of the masks.

The troops indicated frequently that the new mask was superior in that it afforded better vision and much better speech transmission and intelligibility characteristics than the standard mask. A general preference for the E13R9 over the standard M9 was found to be at a ratio of almost six to one.

9. Human Factors Engineering In the Transportation Corps

Dr. John W. Bailey
Transportation Corps Research & Engineering Command
Ft. Eustis, Va.

[Dr. Bailey commented on major Transportation Corps problems to which human factors engineering considerations are important. Among these he mentioned: design of rail passenger equipment; motor truck instrumentation, controls, and seating; ship loading facilities and harbor and convoy communications; terminal and warehousing operations; and design of aircraft instrumentation and controls.]

10. Selected Significant Results of Recent Signal Corps Research, and Major Future Studies Planned

Mr. Paul E. Griffith
Office of Engineering Operations
US Army Electronics Engineering Laboratories
Ft. Monmouth, N.J.

The remarks that I have to make apply to our work at the U. S. Army Signal Engineering Laboratory only. They are not concerned with human engineering work at the U. S. Army Electronic Proving Grounds or other Signal Corps installations.

I am aware that I should make a little introductory statement as to what we have been doing at the laboratories in the past year, our general method of operations, etc. For this, however, I simply refer you to the description of our work published in the last year's conference record; we are still doing much the same work: we are carrying on with the conduct of human factors engineering training courses; we are carrying on contract surveillance and some contract supervision (primarily through our contract with Dunlap and Associates for H ıan Engineering studies, whereby the much larger equipment reviews are made and special studies carried on); we also do a great deal of consultation work.

One thing that has come out of our routine efforts this last year is the drafting of a new Signal Corps specification called "Human Factors Engineering for Signal Corps Equipment". It is in the drafting review stage now, and a copy of the draft in its present form is included in Appendix 3 to the Report of this Conference (page 108).

I want to pass on to one thing we have been doing in the past two years which, I think, is quite interesting. It is the application phase. There is no research in this; it is simply human engineering application in the Signal Corps "Product Review Activity." We have two types of product review. One is preliminary product review which is carried on with the arrival of the development model of a piece of equipment. It is gone over from stem to stern, in a total of about 15 types of review. The elements considered in this product review are: producibility of the equipment; conservation of critical and strategic materials; availability of product; ease of maintenance; standard, reliable components in preferred sizes; adequacy of procurement; interchangeability; test equipment; coordination; scheduling; preparation of master index checklist; use of commercial equipment; schedule of equipment; conformance with MC's; and human engineering. By the time the equipment is reviewed for all of these items, it is gone over pretty thoroughly. Thereafter, we participate again in the final product review which must be made before the equipment may be standardized.

During the past couple of years, we have thus reviewed 41 pieces of equipment. They are broken down as follows: wire communication equipment, 11; test equipment, 10; radio equipment, 8; meteorological equipment, 5; audio, 2; radar instrumentation, 2; radio equipment, 2; and photographic equipment, 1. Specialist Third Class Montgomery, assigned to our office, ran a sample of the number of changes recommended by us in the above reviews, and the number of acceptances of our recommendations. The number of accepted changes in all was 365. Those are just the human engineering changes in the 41 equipments. From a sample of 117 such changes recommended, 76 were accepted.

Another sample of 168 such recommendations yielded the following information on types of faults: labeling faults, 33 percent; display faults, 27 percent; control faults, 14 percent; equipment features contributing to operator or maintenance errors, 11 percent; operator safety and comfort faults, 11 percent; and panel layout and miscellaneous faults, 4 percent.

Examples of the things that we call label faults were: the complete lack of any labeling where there should have been some (the most prevalent); insufficient information in the label (2nd most prevalent): and wrong location of the label.

We are quite concerned about this whole field of the contents of the labels and we want to go into studies to find out whether we shouldn't set up a standard to assure that the labels are "operator oriented." To illustrate what I mean, if you have a Signal Corps generator with some output adjustment, the design engineer's tendency is to label the generator output control, "Attenuator." That doesn't tell the poor man who has to use it what it does, really. We feel it would be much better for the label to say "output," with an arrow over the control to indicate the direction for increase.

We also want to try to standardize on labeling for various test equipments, so that when a man goes from one type of test equipment to another, he will know that a given word labeled on the knob of one equipment refers to the same functions when used on another. This means standardization, and is part of the whole coding program; you have to consider labeling when you consider coding.

These problems illustrate the nature of Signal Corps requirements for continuing consulting services in human factors engineering applications. We consider this aspect of development to be fully as necessary and important as research in human factors.

11. Industry's Acceptance of Ease-of-Maintenance Features in Design

Alonzo J. Vrooman, Chief, Application Eng. Br., Mech. Eng. Dept
USAERDL Ft. Belvoir, Va.

From an ease of maintenance viewpoint, it would be preferable to provide equipment that would meet the Military requirements and would operate for the normal life without requiring any maintenance. The motor-compressor unit installed in most home refrigerators is a splendid example of such design. Unfortunately, it has not been feasible to duplicate such design in most of the equipment furnished by the Corps of Engineers. Some progress has been made in this area; for example, the present track rollers for crawler tractors are designed to operate for 500 hours without maintenance or lubrication, whereas the old style track rollers required lubrication after 8 hours of operation.

For those items requiring maintenance it would be preferable to design equipment so that it could be maintained without tools, repair parts and materials. As we approach this condition by limiting the number of skills, tools, and parts required to support equipment, we tend to reduce and simplify maintenance.

The Engineer Research and Development Laboratories (ERDL) have conducted extensive studies of representative commercial items of equipment in order to establish the design changes required to improve the ease-of-maintenance characteristics. As a result of these studies, it was determined that considerable time could be saved in accomplishing maintenance operations by altering the design. For example, removal and replacement of the engine from a specific make and model of commercial grader required slightly over 4 manhours. After changing the method of mounting the engine and accessories, as well as using quick disconnect fittings for the electrical and fuel systems, it was possible to remove and replace the engine in 9 minutes, using less tools. This is indicative of some of the improvements in design which simplify maintenance. As a result of this study, the specifications are being changed to require (1) the use of quick disconnect fittings for the electrical and fuel systems and (2) designs which permit easy removal of components without disturbing other attachments or components. Other ease-of-maintenance considerations have been or will be included in the specifications, which will require that the design engineer consider ease-of-maintenance requirements. In addition, the specifications will require examination of equipment during pre-production tests to insure that the equipment conforms with ease-of-maintenance requirements.

ERDL also invited representatives of various Technical Services, as well as other Government Agencies and the manufacturers of the equipment involved, to review the findings of the Laboratory in conjunction with ease-of-maintenance improvements. Most of the other services, agencies and manufacturers agreed that the changes recommended by ERDL were desirable; however, the manufacturers were not willing to change the present production lines or redesign their present equipment. Nevertheless, many of the manufacturers have improved their ease of maintenance characteristics in subsequent design.

Inasmuch as most of Engineer equipment is of commercial design, it is essential that industry be apprised of our requirements for ease of maintenance in order that they can incorporate such requirements in their commercial design. We have found that most manufacturers are receptive to the idea, since it is an added selling point for their equipment now that the public is becoming maintenance conscious. In this connection, some of the newer automobiles are advertising self-adjusting brakes, one-shot lubrication, and other ease-of-maintenance characteristics. Further, some of the tractor equipment manufacturers are stressing the fact that components such as engines, steering clutches, master clutches, transmissions, etc. can be easily removed without disturbing other components or assemblies.

It is felt that considerable progress can and will be made to achieve some of the most important ease-of-maintenance characteristics desired in commercial equipment, which will tend to reduce the maintenance support cost of Engineer equipment. It is recognized that there is considerable work to be done in this area. Nevertheless, industry is convinced of the importance of ease of maintenance, which is indeed a big step in the right direction.

12. "Effect of Flicker on Humans"*

Abstracted by Mr. Benjamin Goldberg,
U. S. Army Engineers Research & Development Laboratory,
from report of contract research of L. M. N. Back, et al,
at Tulane University.

Considerable interest has been attached to the unpleasant, distracting and even incapacitating effects of flickering or flashing lights upon human subjects. Many have experienced the unpleasant effects of driving through a forest which resulted in flickering sunlight with a highly distracting effect on the driver. Electroencephalographers have recently developed the technique of using flashing lights in conjunction with the use of certain drugs for the purpose of producing the electroencephalographic (EEG) signs of latent petit mal epilepsy.

The present experiments were undertaken with the idea of trying to develop the use of a flickering light source which would provide a possible tactic in battlefield operations by causing some degree of interference with the cognitive functions of enemy troops.

*Abstract.--The complete report may be obtained by addressing request to Night Vision Equipment Br., USAERDL, Ft. Belvoir, Va.

The first series of experiments which were carried out dealt with a measurement of the frequency of flicker which would be most likely to cause dizziness, sleep, or unconsciousness in the subjects. After several preliminary explorations with various colors and various intensities of light, it was finally determined that white light and maximum brightness (but not enough to cause pain) were easily as effective as other colors and other intensities, if not more so. A series of subjects were then systematically studied and their responses carefully recorded while being exposed to various frequencies of white light of maximal (non-painful) brightness. It was at once determined that frequencies much above 20 cps were without effect because fusion of the flicker was apparent and the subjects were never discomfited; frequencies below about 7 cps were also not useful because then the effect became an alternating darkness and brightness which was disturbing but not of the character of the effects of flicker.

There were several frequencies which were effective in producing disturbing effects but it was found that 9 cps were most often the most effective source of disturbance. Usually the subjects would report a sensation akin to "falling asleep," "feel hypnotized," "drowsy," etc., although only two subjects ever did actually fall asleep. Very often the subjects would also report painful or disturbing sensations relating to the eyes or to headaches or to sensations of nausea or apprehension. Female subjects appeared to suffer such disturbances much more often and these sensations more often persisted for some hours after the trial in women than in men. It was not possible to get any more intensive or more consistent effects by prolonging an exposure trial beyond five minutes (even up to one-half hour).

Some experiments were done in which the EEG rhythms (brain waves) of the subject were recorded, amplified and used to trigger the light source at the same frequency. When the subject was exposed to a light flickering at the same frequency as his EEG, the subjective effects were no more pronounced than when a 9 cps flicker was used: they were most pronounced when his own EEG was modulating the flicker at 9 cps, however.

Subjective responses are sometimes difficult to classify and compare. To obviate this difficulty certain objective tests of cognition were tried to see whether the subject's sense of awareness was really attenuated or blocked in any way. The subject was required to tap in a certain sequence (ascending sequence from one to five taps on left tap board and a descending sequence of five to one on the right tap board). Tests such as these failed to show consistent, significant interference with cognition by the flickering light.

The major premise of the investigation was apparently blocked at this point so we turned to a study of some other effects of flickering light which we noted in passing in earlier experiments. Thus, there always appeared to be some difficulty in walking in the presence of a flickering light. In preliminary trials this early experience was well borne out as long as the walking involved turning; experiments involving straight-away walking completely failed to show interference by flicker. In order to make the walking experiments more effective, we devised a series of small hurdles to provide shadow effects. The flickering light was also mounted on a swinging (from side to side) arm to cause wavering of shadows. Under these formidable circumstances the investigators and several sophisticated observers were variously nauseated, unable to maintain their balance and were definitely slowed down in their performance in the presence of flickering light. When we took a group of unsophisticated subjects (younger students who were completely unfamiliar with the experiment or its purpose) the experiment was a flat failure; if anything the presence of the flickering light improved their performance. Social effects and knowledge of results for the groups of subjects had absolutely no effect on the flicker influence on performance.

Finally we attempted several hand-eye performance tasks. By and large these were obviously depressed by the flickering light (by as much as 50%) but with practice and continued exposure performance was soon returned to normal. Thus in rifle firing experiments it was found that flickering light behind the target (i.e., behind friendly troops) would reduce firing accuracy by as much as 50%; experienced marksmen, however, were only temporarily confused by this situation when firing at moving targets, and scores soon returned to their control values.

A last attempt was made to determine whether longer flash durations would possibly provide a more effective interference with cognition. It was found that minimum flash durations were more effective than long flash durations in these respects.

The principal findings of this investigation are that flickering lights between 7 cps and 20 cps, but particularly at 9 cps, are effective in producing sensations relating to interference with consciousness. It is felt that such sensations are indicative of real, but ineffectual, interference with cognition by flickering light. To achieve objective and effective interference with consciousness by flickering lights or by any other suitable technique will probably require (a) a better knowledge of the basic physiological nature of consciousness and sleep and (b) possibly other, even radically different, techniques than flickering light alone.

13. The Human Engineering Factor in Equipment Specifications

Mr. Henryk J. Bukowski, U. S. Army Engineer
Maintenance Center, Columbus, Ohio

We are heavily concerned in the Corps of Engineers with the use of commercial items, as contrasted with those of military design. Accordingly, our principal influence on machine design, including human factors engineering, is through the specification.

In exerting this influence we have found that general requirements for good human engineering are ineffectual, and that specific requirements are necessary. In doing this, the following areas are emphasized. You will find that most of these areas are contained in the list compiled by Woodson as a guide to designers.*

a. Interchangeability and standardization.
b. Good displays.
c. Positioning of assemblies.
d. Assembly replacement.
e. Quick fasteners.
f. Indexing markings.
g. Access doors.
h. Go, No-Go indicators.
i. Definition of marginal and sub-standard performance.
j. Accessibility of controls and adjustments.
k. Elimination of hazards.
l. Installation of warning and safety devices.
m. Color coding and marking of circuits.
n. Minimal servicing requirements.
o. Reliability--minimal repair.

However, the instilling of good human factors engineering into the design of a machine is not always successfully accomplished through the specification. In that case, it must be introduced after the design phase. The process of system analysis by which this is done consists of:

a. Communication with producing and using activities.
b. Collection of statistical data.
c. Evaluation of data.
d. Statistical analysis of data.
e. Corrective adjustment of the system.

The analysis is performed most intensively in the production phase immediately following design, since correction of the machine design can be made most quickly and at the least cost at that time. Whenever possible, the first production units are tested and subjected to physical review concurrently with subsequent production, and adjustments are made in production through a feed-back process based upon contractual communication channels. At the same time, the other element of the man-machine system is not only considered in the analysis but is also required to make changes to bring the system into control.

The man-element of the man-machine system sometimes resists changes so strongly that adjustment must be confined to the machine, but in many cases the human proves surprisingly flexible and tolerates gross errors in engineering design of the machine. There is great temptation to take advantage of this broad human capacity, but it is dangerous practice. The Army must design its systems to meet combat and other emergency conditions. It must be realized that in such times of stress the human capacity to compensate for failings in the design of the machine is decreased markedly.

Nevertheless, the human element is the more responsive and has the wider range of adjustment. Accordingly, extensive use is made of training courses, publications, and personal consultation. Some publications tell the operator of the machine how to make expedient changes in design. Others are in the form of official modification work orders, with all required materials and tools supplied.

A frequent source of difficulty in commercial equipment which must be corrected after the design is conflict between ease of operation and ease of maintenance, usually to the disadvantage of maintenance.

The reason for the prevalent neglect of ease of maintenance appears to be the assumption that maintenance is performed during a much smaller fraction of the life of the machine than is operation. This reasoning envisions a system made of functional elements, varying throughout the life of the machine, rather than the physical elements of man and machine which we had previously considered to be the system. Both aspects of the system must be considered in order to obtain valid results.

Statistical analysis of the functional history of some machines has revealed a much greater proportion of the life of the machine to be devoted to maintenance than is popularly assumed. In the lives of some machines the maintenance element has been the greatest of all the time elements. When statistical data of this nature are available and applied, ease of maintenance takes on far greater importance.

In dealing with ease of maintenance we are dealing with the servicing and adjustment which is concurrent with operation, as well as the special case wherein the system contains a machine which is inoperative or operating outside of control limits. In this special case, it is important to consider the machine as part of the same system, rather than studying

*Wesley E. Woodson, U.S. Navy Electronics Lab., San Diego, Calif.; Tele-Tech and Electronic Ind., Vol. 14, pp 86-87, Dec 1955.

the machine alone or making it part of a new system for maintenance purposes. When new elements must enter the system in order to achieve repair, the original definition of the system is invalidated along with the results of any system analysis based upon that definition.

The definition of the man-machine system which leads to valid results includes idle time, down time, storage time; all operating procedures, environments and circumstances; maintenance and supply personnel; repair parts stocks, any applicable maintenance float, and any substitute machines; tools and test and support equipment; and the financial resources of the system. The importance of treating with a single system which is a complete statistical universe in itself cannot be over-emphasized.

In summary, what has been described in the foregoing is the engineering of a system with emphasis on human factors. The important elements of this systems engineering are the feed-back mechanism and that part of the analysis and evaluation of the data which encompasses the entire system as a whole. Our performance of this systems engineering would be greatly enhanced by changes in current Army procedures.

We rely heavily on deficiency reports for the data upon which to base statistical analysis. Frequently, such reports are not submitted at all, in violation of regulations, and those which are submitted are usually delayed in transmission by the cumbersome procedures now required. These delays are as characteristic of the electronic data processing report cards (required for aircraft and electronic equipment) as they are for the narrative reports required by AR 700-38. Furthermore, the reports do not yield data pertaining to the performance of the whole system, but are confined to certain working parts and mechanical functions.

What is needed is a periodic report regarding certain selected performance variables which will enable action to be taken prior to the system going out of control. Such data could be the basis for Shewhart charts and similar statistical procedures leading to the exercise of a certain amount of control over the system. To achieve this would be a significant step toward the ideal of a true process of feed-back wherein variations in the output of the system would cause automatic adjustments in both the men and the machine to maintain statistical control and minimize stoppages.

A study of the Army procedures for product analysis is recommended with a view toward reporting performance of the complete system in lieu of reporting failure of components, and particular emphasis on speed of communication.

VI. REPORTS OF CONFERENCE WORKING GROUPS

WORKING GROUP A

Utilization of Available User Experience Information During Engineer Design Stage of New Equipment Development

Colonel E. A. Fossum, USCONARC, Chairman

CONCLUSIONS:

1. Reports of Human Engineering failures which are revealed during service test are frequently too late to be of any value or result in costly modification.

2. The transitory nature of the military assignment system causes confusion because the user guidance provided by one military project officer is so frequently contradicted or changed by his successor.

3. Oral user guidance is subject to frequent misinterpretations, misquotations, and outright repudiation.

4. Communication through normal paper channels is frequently too slow to be of value in providing user guidance when immediate design problems arise.

RECOMMENDATIONS:

1. Developing agency personnel should utilize approved user guidance which is available in such documents as Combat Development Objectives Guide, US CONARC Test Board reports on similar and related items, etc.

2. Insofar as possible user guidance should be requested and furnished in formal correspondence, thus insuring that it is valid and not mere personal opinion of one individual. When it is necessary to provide oral user guidance, written confirmation of such guidance should be provided immediately thereafter.

3. It should be a normal required procedure for developing agencies to invite participation of using agency personnel in evaluations of designs, mock-ups, and prototypes, as appropriate.

4. Using agency representatives (from US CONARC Headquarters and Test Boards) should be empowered whenever possible to speak officially for their command at steering committee and design evaluation meetings. When this is not possible, they should be required immediately after such meetings to provide staffed answers to questions which arise at the meetings.

WORKING GROUP B

"Training of Engineers in Application of Human Factors Data, and Optimum Utilization of Engineering Psychologists in the Technical Services"

Dr. Henry Gaydos, QM R&E Cmd, Chairman

1. The Working Group considers the problem of training in this field to involve three levels of requirement:

a. a level of general familiarity with the aims and methods of human factors engineering to acquaint officers with the nature of human factors considerations in design.

b. a level of that greater degree of understanding of human factors engineering which will enable, e.g., precise specification of human factors in desired military characteristics of design.

c. a level of advanced technical proficiency required for research and developmental solutions of specific design problems.

2. The Working Group recommends that these levels of need for training be taken into consideration in the establishment of Army training requirements in this field.

WORKING GROUP C

Establishment of an NRC Committee to Select and Arrange for English Translations of the Best Foreign Literature in Human Factors Engineering

Dr. John Kobrick, QM R&E Cmd, Chairman

1. The working group considers that, while such translations might be of value to Army human factors research and development, formal establishment of such a facility requires investigation of existing agencies which may now be doing related work, determination of the nature and scope of the work to be done and specific Army requirements for such work, and consideration of the best means for management of the facility. The working group lacks information on these matters.

2. The group, therefore, recommends that the Army Chief Psychologist consider the advisability of further action on this matter.

WORKING GROUP D

Human Factors Contributions to Equipment Design for Night Operations

Col Charles W. Hill, MSC, OTSG, Chairman

Current Requirements.

The tactical and technical troop users have requirements for improved surveillance and detection on the battlefield, direction and control of weapons firing, identification of own material and personnel, and communications in group or team functioning. In addition, there is the concomitant development of security measures for the equipments that are developed to meet the above requirements.

The equipment developers and designers have requirements for identification materials and devices with minimum potential for detection by the enemy; optimum coding and communication symbols and configurations; and increased range and resolution in surveillance and detecting equipment such as radar, infra-red, etc.

Requirements at the basic supporting level are (1) specific visual capabilities and limitations under limited illumination, (2) specific visual capabilities and limitations with optical and electronic equipment, (3) selection techniques for capabilities related to night operations, and (4) training methods to increase abilities related to night operations.

Current Research.

The current research effort designed to meet the above requirements includes the following areas. Equipments for extending the perceptive capabilities of human individuals are being developed with special attention to searchlights, infra-red devices, artificial moonlight, radar, night binoculars, night photography, seismic devices, and sound amplifiers. Equipments for enhancing environmental cues include radioactive self-luminous sources, dim electric lights, infra-red lights, and braille maps. Under supporting research, projects are being conducted on testing devices for night vision, training methods for night operations, definition of spatial cues in areas of low illumination, and the determination of detectability thresholds for specific cue-enhancing equipments.

Recommendations.

Research could well be devoted to the investigation of kinesthetic space similar to the work now going on with regard to visual space, to the definition of visual abilities of the military population, to the interpretation of non-visual signals, and to the feasibility of the use of animals as detectors and guides. Supplementing research in these areas, some value could be obtained by reviewing related research results in other areas which might be pertinent to these problems, such as the electromagnetic trail which was developed for use in Arctic operations and might also be useful in night operations.

There appears to be a need for improving the communications among human engineering research and supporting or related research agencies. The communication contact between users or operators and research is adequate in general although there are some weak spots at various points within this system. The main problem, however, is one of systematic integration of efforts within research and development in order to satisfy user requirements most efficiently.

Finally, there is a need for continuation of the activity of the Working Group. The

Group should continue to operate by mail and visits as the opportunity and funds permit, to follow up on a more comprehensive definition of the problem and to insure the advancement of the various recommendations presented above.

WORKING GROUP E

Human Factors in Design for Ease of Maintenance of Army Materiel

Mr. Henryk J. Bukowski, Engineer Maintenance Center, Chairman

1. The problems faced by this working group require further study before specific recommendations can be presented.
2. The group, therefore, recommends that the Human Factors Engineering Council arrange for continuing study of the problem by this group, with a view to presentation of firm recommendations at the next conference.

VII. INVITED PAPER

HUMAN FACTORS IN SYSTEMS ENGINEERING*

Alphonse Chapanis

Departments of Psychology and Industrial Engineering
The Johns Hopkins University
Baltimore 18, Maryland

The title of my talk is sufficiently broad that one could easily write whole books on the topic. What I plan to do, however, is to confine my attention to a rather narrow group of problems, namely, some of the human factors involved in the design of automatic and semi-automatic machine systems.

Some Basic Premises

Within the last few years there has been a great deal written about automation. As I read some of this literature it seems to me that there are three very broad generalizations we can make about the subject. Since these are basic to what I shall say later, I should like to list them right at the start:

Automation is not something new. The first basic premise is that automation is not something brand new in engineering. Indeed, in 1784 Oliver Evans built an entirely automatic factory just outside Philadelphia--a continuous process flour mill. Not long thereafter in Paris, in 1801, Joseph Marie Jacquard exhibited an automatic loom controlled by punched paper cards similar in some ways to the punched cards now used extensively for business and accounting purposes. His loom was so successful that in 1812 there were 11,000 of them operating in France alone. For years now we have had automatic machinery for the production of screws, paper, glass and steel, and for a thousand other purposes.

Machines have become much more complex and much more versatile. Although automation is not something new, what has been happening is that automatic machines have been becoming much more complex and much more versatile. Evans' automatic flour mill was a single process machine system. It accepted grain at the input side and produced bags of flour at the output side. But this was all it could do. Some automatic machines today can accept many different kinds of inputs, perform alternative kinds of operations on these inputs, and present the results in different ways. Increased complexity and versatility is, I think, the distinguishing characteristic of the automatic machine system today.

Automatic machine systems still use, and will continue to use, human operators. This, I think, is the most important premise of the three. Although many machine systems in use today are described as fully automatic, all those which I know about still use human operators in one way or another. Moreover, I think it is easy to overlook or to be misled about the amount of work human operators may still do in automatic systems. Since this point is so important to the rest of my paper, I would like to elaborate on it here.

Recently I read in an engineering journal (2) about "...a new automatic control system...designed to give the ultimate user increased machine productivity, higher machine speed and greater accuracy since it eliminates the human factor." This sounded like a completely automatic system. Yet as I read further I was struck by the number of times the author, perhaps without realizing it, had to refer to human operators doing something in this "automatic system." Below, I shall quote certain phrases and statements from this article to illustrate my point. It is true that I am quoting them out of context, but this does not seem entirely unfair. I have underlined, for emphasis, those activities which are performed by human operators.

"While little machine modification is necessary...It is particularly suited for control of production machines on which a moderate number of pieces of one type are to be made, since it is simple to change from one variation of product to another simply by providing another deck of director cards...Machine directions that would normally be programmed...Standard card processing equipment...is used for punching, sorting and stocking the cards. Positioning information is punched into the cards...This permits the operator to read directions directly from the card... The cards also have space for...operator's instructions...

* This is an elaboration of some remarks made at a Symposium on the Psychological and Social Aspects of Automation held at the XVth International Congress of Psychology in Brussels, Belgium, on 3 August 1957. Preparation of this report was supported under Contract N5-ori-166, Task Order I, between the Office of Naval Research and The Johns Hopkins University.

"...the operator initiates the control and the first card directs the table motion... The operator then clamps the steel sheet on the table and initiates the control again.

"The positioning information can be read off a blueprint or table of coordinates. The remaining information punched into the card includes drawing and part numbers, card sequence checking, machine instructions,...operator's instructions,...etc.

"If power is removed during any part of a cycle it is only necessary to push the 'Control On' button...It is also possible to place the control on 'Hand' operation while running through a deck, move the various motions (sic) to any other point; and return the control to 'Auto'...By reading the cards in a definite order the machine operation may be halted at specified points, and through the illumination of an indicating light the operator is told to check his planning card...If for any reason the sequence becomes disrupted, the operator can reset the sequence to any desired number by means of manual switches provided on the control console."

These selections do not exhaust all references to human activities in this system. But I hope that you are left with the definite impression, as I was, that there is still a very substantial amount of human control required here. To be sure, the operators in this system are doing different things than the conventional skilled machine-tool operator does, but they are an important and integral part of the system nonetheless. Notice also that this system cannot be operated by unskilled help. Reading blueprints, programming the operations, recognizing where and when a sequence should be reset--all these activities assume a high level of skill, perhaps even a higher level than that required for conventional machine shop work.

To continue with a somewhat different thought, I think we should be careful not to confuse remote control with full automaticity. In many guided missile and drone aircraft systems, for example, the human operator is still in the control loop. He is merely sitting on the ground instead of in a cockpit. If you think that guided missiles are fully automatic systems, count the number of soldiers, technicians and engineers you will find stationed at a typical missile installation. Essentially the same is true of robot tractors, ships, trains (1), and other vehicles.

The proportion of men to machine units is steadily decreasing in modern systems, to be sure, and operators are required to perform different kinds of functions than they do in non-automatic machine systems, but they are there nonetheless. Moreover, I have yet to find any engineer who seriously considers dispensing with all human operators in any system which is planned for the foreseeable future. It is this fact--the fact that operators will still continue to be used in automatic systems--which makes this field an interesting and important one for behavioral scientists.

The Field of Systems Engineering

In the United States today there is great interest in systems engineering. One finds an increasing number of job opportunities available for "systems engineers" and a few universities, Johns Hopkins among them, have become greatly interested in setting up courses in this area. Who and what is this systems engineer and why do I mention him in connection with the problem of automation?

Although I have not been able to find a universally acceptable definition of systems engineering, I think it is fair to say that the systems engineer is the man who is generally concerned with the overall planning, design, testing, and production of today's automatic and semi-automatic systems. The first need for this kind of engineering appeared when it was discovered that satisfactory components do not necessarily combine to produce a satisfactory system. Even though individual components may satisfy all specifications, very often the system as a whole will not work. Complexity of our modern machine assemblages has apparently created the need for systems design and systems engineering. An especially important point is that people in this business (13, 14) seem to agree that the behavioral sciences have something to contribute to systems engineering. Why is this so?

Human Factors in Systems Design

It seems to me that the important human considerations in systems engineering can be grouped under four major headings: (a) the allocation of responsibility between men and machines, (b) the synthesis of men and machines into systems, (c) the human engineering of systems components, and (d) the evaluation of systems.

Although these various factors are not always explicitly recognized and identified, they all, I think, enter into every system problem. However, the relative emphasis attached to each ingredient varies with the particular system. In one, considerations about the allocation of responsibility between men and machines may be an especially important part of the initial planning. In another, the major psychological contributions can be made in the human engineering of components.

ALLOCATION OF RESPONSIBILITY BETWEEN MEN AND MACHINES

In planning the design of a large system, it seems to me that the basic question which has to be answered by designers is not man or automatic machinery, but rather: What role should the human be assigned in the system?

Several years ago, a number of us got together to prepare a report on human engineering for air navigation and traffic control (7). In that report we pointed out that it was possible to design several kinds of control systems which could be distinguished in terms of the degree of human participation in the control process. At one extreme, primary control could be left in the hands of human operators who are assisted by data analysis, transmission, and display equipment. At the other extreme are those systems which are almost "fully automatic" and in which almost every function is performed by machinery. In these human operators would be used for monitoring, checking and maintaining the machines. Between these two extremes systems can be designed with still other degrees of human participation. Thus, a system could be designed so that its major work is performed by semi-automatic machinery but in which the human operator routinely performs certain critical functions, for example, planning and decision-making.

Although the engineer may not always consider the problem in precisely these terms, it seems to me that, implicitly or explicitly, he must make some decision about the role of the human. When he says that there will be no people in the system, what he usually means is that human operators will be used solely for monitoring and maintenance. But this does not dispense with people; it merely means that the human tasks are different from those in conventional machine systems.

Rational decisions about the role of human operators in automatic systems can be made, it seem to me, only by considering carefully some general characteristics of human performance as contrasted with those of machine performance. Such factors as alertness, overloading, fallibility, flexibility, judgment, information-handling, and so on, have to be viewed from the standpoint of the requirements of the system. The functions to be performed by the system must be listed and evaluated by comparing what men can do better than machines, and vice versa. It is important to point out, however, that mere speculation and arm-chair philosophizing may not be enough to provide valid answers. For example, I read with interest about a research program recently let by the Air Force to the Ryan Aeronautical Company (3). One of the basic questions to be answered is this one: Exactly what balance of automatic and manual control should be provided in an aircraft cockpit? The solution in this case is being sought by an experimental program using pilots who will "fly" aircraft simulators with various amounts of automaticity.

At this point it might be of interest to see how these considerations were applied in a specific case.

The RCA Bizmac Electronic Accounting System. Several of the considerations mentioned above are illustrated very well in the design of the RCA Bizmac Electronic Accounting System--said to be the largest commercial data-processing system so far constructed (9, 11, 12). The installation covers about 20,000 square feet and consists of 357 separate equipment units, among them 12 major electronic machines and about 200 other auxiliary automatic or semi-automatic equipments. This particular development was designed for the job of maintaining continuous and rapid stock and inventory control of over 250,000 catalog items. It also handles all the files, orders, receipts, payments, bills, and associated business paper work.

One of the first and most important series of psychological questions occurred at the planning stage. It was at this stage that the systems engineers, in combination with psychologists, carefully sorted out and separated the functions of planning, decision, execution, and monitoring. The results of these early deliberations led to the decision that operators would be used in three ways: (1) for purposes of planning and preparing the work (that is, for programming the work); (2) for operating the system; and (3) for maintaining it. The task of the first group of personnel was to specify the data-processing job and to prepare a detailed and specific set of operating instructions for the job (that is, program the job). The task of the second group of personnel was to receive the operating instructions, direct, control, and monitor the processing of data through the machines. The task of the maintenance group was to inspect, test, and repair machines as required.

THE SYNTHESIS OF MEN AND MACHINES INTO SYSTEMS

Having decided on the functions which operating personnel will have in a system and on the division of responsibility between men and machines, the engineer then faces the problem of integrating these personnel into the system. By this I have in mind something much more general than the human engineering design of components for efficient use--about which I shall speak in a few moments. Rather, at this point I am concerned with some general principles about ways in which men and machines should complement each other in automatic or semi-automatic systems. This is an area of human engineering which has not received very much attention by psychologists and is one which interests me greatly. Perhaps the best thing for me to do is to illustrate what I mean by an example of what I consider to be a general principle of man-machine systems design.

The principle of verification through independent duplication. As we have already seen, in planning the RCA Bizmac the decision was made that programming of data into the system would be done by human operators because of their flexibility and because of the nature of the input data. Yet it is generally known that even when equipment has been well engineered for maximum efficiency, human operators still make mistakes. These mistakes may run something on the order of 1% or 2%, depending on the particular task. The accuracy requirements of this electronic accounting system were very much more stringent than this. How then is it possible to design the system to make use of the flexibility which characterizes human operators and yet to provide the extreme accuracy required?

The solution of this problem was to use two operator-verifier teams. The members of each team make identical set-ups on different consoles. Special equipment has been designed to compare the output of the two human operators and to accept for processing only those items which agree exactly. Discrepancies are rejected for correction. Under certain conditions this technique will reduce the error rate to a few per million even though the error rate for a single operator may be one in a hundred. A somewhat fuller description of this principle and the statistical reason why it works so well is contained in a recent publication of mine (5).

Time does not permit me to discuss any more of these general principles. Let me just mention two others: (1) Machines should monitor men so that critical human decisions do not violate basic safety or operational rules. (2) The system as a whole should be designed for efficient fault location.

THE HUMAN ENGINEERING OF SYSTEMS COMPONENTS

There is usually a lot of human engineering work to be done on the components of automatic and semi-automatic machine systems. These fall into two rather broad classes which I should like to consider separately.

The design of components for operator use. Since automatic systems do not really dispense with human operators we can see that there is ample opportunity for the human engineering design of the machine components with which these operators must work. So much material has been written about ordinary human engineering problems that I shall not dwell on them here. Rather I shall illustrate how human engineering was carried out in the design of the components for the RCA Bizmac system. Some of the highlights are these: The control room was carefully designed to make the working environment pleasant. Colors and materials for floors, walls, and ceilings; lighting; and the arrangement of all consoles and desks was designed so that the room would be quiet and pleasant to work in.

In addition, particular attention was paid to the design of operator consoles for rapid and efficient human use. The controls and indicators for each machine were first divided into two classes, operation and maintenance; where possible, they were grouped separately. The operating panel was made easily accessible to the operator, as was the maintenance panel to the maintenance man. But over and above such simple and obvious human engineering features, the design of the consoles make use of all the established human engineering design principles one can find in any of several sources. Controls are grouped functionally; their arrangement and meaning are standardized throughout the entire system so that operators can switch readily from one console to another; controls and indicators are arranged in the sequence in which they are normally used; color coding is used throughout; special attention was given to the legibility of labels and indicators; the controls and their placement are carefully designed on the basis of anthropometric considerations; and finally the punched cards which are used in the system are designed so that the information coded on them is arranged in the same pattern as the controls on the consoles.

The RCA Bizmac system makes more extensive use of human operators than many other systems do. However, I want to emphasize that even if the only function of the human operator is to monitor the system and take over in emergencies, this does not dispense with the need for human engineering. On the contrary, it intensifies the problem. When the operator has nothing to do for long periods of time, it is difficult to keep him alert and responsive. Yet if he is to take over in an emergency he should have information about the past history of the performance of the system, what ails it, and what he should do to overcome the difficulty. Designing displays, emergency signals, control consoles, and operating procedures for such conditions taxes the ingenuity of both the engineer and psychologist.

The design of components for maintenance. One consequence of the growth of semi-automatic systems is that problems of maintenance are becoming increasingly more severe. Javitz has recently prepared a survey of the present state of human engineering in American industry (10). This is an especially interesting report because the author is not himself a human engineer or psychologist and because in preparing his report he contacted a very large number of persons in academic institutions, consulting organizations and industries.

One topic which keeps appearing throughout his report is that of maintenance. It occurs not only with respect to large systems of machines, but throughout the full gamut of modern instruments and devices. He cites, for example, a report from the Consumer Service Division of the Detroit Edison Company on the excessive amount of servicing and repairs on both small and major appliances. In one year, 1953, this company had to repair 600,000 small appliances. One in every 7.5 toasters in the Detroit area, one in every 9 clocks, and one in every 5 coffeemakers required some type of repair. One of the major criticisms arising from this picture concerned the design of the equipment from the standpoint of its maintainability. In some instances appliances had to be taken apart completely to replace something as trivial as a pilot light.

The problem of maintenance has become sufficiently important to the military buyers of complex equipment that some of them have begun to write human engineering clauses into their contracts. For example, specifications for equipment developed for the Signal Corps contain a standard paragraph requiring the contractor to apply human engineering principles to the design of the equipment. This requirement mentions several different human engineering factors and, in particular, specifically requires the contractor to consider "human space limitations for operation and maintenance." (The emphasis is mine.)

The picture is not completely negative, however. In discussing the RCA Bizmac system I pointed out how maintenance functions were carefully designed into it. Another company that has a good record in this respect is the telephone company. Because it is responsible for its own maintenance the telephone company in America seems to have been more alert to the problems of maintenance than many other industries. New developments for the telephone system frequently give maintenance considerations prominence equal to that given other kinds of considerations.

It would be impossible for me to give you a complete picture of the kinds of recommendations which can be made about the design of equipment for maintenance. I would like, however, to call attention to two publications which discuss these problems in some detail (4, 8).

SYSTEMS EVALUATION

The fourth and final area in which human factors become involved in systems engineering is in the evaluation of systems. Most current definitions of systems engineering emphasize the importance of evaluating the entire system before it is actually put into production. As we have already seen, many systems include a human operator as a vital part of the system. Thus, any reasonable attempt to evaluate the performance of the system must include an evaluation of the performance of the human operator working with the equipment provided him.

An illustration is provided by the Bizmac system to which I have already referred on several occasions. When the system was fairly well along in its design, tests were set up and run under simulated operating conditions: (1) to test the operating conditions; (2) to get some measure of operator load at the various operating positions; (3) to see what the effects of equipment breakdown were on overall system performance, and (4) to get some indication of the adequacy of the proposed operator and machine combination.

It would be easy to multiply examples of this sort, but I think perhaps my point is clear. Systems engineers are frequently responsible for designing and running tests on complicated man-machine combinations. Those who have actually run some appreciate that such tests are much more complicated than doing ordinary engineering evaluations. People differ, and tests run on one subject may not be at all typical of the performance of the average person. People learn during the course of an experiment; often they become bored or fatigued; they are sensitive to the kinds of instructions which precede the experiment and to words of praise or reproof given during it; they interact with the experimenter in strange and sometimes unexpected ways--they may try to outguess the experimenter, or, on occasions, may deliberately sabotage the outcome of the tests. These and still other factors must be anticipated and controlled if the results of man-machine experiments are to be trusted.

Psychologists, of course, have been face to face with these problems for years and, in the course of their work, have evolved techniques for handling many of them. For this reason it is perhaps not surprising to find that psychologists are frequently consulted for their advice on problems of technique and methodology. A monograph (6) I prepared recently is an attempt to pull together some of this information into a single source.

Summary

In summary, I have tried to give you my impressions of some of the human factors involved in the design of automatic and semi-automatic machine systems. I hope first that I have been able to show you that there are still a substantial number of human problems in most such systems. A successful automatic system requires that the engineer carefully consider the role of the human operator and how he is designed into the system. Second, I hope that I have been able to suggest why the human factors specialist is often considered a member of the systems design team and in what ways he can contribute to the important and challenging task of designing new systems for our automatic world of tomorrow.

References

1. Anonymous. Look, no hands on the throttle--no throttle! Industrial Science and Engineering, January 1956, Vol. 3, No. 1, P. 27.
2. Anonymous. Numerical positioning control. Electrical Manufacturing, September 1955, Vol. 56, No. 3, Pp. 122-127.
3. Anonymous. Pilots are only human! Ryan Reporter, August 1956, Vol. 17, No. 4, Pp. 1 & 39.
4. Bean, E. S., and Woodson, W. E.: Human-engineered design for reliability and maintenance. Electrical Manufacturing, July 1955, Vol. 56, No. 1, Pp. 100-105.
5. Chapanis, A.: L'Adaptation de la Machine a L'Homme L'Étude des Relations Homme-Machine. Revue de Psychologie Appliquée, October 1956, Vol. 6, No. 4, Pp. 213-234.
6. Chapanis, A.: The Design and Conduct of Human Engineering Studies. San Diego, Cal.: San Diego State College Foundation; 1956.
7. Fitts, P. M. (Ed.) Human engineering for an effective air-navigation and traffic-control system. Washington, D. C.: National Research Council; 1951.
8. Folley, J. D., Jr., and Altman, J. W.: Guide to design of electronic equipment for maintainability. Wright Air Development Center (Wright-Patterson Air Force Base, Ohio) Technical Report 56-218. 1956.
9. Halstead, W. K.: The RCA Bizmac electronic accounting system. RCA Engineer, 1955-56, Vol. 1, No. 4, Pp. 12-21.
10. Javitz, Alex E.: Human engineering in equipment design. Electrical Manufacturing, October 1956, Vol. 58, No. 4, Pp. 107-126.
11. Leas, J. W.: Engineering the RCA Bizmac system. RCA Engineer, 1955-56, Vol. 1, No. 4, Pp. 10-11.
12. Owings, J. L.: Human engineering the Bizmac system. RCA Engineering, 1956, Vol. 2, No. 3, Pp. 16-22.
13. Salveson, M. E.: Suggestions for graduate study in operations research and systems engineering. Journal of Engineering Education, November 1956, Vol. 47, No. 3, Pp. 211-222.
14. Schlager, K. J.: Systems engineering--key to modern development. IRE Trans. Eng. Managmt., 1956, Vol. EM-3, No. 3, Pp. 64-66.

VIII. GENERAL CHAIRMAN'S SUMMARY OF THE CONFERENCE

SUMMARY OF PREVIOUS CONFERENCE RECOMMENDATIONS AND ARMY ACTIONS THEREON, 1 OCTOBER 1957

By Dr. Lynn E. Baker, U. S. Army Chief Psychologist, OCR&D

As is customary at these meetings it is my pleasure to render a summary report of actions taken in response to your previous recommendations. This summary will appear in the usual tabular form in the Conference Report. You will note from the following table that:

1. We are continuing action on the human factors engineering Guide for Design Engineers.

2. We have taken action to arrange short-course training in human factors engineering at Ohio State University and McGill University for 6 officers in 1957; and propose to arrange establishment of standing quotas for future years.

3. Both Ordnance Corps and The Surgeon General Corps have taken action appropriate to your recommendations for human factors engineering observations during Arctic and icecap operations.

4. Action is underway to establish, by Army Regulation, a permanent Council for the planning and coordination of human factors engineering conference matters.

As respects the present conference, the members of the Human Factors Engineering Conference Committee have been canvassed for their views as to its "highlights." The concensus of their views, which largely corresponds with the intentions of the planning for this Conference, is that the following are "highlights":

1. Dr. Edson's keynote address, which calls for new departures from the beaten path;

2. the USCONARC presentations, which outline the tactical doctrinal basis for all Army research and development;

3. Col Maurice Fletcher's presentation on prosthetics developments, which gives emphasis to Dr. Edson's address by indicating a most important direction in which new departures appear feasible.

4. Dr. Chapanis's paper on human factors in systems engineering, which at last gives some rational specification to previously vaguely understood notions.

Finally, there are a number of people who should be named as having earned our gratitude for the skill and care which they exerted to assure the success of this Conference. In addition to our host, General Calloway, our thanks go unreservedly to:

- Lt Col Rhode, for his executive overview of all arrangements;
- Captain Bridges, who arranged our hotel accommodations
- Captain Rita Smith, WAC, who arranged our messing and "social" facilities;
- Messrs. George Danton and Nick Guido, who handled our photographic and projection facilities;
- Mr. Hugh McCraven, who handled our technical services; and
- Mr. Reardon and all of the Conference stenographers, who did their work during and after our sessions to give us a record of our accomplishments.

To all of these, and more, goes a rising vote of thanks as, at six minutes after 2:00 p.m. the Conference is Adjourned.

TABLE I.

SUMMARY REPORT TO 3rd ANNUAL ARMY HUMAN FACTORS ENGINEERING CONFERENCE ON MAJOR RECOMMENDATIONS OF ARMY ENGINEERING PSYCHOLOGY CONFERENCE Army Medical Research Laboratory, Ft. Knox, Ky., 7-9 Nov 1956, AND ON ACTIONS RESULTING THEREFROM

RECOMMENDATION	ACTIONS		TARGET DATE
	TAKEN	TO BE TAKEN	
1. Augment Army participation by working design engineers from the Army Technical Services in JSSC preparation of the Human Engineering Guide for Design Engineers. (Conference Report, "Army Human Engineering Conference," the Pentagon 14-15 Dec 55, page 15)	a. D/F from C/R&D to TQMG, C/Ord, CSigO, C/Engrs, CCmlO, & C/T, dtd 13 Mar 56, subj: "Joint Services Steering Committee for the Human Engineering Guide to Equipment Design" requests designation of representatives for review of "Guide" chapters who are, or have available to assist them, working design engineers. b. Letter from Army Member, to Chmn, Exec Council of JSSC dtd 3 May 56, subj: "Army Participants in Human Engineering Handbook Review," based on replies to above, informs all concerned of Army's designated tech service participants & authorizes procedures for direct contact.	Based on Army reviews (info cys to OC/R&D) of "Guide" chapters, monitor production of "Guide" via Exec. Council, JSSC	Continuing
2. Invite CONARC's consideration of the advisability of its Boards' participating in the work of the Committee. (Conference Report, "Army Human Engineering conference," the Pentagon 14-15 Dec 55, page 15)	a. Ltr fr C/R&D to CONARC dtd 7 May 56, subj: "Participation of CONARC Boards in Work of the JSSC for the Human Engineering Guide," outlines the problem & requests CONARC cmts on advisability of participation by CONARC Bds in critical review of Guide chapters. b. 1st Ind fr CONARC, dtd 29 Jun 56, concurs in participation of CONARC Bds (including Arctic Test Br, Ft Greely, Alaska), & suggests channel for action. c. Memo dtd 19 Jul 56 fr Army Mbr, Exec Council, JSSC to its Chmn, subj: "Army Participants in Hum Engr Handbook Review" establishes channel per CONARC suggestion.	Same as 1., above	Continuing
3. Establish Army Human Factors Engineering Conference on an Annual Basis (Conference Report "Army Human Engineering Conference" the Pentagon, 14-15 Dec 55, page 15)	Human Factors Engineering Conference Committee (HFECC) established. (See Appendix 2 for documentation, Terms of Reference, and membership.)	Establish HFEC Council as permanent agency in Army Regulations.	1 Jan 1958

RECOMMENDATION	ACTIONS		TARGET DATE
	TAKEN	TO BE TAKEN	
4. Establish a working group to determine content, qualifications, & procedures for training of officers in human factors engineering. (Rpt, 2nd Annual Army Engineering Psychology Conference, 7-9 Nov 56, page 21)	No action deemed advisable at this time.		
5. "There are requirements for R&D personnel to observe human performance ... during Arctic and icecap operations." (Report, Ibid, page 22)	Human Engineering Laboratory, OrdC, has established as normal procedure; TSG planning action for present season.		
6. "... Develop a methodology for determining the cost differential (cost expressed in broad terms such as manpower required, dollars, time, etc.) resulting from human engineering changes." (Report, Ibid, page 22)	No action deemed advisable at this time.		
7. OCR&D investigate possibilities of Army officers' attending short course in human factors engineering. (Report, Ibid, page 21)	Summer, 1957: 2 officers to short course at McGill University; 4 officers to short course at Ohio State University.	Establish further quotas for such training in 1958 et seq.	March 1958

APPENDIX I

ALPHABETICAL ROSTER OF CONFEREES AND GUESTS

NAME	ORGANIZATION
AIKEN, Mr. Marshall D.	OCSigO, Washington, D. C.
ALLEN, Col. William J.	Army Chemical Center, Maryland
ALLUISI, Capt. Earl A.	U. S. Army Medical Research Laboratory, Fort Knox, Ky.
ANDREWS, Mr. Robert S. Jr.	QM R&E Field Evaluation Agency, Fort Lee, Va.
BAILEY, Dr. John W.	Transportation R&D Command, Fort Eustis, Va.
BAKER, Dr. C. H.	Defence Research Board, Ottawa, Canada
BAKER, Dr. Lynn E.	Office, Chief of R&D, Dept of the Army Washington, D. C.
BAKER, Dr. Robert	Human Resources Research Office, Fort Knox, Ky.
BATES, Col. Raymond H.	CONARC Board Nr. 5, Fort Bragg, N. C.
BESSEY, Dr. Otto A.	QM R&E Center, Natick, Mass.
BOARDMAN, Mr. W. J.	QM R&E Center, Natick, Mass.
BUKOWSKI, Mr. Henryk J.	Engineering Maintenance Center, Columbus, Ohio
BURKHALTER, Lt. T. H.	QM R&E Center, Natick, Mass.
CALDWELL, Dr. Lee	U. S. Army Medical Research Laboratory, Fort Knox, Ky.
CALLOWAY, Brig. Gen. C. G.	Commanding General, Hq QM R&E Command, Natick, Mass.
CAPASSO, Mr. N. S.	HQ US Army Chemical Corps, Washington, D. C.
CARNEY, Mr. William	Detroit Arsenal, Centre Line, Mich.
CHAPANIS, Dr. Alphonse	Johns Hopkins University, Baltimore, Md.
CONWAY, Brig. Gen. T. J.	Office, Chief of R&D, Dept of the Army Washington, D. C.
CRAWFORD, Dr. Meredith P.	Director, Human Resources Research Office, Washington 7, D. C.
DAMON, Dr. Albert	Harvard School of Public Health, Boston, Mass.
DAVEY, Dr. Earl	Army Chemical Center, Maryland

DeTOGNI, Mr. G. R.	Watervliet Arsenal, Watervliet, N. Y.
DOMEY, Dr. R. G.	Harvard School of Public Health, Boston, Mass.
DUSEK, Dr. E. Ralph	QM R&E Center, Natick, Mass.
EDSON, Dr. James B.	Ass't to Director of R&D, D/A, Washington, D. C.
ERNST, Mr. H. W.	Watertown Arsenal, Watertown, Mass.
FILIPPI, Dr. M. J.	Office of Chief Chemical Officer, Washington, D. C.
FINE, Dr. B. J.	QM R&E Center, Natick, Mass.
FLETCHER, Capt. John	U. S. Army Medical Research Laboratory, Fort Knox, Ky.
FLETCHER, Col. Maurice J.	Army Prosthetics Research Laboratory, WRAMC, Washington, D. C.
FOSSUM, Lt. Col. E. A.	Hq USCONARC (MD), Fort Monroe, Va.
GAYDOS, Dr. Henry F.	QM R&E Center, Natick, Mass.
GILLEN, Capt. Frederick R.	Hq Air R&D Command, Baltimore, Md.
GOLDSMITH, Mr. C. T.	Picatinny Arsenal, Dover, N. J.
GRAHAM, Mr. Donald I. Jr.	Redstone Arsenal, Huntsville, Alabama
GRIFFITH, Mr. Paul E.	USASEL, Fort Monmouth, N. J.
HANSEN, Mr. Alfred A. E.	Ordnance Tank Antarctic Command, Centre Line, Michigan
HARKER, Dr. George S.	U. S. Army Medical Research Laboratory, Fort Knox, Ky.
HARPER, Mr. Walter R.	Defence Research Board Member, Washington, D. C.
HARRIS, Dr. Frank J.	Operations Research Office, Washington, D. C.
HASTINGS, Mr. Dwight L.	QM R&E Center, Natick, Mass.
HEIDEL, Mr. William E. Jr.	Rock Island Arsenal, Rock Island, Illinois
HIGHT, Lt. Col. James L.	AFDRD, Washington, D. C.
HENNEMAN, Dr. Richard	University of Virginia, Charlottesville, Va.
HENSCHEL, Dr. Austin	QM R&E Center, Natick, Mass.
HICKS, Col. Herbert C. Jr.	O/C R&D, Washington, D. C.
HILL, Col. Charles W.	R&D Division, OTSG, Washington, D. C.
HOYT, Dr. Ruth	Dept of National Defence, Ottawa, Canada
IDES, Mr. Martin	USASEL, Fort Monmouth, N. J.
JONES, Mr. Clarke E.	QM R&E Center, Natick, Mass.

JONES, Mr. Harold S.	QM R&E Center, Natick, Mass.
JOSEPHSON, Dr. Edward S.	QM R&E Center, Natick, Mass.
KARR, Mr. A. Charles	Frankford Arsenal, Philadelphia, Pa.
KATCHMAR, Dr. L. T.	Ordnance Human Engineering Laboratory, Aberdeen Proving Ground, Md.
KOBRICK, Dr. John L.	QM R&E Center, Natick, Mass.
KRAEMER, Dr. Alfred	Human Resources Research Office, Fort Knox, Ky.
LANDSBERG, Mr. M. L.	QM R&E Center, Natick, Mass.
LANZALOTTI, Mr. Samuel J.	USASEL, Fort Monmouth, N. J.
LEVIN, Mr. A.	QM R&E Center, Natick, Mass.
LIPTON, Mr. Milton A.	USASEL, Fort Monmouth, N. J.
LORENZEN, Mr. T. G. Jr.	Ordnance Weapons Command, Rock Island Arsenal, Illinois
LUND, Dr. Max W.	US Naval Electronics Laboratory, San Diego 52, California
LYMAN, Dr. John	University of California, Los Angeles 24, California
MAHONE, Maj. Nelson A.	USCONARC Avn. Bd., Fort Rucker, Alabama
MARKS, Lt. Col. R. L.	Medical Liaison Officer, British Joint Services Mission, Washington, D. C.
MATTHEWS, Col. Jack B.	USCONARC Inf. Bd., Fort Benning, Georgia
MAZZUCCHI, Maj. Reno A.	USCONARC Arty. Bd., Fort Sill, Okla.
McGINNIS, Dr. John M.	QM R&E Center, Natick, Mass.
MEAD, Dr. Leonard C.	Tufts University, Medford, Mass.
MELTON, Dr. Arthur W.	University of Michigan Ypsilanti, Michigan
MENDENHALL, Capt. Robert L.	QM R&E Center, Natick, Mass.
MIDDLEWORTH, Col. H. V.	Hq USCONARC (CD), Fort Monroe, Va.
MITCHELL, Col. Philip H.	OASD(R&E), DOD, Washington, D. C.
MONTAGUE, Lt. Col. Ernest K.	U. S. Army Medical Research Laboratory, Fort Knox, Ky.
MORGAN, Mr. I. B.	Office of Chief Chemical Officer Washington, D. C.
PETERSON, Mr. Arnold C.	USASEL, Fort Monmouth, N. J.
PFAFFMANN, Dr. Carl	Brown University, Providence, R. I.
RECHEL, Mr. Ernest	Frankford Arsenal, Phila. Pa.
REDFERN, Mr. Robert E.	USASEL, Fort Monmouth, N. J.

REVESMAN, Dr. Stanley	University of Michigan, Ypsilanti, Michigan
RIOPELLE, Dr. Arthur J.	U. S. Army Medical Research Laboratory, Fort Knox, Ky.
ROCHA, Mr. John	Springfield Armory, Springfield, Mass.
SAUL, Dr. Ezra V.	Tufts University, Medford, Mass.
SCHLOSBERG, Dr. Harold	Brown University, Providence, R. I.
SCOTT, Dr. M. Gladys	State University of Iowa, Iowa City, Iowa
SEIDEL, Mr. William	Rock Island Arsenal, Illinois
SEMINARA, Mr. Joseph L.	Picatinny Arsenal, Dover, N. J.
SIDERMAN, Mr. Joseph A.	USASEL, Fort Monmouth, N. J.
SPANO, Mr. Leo	QM R&E Center, Natick, Mass.
SPENCE, Dr. Kenneth W.	State University of Iowa, Iowa City, Iowa
SPERLING, Dr. Philip	R&D Division, OTSG, Washington, D. C.
STERETT, Mr. John K.	OQMG, Washington, D. C.
STOUDT, Dr. Howard W. Jr.	Harvard School of Public Health, Boston, Mass.
SULLIVAN, Capt. John J.	USCONARC Arm. Bd., Fort Knox, Ky.
TEICHNER, Dr. Warren H.	University of Mass., Amherst, Mass.
THORNDIKE, Dr. Robert L.	Columbia University, New York, N. Y.
UHLANER, Dr. J. E.	TAGO, D/A, Washington, D. C.
VINING, Mr. T. M.	Army Chemical Center, Maryland
WEISS, Mr. Murray	USASEL, Fort Monmouth, N. J.
WEISZ, Dr. John D.	Ordnance Human Engineering Laboratory Aberdeen Proving Ground, Md.
WELLS, Col. James F.	DCSOPS, Avn. Safety Div., Washington, D.C.
WHITTLESEY, Mr. W. C.	QM R&E Center, Natick, Mass.
WILLIAMS, Dr. Wyman L.	Human Resources Research Office, Fort Knox, Ky.
WOODBURY, Mr. Robert L.	QM R&E Center, Natick, Mass.
WULFECK, Dr. Joseph W.	Tufts University, Medford, Mass.

APPENDIX 2

HUMAN FACTORS ENGINEERING ADVISORY COUNCIL

TABLE OF CONTENTS

DISPOSITION FORM

FILE NO. CRD/J 5495 U

SUBJECT: Third Annual Army Human Factors Engineering Conference

TO: Chief Chemical Officer
Chief of Engineers
Chief of Ordnance
The Quartermaster General
Chief Signal Officer
The Surgeon General
Chief of Transportation

FROM: C/R&D DATE: 15 May 57 COMMENT NO. 1

1. References:

a. Conference Report, Army Human Engineering Conference, The Pentagon, 14-15 December 1955.

b. Report, Second Annual Army Engineering Psychology Conference, Army Medical Research Laboratory, Ft. Knox, 7-9 November 1956.

2. Referenced two conferences have demonstrated great value to the Army. By improving interchange of information concerned in subject field, they have contributed to development agency programs to make new weapons and equipment ever more compatible with the skills and abilities of the troops who use them.

3. In accordance with the terms of the two referenced conferences, steps are now being taken to establish the subject conference as an annual occurrence, and AR 70-8 is being revised accordingly.

4. Arrangements are being made to hold the next such conference at the Quartermaster Research and Development Center, Natick, Mass., during the last week of September or first week of October 1957.

5. Incl 1 presents a summary phasing plan of preparation of the conference program and publication of the Conference Report. As a major element of such preparation the plan calls for establishment of a Human Factors Engineering Conference Committee (HFECC), with Terms of Reference as outlined in Incl 2.

6. It is contemplated that the revision of AR 70-8 noted in paragraph 3 will establish HFECC, with duties and responsibilities substantially as indicated in Incl 2, as a standing Committee for this purpose.

7. Request that you designate a representative of your office to serve as a member of HFECC. Such representative should have a broad knowledge of human factors problems and programs of your office. He should be authorized to correspond directly with the Human Factors Research Division, this office, on matters concerning the proposed conference.

BY DIRECTION OF THE CHIEF OF RESEARCH AND DEVELOPMENT:

"Signed"

T. J. CONWAY
Brigadier General, GS
Director of Research

2 Incl
1. Summary Phasing Plan
2. Terms of Reference

HUMAN FACTORS ENGINEERING CONFERENCE COMMITTEE

Terms of Reference

1. Purposes of the Conference:

a. To provide improved interchange of information on requirements, accomplishments, and future plans among Army agencies concerned with human factors engineering; and

b. To recommend improvement of programs and procedures common to all development and user agencies to make new Army weapons and equipment ever more compatible with the skills and abilities of the troops who will use them.

2. Purposes of the Committee:

To represent development agencies and USCONARC in the planning of the Conference, especially as regards determination of Conference:

a. Agenda, topics, and presentations;

b. Membership;

c. Report format, organization, and distribution;

d. Working Group compositions and missions;

e. Evaluation and follow-up of recommendations;

and other matters to facilitate the purposes of the Conference.

3. Members of the Committee:

The Committee will consist of:

a. A Committee Chairman to be a representative designated by the Chief, Research and Development.

b. One member (seven in all), and an alternate, to be designated by each Chief of a Technical Service as knowledgeable of, and empowered to speak for, human factors engineering requirements and programs of his command.

c. One member, and an alternate, to be designated by the Commanding General, USCONARC as knowledgeable of, and empowered to speak for, human factors engineering requirements as viewed by the USCONARC Boards.

Representation on Human Factors Engineering Advisory Council

ORGANIZATION	NAME
Office, Chief of Engineers, US Army Engineer Research & Development Laboratories	Mr. Benjamin Goldberg Mr. Lawrence W. Shanahan, Alternate
US Continental Army Command, Fort Monroe, Virginia	Lt Col Embert A. Fossum Col Keith H. Ewbank, Alternate
O Dep CCm10 Scientific Activities, Washington, D. C.	Mr. Irving B. Morgan
Director of Human Engineering Laboratories, Aberdeen Proving Ground, Maryland	Dr. John Weisz
Office, Chief of Ordnance Washington, D. C.	Mr. Joseph Kaufman, Alternate

ORGANIZATION	NAME
QM R&E Command, Natick, Mass.	Dr. Henry F. Gaydos Dr. Donald F. Haggard, Jr., Alternate
Office, Chief Signal Officer Washington, D. C.	Mr. Marshall D. Aiken Mr. Toivo E. Hedman, Alternate
Transportation R&E Command Ft Eustis, Va.	Dr. John Wendell Bailey
R&D Division, OTSG Washington, D. C.	Col Charles W. Hill Dr. Philip I. Sperling, Alternate

APPENDIX 3

CONFERENCE REFERENCE MATERIALS

TABLE OF CONTENTS

U. S. ARMY MEDICAL RESEARCH LABORATORY

Fort Knox, Kentucky

I. Vitae

II. Current Projects

III. Bibliography of Published Reports

I. VITAE

Alluisi, Dr. Earl A., Capt., MSC, Acting Head, Environmental Factors Section
PhD, Ohio State University, 1954. Area of Specialization: Engineering psychology.

Caldwell, Dr. Lee S., Psychophysiologist
PhD, University of Kentucky, 1955. Area of specialization: Biomechanics.

Carlton, Dr. Peter L., Sp-3, Psychologist
PhD, State University of Iowa, 1955. Area of specialization: Learning theory.

Cramer, Dr. Robert L., Psychophysiologist
PhD, University of Rochester, 1954. Area of specialization: Vestibular physiology.

Daubek, Gerald G., MSp, Psychologist
MS, University of Illinois, 1955. Area of specialization: Educational psychology.

Fletcher, Dr. John L., Capt., MSC, Acting Head, Sound Section
PhD, University of Kentucky, 1955. Area of specialization: Audition and vision.

Gardner, Dr. R. Allen, 1st Lt., MSC, Psychologist
PhD, Northwestern University, 1954. Area of specialization: Vision.

Gogel, Dr. Walter C., Psychophysiologist
PhD, University of Chicago, 1951. Area of specialization: Vision.

Guedry, Dr. Fred E., Jr., Head, Motion Section
PhD, Tulane University, 1953. Area of specialization: Vestibular Psychophysiology.

Harker, Dr. George S., Head, Vision Section
PhD, State University of Iowa, 1950. Area of specialization: Vision.

Herbert, Dr. Marvin J., Head, Control Coordination Section
PhD, University of Minnesota, 1953. Area of specialization: Motor skills.

Jaynes, Dr. William, 1st Lt., MSC, Psychologist
PhD, Ohio State University, 1955. Area of specialization: Statistics.

Johnson, David E., 1st Lt., MSC, Optometrist
BS, Ohio State University, 1954. Area of specialization: Optometry.

Montague, Dr. Ernest K., Lt. Col., MSC, Deputy Head, Experimental Psychology Department, PhD, State University of Iowa, 1950 Area of specialization: Human engineering.

Newton, Dr. John M., 1st Lt., MSC, Psychologist
PhD, Ohio State University, 1955. Area of specialization: Physiological psychology.

Riopelle, Dr. Arthur J., Head, Experimental Psychology Department
PhD, University of Wisconsin, 1950. Area of specialization: Sensory processes, brain functions.

Schaefer, Dr. Vernon H., 1st Lt., MSC, Psychologist
PhD, University of Illinois, 1957. Area of specialization: Experimental psychology.

Silver, Dr. Carl A., 1st Lt., MSC, Psychologist
PhD, Ohio State University, 1955. Area of specialization: Physiological psychology, audition, human engineering.

II. CURRENT PROJECTS

A. Control Coordination Section

1. In Service Research

	Title	Experimenter	Date Started	Estimated Completion Date
a.	Decrement in Driving Skill as a Function of Cumulative Environmental Stresses.	Herbert Hartman Jaynes	Jul 56	Dec 57

A battery of tests was designed to detect and measure driving skill fatigue. Test results also were used to supply information on the question of basic factors underlying driving skill.

Trained Army and Air Force personnel drove 3/4-ton weapons carriers on a cross-country desert course for 1, 3, 7 or 9-hour periods and were tested before, during, and after the driving period for evidence of changes in skills pertinent to vehicle manipulation.

Periodic measures were made of the driver's ability to (1) maintain a constant speed over a prescribed distance, (2) come to a sudden stop (response time), and (3) maintain vigilance by responding to the appearance of a colored light either reflected in the rear-vision mirror or at a point 30°, 60° or 90° from line of vision to his right at head level.

The test battery administered before and after driving the desert course consisted of eight driving patterns. Each was designed to elicit a different response-pattern which appeared to be important in vehicle driving. Skill aspects incorporated in the various measures were such items as: simple and complex forward and reverse manipulation of the vehicle accelerator; clutch and brake coordination; utilization of auditory and kinesthetic information; and spatial judgment.

The tests given to subjects while driving on the desert course failed to differentiate between the 1, 3, 7, or 9-hour driving groups. The battery of eight tests proved to be an acceptable instrument for demonstrating increasing skill fatigue associated with increasing length of the driving task. A composite score based on only four of the tests correlated .47 with hours of driving. The reliability coefficient was .74.

A factor analysis of scores from the test battery resulted in the extraction of seven orthogonal factors, three of which correlate significantly with hours of driving. These have been tentatively identified as: (1) Gross Adjustment; (2) Backing (simple); (3) Tracking; (4) Backing (complex); (5) Parallel Parking; (6) Foot Coordination; and (7) Spatial Judgment.

b.	The Influence of Control-Grip Angle on the Performance of a Manual Positioning Task.	Herbert	Mar 57	Oct 57

Eighteen right-handed males served as subjects. Their task was to guide a probe through a metal tube without making contact. Six tubes were positioned so as to require some one of six different directions of arm movement from trial to trial. The handle of the probe could be altered so that the angle between probe and handle could be set at 75°, 90° or 105°.

Every subject used all handle settings and responded an equal number of times in each of the six directions. Though accuracy of response was stressed, both accuracy and speed measures were analyzed. Accuracy was not influenced by the different handles, however, the 90° grip allowed significantly faster responses than did either the 75° or 105° handles. The latter two were not significantly different.

c.	To What Extent Does the Location of a Hand Control Affect the Maximum Forces Which Can Be Exerted on It?	Caldwell	Sept 56	Aug 57

Five subjects were employed in an investigation to determine the relative influence of elevation, lateral position and distance of a control on the strength of 6 linear hand movements. Four elevations, 4 lateral positions, and 5 distances provided 80 control positions which covered most of the working-space of the right hand.

The control distances accounted for more of the observed variations in the strength of the movements than did either the elevations or the lateral positions. The control distances strongly affected all movements, whereas the elevations and lateral positions were selective in their influences.

d. The Judgment of Angular Positions in the Horizontal Plane, on the Basis of Kinesthetic and Visual Cues Alone and in Combination.	Herbert Caldwell	Jun 57	Sept 57

Twenty-one subjects judged the location of angular positions from 0° to 90° in the horizontal plane. Three cue conditions were presented: (1) kinesthetic only, in which the subject wore a blindfold and moved his arm to a designated angular position; (2) vision only, where the subject, without blindfold and with hands in light, directed the experimenter in positioning a long, luminous pointer; and (3) kinesthetic-plus-vision, in which the subject was allowed to position his arm while viewing a luminous pointer which showed the position of the arm.

Performance was most accurate for the subjects using only the visual cue. The combined cue condition was better than the kinesthetic condition, but not significantly so. The greatest errors of localization were obtained in the regions between the mid-point of the scale and the ends--that is, around 30° and 70°. This was true for all 3 cue conditions.

e. The Effect of Joystick Mass on Tracking Performance.	Hartman	May 57	Sept 57

The study was concerned with the effect of mass of the control (moment of inertia) on performance. The joystick handles weighed 1 oz., 8 oz., 16 oz., 24 oz., 32 oz., and 40 ounces. The optimal stick length (18 in.) was used. Two conditions of sensitivity were used--the best had a sensitivity ratio of 2.85:1, and the worst had a sensitivity ratio of 0.5:1. The variables outlined indicate that the study is designed to answer two questions: First, what is the effect of control mass on accuracy of tracking? Second, is that effect different for large tracking movements than for small tracking movements?

f. Decrement in Driving Skill Associated with Increasing Time of Exposure to Environmental Stresses.	Herbert Jaynes	Sept 5"	Mar 58

In the summer of 1956 a study was conducted at the Yuma Test Station to: design a battery of driving performance tests that would aid in the identification of some of the basic response patterns required in vehicle manipulation; and to measure changes in these patterns as a function of increasing environmental stress.

The present study, to be done at Fort Knox, is an elaboration of the efforts of a year ago. The battery of 8 tests will be further refined and some new tests will be added.

Twenty-four trained operators will drive 1/4 ton trucks (jeeps) on a "fatigue" course on 8 separate occasions. Each man will twice drive for 3, 7, 11 and 15 hours with the test times and driving periods so balanced that one-half of the driving will be done under daylight conditions and the other half during darkness (using headlights). The final hour of driving in all cases will be done on a driving performance test course composed of 12 sub-tests.

Data will be analyzed by correlation and factoring techniques to supply information on the following points: (1) What are some of the specific skills underlying driving ability? (2) How much does driving skill decrease as the driving task is lengthened? (3) Does performance on the test battery reflect a difference between daylight and night driving? (4) Does temperature influence performance on the test battery?

g. The Effect of Various Body Supports on the Strength of Linear Hand Movements. — Caldwell — Sept 57 — Dec 57

The next study in the present series will deal with possible methods of increasing the forces which an operator can exert on a hand control. The effects of a safety belt, shoulder harness, and auxiliary hand-hold will be investigated. The forces exerted by the operator on a hand control at diverse orientations to the body will be measured with and without these supports.

h. A Theoretical Investigation of the Problem of Repeated Measurements. — Jaynes — Jun 57 — Mar 58

An attempt will be made to develop a mathematical model which will enable one to specify the interrelations between experiments in which different subjects are used under each condition and those in which the same subjects are used under all conditions.

i. A Manual for Statistical Computations. — Jaynes — Dec 56 — Feb 58

This manual will provide formats for the tabling of experimental data and simple computational directions for common statistical analyses based on such tables. Notation will demand nothing more than a knowledge of high school algebra. A section dealing with some useful wiring plans for the IBM 602-A and 604 calculating punches will also be included. Comments on experimental design and interpretation of results will be provided for the more sophisticated reader.

j. A Methodological Study of Tracking Scores. — Jaynes — Sept 56 — May 58

Graphic records have been obtained of the performance during the first hour of tracking by 30 naive subjects. These records include the target signal, the error signal, and the graphic time-on-target signal. The problem is to find a way to convert these graphic records into numerical data while retaining a maximum amount of information with a minimum amount of redundancy. Each graphic record will be scored in a number of different ways. Each score will then be checked for reliability, and systematic changes of these scores as a function of practice will be noted. Interrelations of the scores will be made in order to specify several relatively independent, reliable scores which change systematically with practice.

2. Contract Research

	Title	Contractor	Date Started	Completion Date
a.	Factors Influencing Complex Decision-Making Behavior	Dr. Richard H. Henneman, University of Virginia, Charlottesville, Virginia	May 1954	continuing

Research activities on the contract during the past year continued along the lines developed during the preceding year. Some of the experimental studies have been concerned with factors influencing choice behavior under simple responding conditions; other experiments have involved decisions in more complex behavioral situations. Studies have been carried on regarding: conditions determining the efficiency of multiple task performance; variables influencing choice behavior in simple response situations; and the role of response restriction in the perception of ambiguous stimuli.

The fourth project area of a year ago (the effect of stimulus encoding on multiple task performance) was abandoned to allow research on a new high-priority project derived from the general problem of the consolidation of information from single and multiple stimulus sources. The initial study involved the effect of irrelevant information upon complex visual discrimination. Research findings on this project would be expected to apply to operational situations requiring the operator to "filter" relevant from irrelevant data while monitoring various types of displays.

b. Sensing Mechanisms and Control of Fine Movements in Perception, Motor Precision, and Performance. | Dr. Edward Girden, Brooklyn College, Brooklyn, New York | Jun 1955 | Aug 1958

Impairment in the precision of pursuit tracking has been produced as a consequence of interpolated work-activity. This decrement in performance is not revealed unless the practice-effect is carefully controlled--with relatively unskilled Ss, the performance continues to improve with no decrement resulting from interpolated work; with sufficiently trained Ss, the interpolated work impairs the precision of the tracking performance. With practice accounted for, work-impaired performance was readily demonstrated with stationary as well as moving targets, and was obtained both with the pressure and the free-moving control. The results suggest a greater impairment of performance with the free-moving control than when the pressure control was used.

c. Certain Physiological Correlates of Psychomotor Functioning. | Dr. Robert B. Malmo. McGill University, Montreal, Canada | Jan 1955 | continuing

The circuitry of the visual tracking system has been revised in order to eliminate the need for d-c amplifiers (which drift and require adjustments) and for contact meter-relays (which need replacement). Time off-target, distance off-target and error amplitudes may still be scored and synchronized with the other physiological measures. A vibratory tracking system was designed and tested in several subjects. Data gathered so far indicate the null point type of apparatus used in auditory tracking may also be used in vibratory tracking. Also, except for the fact that the vibratory units may need redesigning so that they match the mechanical impedance of the skin more closely, it seems feasible to record action potentials, EMG's, EEG's, etc. without interference from the application of mechanical vibration to the body.

Tracings are continuing on sleep deprived subject. Most of this period has been expended in apparatus construction.

d. Context Effects in Psychophysical Judgments. | Dr. William E. Kappauf, University of Illinois, Urbana, Illinois | Jul 1957 | continuing

This is a new project which has been in effect for less than one (1) month. There has been no progress reported to date.

Context effects may arise in psychophysical judgment situations as a function of two major variables which have to do with the scheduling of trials: (a) the sequence of trials, as determined by the psychophysical method which has been chosen; and (b) the massing of trials. Although these effects may be eliminated completely in certain experiments by using each subject for only one trial (as Stevens has suggested), there are many experiments in which complete data for single subjects are desired. It is therefore proposed to determine to what extent context effects may be reduced by judicious choice of psychophysical method and inter-trial interval.

The present work would aim specifically at assembling data on the usefulness of the so-called "up-and-down" method in psychophysical measurement and would compare results obtained by this method with parallel measure on the same subjects obtained by more traditional measurement methods.

Because it seems best to deal with methodological problems with respect to specific content questions, it is proposed that the research be done with reference to the time error, and possibly also with reference to stereoscopic depth perception. Stevens has recently presented a view of the time error which relates it to effects obtained in the use of category scales. This view is reasonable if the time error is in fact no larger than the method of constant stimuli has revealed it to be. Results of the writer, however, suggest that by the up-and-down method conspicuously larger time errors may be obtained. It is therefore appropriate to obtain new data on the time error. It is proposed to conduct studies comparing the up-and-down method, and others dealing with the time error as a function of time for visual brightness, for auditory loudness and for lifted weights.

B. Vision Section

1. In Service Research

Title	Experimenter	Date Started	Estimated Completion Date
a. The Influence of Lack of Collimation and Eyepiece Defocusing Upon Stereoscopic and Vernier Acuity.	Harker Johnson	Mar 56	June 58

Data have been taken on a group of 24 subjects between the ages of 18 and 28 with uncorrected 20/20 vision in both eyes. Experimental conditions sampled a range of forced vergence from four prism diopters of divergence to sixteen prism diopters of convergence. Eyepiece defocusing was sampled over a range from plus one lens diopter to minus three lens diopters. The tasks employed were: fixation disparity alignment, vernier alignment and stereoscopic ranging. The results obtained indicate that the influence of "out of collimation" upon stereoscopic ranging follows fixation disparity, giving rise to under-ranging for divergence and over-ranging for convergence of the optical system. Eyepiece defocusing influenced the obtained acuities. Follow-up experimentation, utilizing conditions of symmetrical and asymmetrical vergence, is planned.

b. Response of an Observer to a Uniformly Illuminated, Unstructured, Visual Field.	Harker	Apr 56	Mar 58

Circuits for the dimming of fluorescent lamps have been purchased and modified to permit their application to small tubes. Illumination seen through milk lucite eye cups provided with an aperture is matched to the illumination seen directly through the aperture to present to the observer an illuminated field of maximal extent unbroken by distinct contour. Observation by the subject of illuminated targets in his field of view is possible through the aperture in the eye cups by the use of a semi-reflectant surface. Preliminary observations have indicated that the situation is sufficiently controlled to give rise to the accommodative searching characteristic of the "Whiteside Phenomena" or "High Altitude Myopia." A trip to Northern Greenland is planned for midsummer to permit direct personal observation of "White-out."

c. The perceptual Interrelation of Frontal and Stereopsis Extents in the Determination of Form.	Gogel	Aug 56	Aug 57

Using stereopsis, the depth component of an object was adjusted to produce a designated form at three distances from the observer. It was found that when cues to relative distance, other than stereopsis were minimized, the ratio of the adjusted stereopsis to the angular size of the frontal component was approximately a constant. The addition of extraneous cues to relative distance was found to affect this result. These experiments are being considered in relation to a previously developed hypothesis concerning the factors involved in translating a stereopsis to a perceived linear extent.

d. The Perceptual Interrelation of Frontal and Stereopsis Extents in the Determination of Perceived Depth.	Gogel	Dec 56	Sept 57

Predictions made from the previously developed hypothesis are being tested under conditions in which a depth interval produced by stereopsis is perceptually duplicated at different distances from the subjects. Measurements of apparently equal frontal extents and apparently equal depth extents are obtained in the same experimental situation. Data have been collected in two experiments which have been concerned with a relation between perceived ratios of stereopsis depths and perceived ratios of corresponding frontal extents.

e. Perception of Continuous, Fluctuating Stimuli.	Gardner	May 56	Dec 58

This project aims at the variables governing the perception of stimulus fluctuations in a monitoring situation. At present the tasks employed to represent this form of perception consist of estimations by the subject of average past and future stimulus values and trends in stimulus values. Experimental conditions were administered to 492 basic trainees and data were collected for 432 of these. There were 4 conditions of stimulus determinacy. The number of stimulus value categories ranged from 2 to 5, as did the number of available response categories. The influence of equivalence of stimulus value categories and available response categories was also explored. Subsequent steps in the research program will include further exploration of functional relationships discovered in the initial experiment over a wider range of these variables.

2. Contract Research

Title	Contractor	Date Started	Completion Date
a. Effect of Noise on the Perception of Forms in Electro-Visual Display Systems	Dr. Mason N. Crook, Tufts University. Medford Massachusetts	Apr 54	Sep 58

Experimental results on the recognizability of irregular forms under noise mentioned in the preceding report have been more fully analyzed. Recognition was found to increase with decreasing noise and with increasing difference between the test and comparison forms. Recognition scores showed relatively little relation to area or perimeter of the forms, or to area/perimeter. Some indication was found that eight-sided forms are more recognizable than four- or sixteen-sided forms. In an experiment using familiar forms, "natural" direction of contrast was found to have no significance for recognizability in the experimental situation. The results pointed to better recognizability under noise for test items printed in black on white than for those printed in white on black, regardless of whether the natural forms are light or dark. A larger and more varied sample of irregular forms has been constructed. The development of additional types of complex backgrounds is in process.

b. Phychophysiology of Perception	Dr. Donald B. Lindsley, University of California, Los Angeles, California	Sep 56	continuing

The general goal of the project is to investigate basic aspects of visual perception, especially from a psychophysiologic viewpoint with reference to new concepts of neurophysiology. Tactual and auditory perception will be involved in some cross-modality studies. The investigation will be concerned particularly with temporal factors in perception, especially perception pushed to temporal limits. It is at this point that psychological and neurophysiological data can best be integrated on a common time base. Some of the proposed problems are as follows: (1) Factors in obliteration of perception by a successive light flash; (2) Perceptual consolidation time following minimal exposure; (3) Sensory and perceptual interaction; (a) Intersensory dissociation, (b) Influence of cross-modality stimulation on perception, (c) Effect of cross-modality stimulation on habituation; (4) Effect of photic driving on perception; (5) Emergence of form or pattern in visual perception. The outcome of basic studies on the psychophysiology of perception can have numerous applications in the field of military operations, particularly in the use of technical instruments which often tax the limits of perceptual capacity.

c. Some Perceptual and Physiological Aspects of Uniform Visual Stimulation	Dr. Walter Cohen, University of Buffalo, Buffalo, New York	Jun 57	continuing

This is a new project which has been in effect for one (1) month. There has been no progress reported to date.

E.E.G. records and other physiological measurements will be obtained under conditions of uniform stimulation of the entire visual field (Ganzfeld) and when a differentiated area is present. The Ganzfeld will be produced by use of special apparatus based on the principle of the photometer sphere. Special attention will be paid to the temporary cessation of visual experience that occurs under these conditions.

Under conditions of inhomogeneity in the Ganzfeld, the following phenomenal characteristics will be studied: (1) color, (2) mode of appearance, (3) apparent distance, (4) definiteness of contour, (5) shape. The following characteristics of the stimuli will be systematically varied: (1) size of figure, (2) mode of appearance, (3) apparent distance, (4) definiteness of contour, (5) shape. The following characteristics of the stimuli will be systematically varied: (1) size of figure, (2) form of the figure, (3) boundary between figure and ground (lines and points).

The results should contribute to the better understanding of some of the basic mechanisms involved in (1) figure-ground segregation, (2) distance perception, (3) color perception, (4) contour formation. From the military point of view, the results may be related to the perception of objects under conditions of relative uniformity, i.e., fog, snow, and sky.

d. Fluctuations in Night Visual Acuity	Dr. E. Parker Johnson, Colby College, Waterville, Maine	Jun 57	continuing

This is a new project which has been in effect for one (1) month. There has been no progress reported to date.

The purposes of the proposed study are two:

(1) To make clear the existence of these fluctuations which, though their implications for night vision testing are important, have never been described at all in the regu. r scientific journals.

(2) To answer the practical question: "What proportion of young men of military age have fluctuations--of what magnitudes, forms, and frequencies?"

The immediate goal, then, is descriptive. Later will come problems of explanation, prediction, control.

C. Sound Section

1. In Service Research

Title	Experimenter	Date Started	Estimated Completion Date
a. The Aural Overload Test as an Indicator of Susceptibility to Noise Induced Hearing Loss.	Fletcher Snyder	May 57	Feb 58

Reference audiograms and aural overload thresholds were obtained for about 100 RFA trainees prior to training. At the end of their 6 months training, audiograms and aural overload thresholds will again be taken from the trainees. Analysis will be made to see if initial aural overload threshold correlates with hearing loss at the end of training. An additional portion of the study will be devoted to obtaining cumulative noise exposure records for the subjects.

b. Attenuation Characteristics of Four Ear Protective Devices.	Fletcher Silver	May 57	Aug 57

Two methods were used to determine the attenuation characteristics of 4 ear protective devices (2 helmets, 2 headsets). A physical calibration of the devices was made using a dummy head, then articulation tests were made using 96 human subjects in a simulated tank noise field. Analysis was made to determine the rank of each device with regard to attenuation.

c. A Hearing Conservation Program	Fletcher	May 57	Continuous

In collaboration with the Chief, Preventive Medicine, USAH, Ft. Knox, a hearing conservation program for Ft. Knox was initiated. Phases of the program include indoctrination and fitting of ear protective devices on personnel working in high noise level environments, periodic audiogramming of such personnel, with consideration being given to rotating personnel suffering losses from their noisy jobs until recovery is evidenced.

d. The Auditory "Sharpening" Phenomenon: I. The Differential Threshold for Frequency.	Silver	Aug 57	Jan 57

The determination of the frequency difference threshold about a stimulated point will be made using recently discovered interaural inhibition to avoid the difficulties imposed by beat phenomena.

f. The Auditory Sharpening Phenomenon: II. An Investigation of the Absolute Threshold for Pure Tones in the Presence of a Contralateral Pure Tone Stimulus.	Silver	Aug 57	Jan 57

Using pure tone to produce contralateral inhibition the absolute threshold for intensity will be investigated in the region around the center of the contralateral inhibition.

2. Contract Research

Title	Contractor	Date Started	Completion Date
a. The Effect of Overstimulation and Internal Factors on the Function of the Inner Ear	Dr. Merle Lawrence, University of Michigan, Ann Arbor, Michigan	Jun 55	continuing

The level above threshold at which the ear overloads is apparently not influenced by conductive lesions. Therefore this measure was compared with bone measurements made pre- and post-operatively in otoschlerotic patients. Results indicate a significant improvement in bone conduction scores after fenestration or stapes mobilization whereas the linear range of hearing, as measured by the aural-overload test, does not vary significantly post-operatively. For this reason, the aural-overload test is considered to be more accurate than the bone conduction test.

Results of examinations of sectional ears of vibrated monkeys indicate that the otolithic membrane of the utricle has been dislodged.

D. Environmental Factors Section

1. In Service Research

Title	Experimenter	Date Started	Estimated Completion Date
a. Effect of Temperature Stress Upon Performance of Certain Tracking Tasks.	Newton	Jan 56	Sep 57

Movement and pressure tracking have been studied as a function of thermal stress. These two modes of tracking are differentially affected by temperature stress, according to a previous study done in this laboratory. The present study attempts to determine optimum temperature ranges for the two methods of control. Data collection has been completed and a report is in preparation.

b. Behavioral Effects of Cold Adaptation in the Rat.	Carlton Marks	July 56	Oct 57

Normal and cold-adapted rats are being compared on various aspects of instrumental conditioning and extinction to determine behavioral concomitants of physiological cold acclimatization. Rats are trained to press abar for 'heat reward' in low levels of ambient temperature. Several reports in this series of studies have been published, and others are in preparation.

c. The Effect of Fatigue in the Establishment of Stimulus Equivalence.	Newton	Jan 57	Sept 57

Four tasks have been given subjects in a manner designed to establish a 'response-mediated stimulus equivalence.' Fatigue of some of the effectors involved in the responses was introduced, with the anticipation that the 'fatigue' may influence the degree of stimulus equivalence obtained. Data collection has been completed and data analysis is currently under way.

2. Contract Research

Title	Contractor	Date Started	Completion Date
a. Neural Correlates of Thermal Sensations	Dr. John P. Nafe, Florida State University, Tallahassee, Florida	Dec 55	continuing

The problem is to secure from sub-human mammals simultaneous records of (1) thermal changes and (2) vascular responses. We assume such changes are accompanied, in these animals as they are in humans, by thermal sensations: warmth, cold, heat, and pain associated with extreme temperatures, both cold and heat. We are particularly interested in the possibility that these thermally-induced vascular responses, in the skin and other superficial surfaces give rise to the nerve discharges associated with thermal sensations and that therefore the vascular elements involved are the receptors for this type of sensitivity.

There is also some interest in the part, if any, played in thermal sensitivity by the hair erector muscles.

E. Vestibular Section

1. In Service Research

Title	Experimenter	Date Started	Estimated Completion Date
a. Apparent Adaptation Effects in Vestibular Reactions.	Guedry Cramer Koella	Jul 56	Aug 57

One study has been completed and others are in progress. The current studies are concerned with a more intensive study of the growth of the apparent adaptation effects. These studies will also provide information on (1) the so-called directional specificity of these 'adaptation effects' and (2) the recovery from these 'adaptation effects." The second report in this series is in preparation.

b. Techniques for Studying Postural Effects of Angular Acceleration.	Guedry Caldwell Cramer	Sept 57	May 58

The vestibular system in conjunction with other response systems influences the resting tonic activity as well as compensatory activity of a large number of muscles. Angular acceleration produces a disturbance in vestibular equilibrium which, among other effects, produces compensatory postural adjustments. It is desirable to have sensitive measurement of these compensatory adjustments (1) to determine possible subtle influence on psychomotor performance and (2) to provide an index of the vestibuiar reaction which would possibly provide a continuous quantitative measure of the reaction throughout its course.

c. Further Studies of Apparent Adaptation Effects in Human Subjects.	Guedry Cramer	Oct 57	Feb 58

Our present studies of 'adaptation' effects indicate a definite need for determining the magnitude of these effects under a variety of conditions. Two additional studies are planned to answer questions concerning (1) influence of adaptation effects on response latency of subsequent stimuli, (2) accumulative adaptation effects with a number of short stimuli of the same direction and (3) "transfer" of these effects to higher magnitude test stimuli.

d. Development of Techniques for Obtaining Continuous Estimates of Subjective Velocity throughout Course of Vestibular Reactions.	Guedry Ceran	May 57	Sept 57

A number of techniques have been attempted including (1) subject-controlled compensatory motion of a small light source for perceived motion of a faint background light, (2) continuous estimates of present speed relative to speed in interval just elapsed, (3) time estimates of apparent rotation through 45 degrees throughout the course of the vestibular reaction. Our research thus far does not single out any one of these methods as clearly superior to the others. It is anticipated that refinement of at least one of these methods will provide a useful technique for future research. A report of part of this work is in preparation.

e. Neurophysiological Study of Apparent Adaptation Effects.	Cramer Wells Guedry	Jun 57	Sept 57

Recent work has demonstrated the presence of changes in vestibular response to an unvarying stimulus. Electrophysiological records will be taken at the level of the vestibular nuclei and, if possible, at the peripheral nerve as it leaves the end-organ during prolonged constant angular acceleration. This should provide important information relating to the apparent adaptation effects already observed.

f. Perception of Moving Objects.	Guedry Gogel	Oct 57	Feb 58

A series of studies is planned concerning the perception of motion of objects moving through as much as 25 degrees visual angle where the magnitude and direction of movement are systematically varied. It is planned to measure errors of prediction of position based upon observation of motion of the object.

g. Influence of Motion Sickness Preventive Drugs on Psychological Factors Involved in the Performance of Various Military Duties.	Cramer & others	Sep 56	Oct 57

The design of this study calls for the use of two motion sickness preventive drugs, one with slight side effects and one with strong side effects, and a placebo. Attention is focused on three issues: (1) the importance of time intervals after ingestion of the drugs, (2) the side effects of the drugs, (3) the interaction between the side effects of the drugs and the time interval.

h.	Interaction of the Effects of Sodium Pentobarbital and Alcohol upon Operant Behavior of the Rat.	Carlton	Dec 56	Jul 57

Light dosages of sodium pentobarbital in water produced a marked reduction in response output, although neither the animals' motorability nor its "alertness" were noticeably altered. However, sodium pentobarbital in solution with propolene glycol and alcohol produced no notable shift in response output. Neither the water solution nor the propolene glycol solution produced a significant shift in "timing behavior" in rats. The report of this work is in press.

i.	Interaction of Vestibular Stimuli and Electrical Stimulation of the Brain Stem.	Koella & Vest. Section	Aug 57	May 58

This is an investigation of the effects of electrical stimulation of different regions of the brain stem on the nystagmic respon of rabbit. It is believed that areas of inhibition and areas of facilitation of the vestibular response will be located.

j.	Differential Satiation Effects Under Fixed-ratio and Regular Reinforcement Schedules.	Carlton	Apr 57	Aug 57

Water deprived rats were extensively trained on concurrent fixed-ratio and regular reinforcement schedules. After their performance had stabilized, the effects of partial satiation of their thirst on the behavior generated by these two schedules were observed. Satiation served to increase the duration of periods of no responding under the fixed-ratio schedule without altering the response rate. On the other hand, responding under the regular reinforcement schedule was unchanged.

2. Contract Research

	Title	Contractor	Date Started	Completion Date
a.	Effect of Large Displacement Vibrations on Human Performance	Bostrom Research Laboratories, Milwaukee, Wisconsin	Apr 57	continuing

This is a new project which has been in effect for four (4) months. There has been no progress reported to date.

The purpose of this research is to study the effects of vibration typically experienced by drivers of trucks, tractors, and heavy earth moving equipment on human psychomotor performance. The frequencies and amplitudes to be studied will be in the range of 1 to 8 cycles per second with displacements between 1/16 of an inch and 8 inches. Approximately 40 subjects will be vibrated for periods up to three hours at various intensity levels. They will be tested before vibration, at regular intervals during vibration and at regular intervals after vibration. The tests will include hand steadiness, body sway, binocular visual acuity, reaction time, hand tracking, a vigilance test, and mental addition. The data gathered from the various intensity levels will be analyzed statistically against a control condition. The analysis will be of mean performance as well as variability of performance. The deterioration in human performance due to vibration will also be analyzed as a function of time.

III. BIBLIOGRAPHY OF PUBLISHED REPORTS, 1956-1957
Experimental Psychology Department
US Army Medical Research Laboratory

Report No. 215, 12 January 1956. The sensing of relative distance. W. C. Gogel and J. A. Schneps.

Report No. 216, 17 January 1956. The judgment of angular positions in the horizontal plane on the basis of kinesthetic cues. L. S. Caldwell and M. J. Herbert.

Report No. 218, 15 February 1956. The effects of noise on eye movements. J. Krauskopf, P. D. Coleman and R. Kalla.

Report No. 221, 27 January 1956. The effects of retinal image motion on contrast thresholds. J. Krauskopf and R. Kalla.

Report No. 223, 6 April 1956. Frequency discrimination of pure and pulse tones. R. Cramer and L. Zeitlin.

Report No. 225, 7 March 1956. Combined environmental stresses and manual dexterity. Edwin G. Aiken.

Report No. 230, 11 April 1956. A field study of a vigilance task. Michel Loeb, Gabriel Jeantheau, and Lelon A. Weaver.

Report No. 231, 18 April 1956. A field study of rifle aiming steadiness and serial reaction performance as affected by thermal stress and activity. L. J. Peacock.

Report No. 232, 20 April 1956. Note on the operation of the standard electric timer from storage batteries by use of a current converter. J. M. Newton.

Report No. 233, 27 April 1956. The accuracy of constant angular displacement of the arm in the horizontal plane as influenced by the direction and locus of the primary adjustive movement. L. S. Caldwell.

Report No. 235, 9 May 1956. The retinal size of a familiar object as a determiner of apparent distance. W. C. Gogel, B. O. Hartman, G. S. Harker, K. Inaba, R. E. Page and J. J. Cox.

Report No. 236, 23 April 1956. "BETA"--A special purpose computer for studies in the human control of complex equipment. Bryce O. Hartman, John K. Wetherbee, Woodrow Bates and George Potenza.

Report No. 239, 24 May 1956. Judgments of visual velocity as a function of length of observation time. A. G. Goldstein and L. K. Williams.

Report No. 242, 23 May 1956. Description of Human Rotation Device. F. E. Guedry, Jr. and Harvey Kalter.

Report No. 245, 28 June 1956. Graphic time-on-target: a tracking score with both qualitative and quantitative aspects. Bryce O. Hartman.

Report No. 248, October 1956. Further studies on frequency discrimination of pure and complex tones. L. R. Zeitlin and R. L. Cramer.

Report No. 258, 31 January 1957. Judgments of visual velocity as a function of the length of observation time of moving or non-moving stimuli. Alvin G. Goldstein.

Report No. 260, 25 March 1957. The speed and accuracy with which six linear arm movements can be visually positioned from two different control locations. Marvin J. Herbert.

Report No. 261, 18 March 1957. Some effects of interacting vestibular stimuli. F. E. Guedry.

Report No. 263, 20 March 1957. The effect of target frequency on pursuit tracking. Bryce O. Hartman.

Report No. 286, 5 April 1957. The influence of intense noise on a precise fatiguing task. M. Loeb.

Report No. 269, 3 June 1957. The effect of intense stimulation on the perception of time. M. Loeb.

Report No. 270, 25 March 1957. The effects of noise on work output and physiological activation. M. M. Helper.

Report No. 272, 25 April 1957. The effect of target frequency on compensatory tracking. Bryce O. Hartman.

Report No. 275, 25 March 1957. Nystagmic eve movements during ineracting vestibular stimuli. F. E. Guedry, L. J. Peacock, and R. L. Cramer.

Report No. 277, 25 March 1957. Response acquisition and reversal under cold stress. Edwin G. Aiken.

Report No. 278, 7 May 1957. The interrelation of vernier and stereoscopic acuities in the making of an equidistant judgment. George S. Harker.

Report No. 279, 9 May 1957. The effect of joystick length on pursuit tracking. Bryce O. Hartman.

Report No. 282, 17 January 1957. A survey of hearing losses among armor personnel. John L. Fletcher and Lawrence N. Solomon.

Report No. 283, 19 December 1956. Behavioral concomitants of cold adaptation: I. Rate of responding at 2.5° C. L. J. Peacock and R. A. Marks.

Report No. 284, 10 June 1957. Behavioral concomitants of cold adaptation: II. Rate of responding at -5° C. L. J. Peacock and R. A. Marks.

Report No. 285, 16 June 1957. The effects of auxiliary tropical heat on manual dexterity in the cold. J. M. Newton and L. J. Peacock.

Report No. 288, in press. Precise control manipulation as a function of control location. Raymond C. Sidorsky.

Report No. 289, 28 June 1957. Response reversal and fatigue. Edwin G. Aiken.

Report No. 293, in press. Adaptation effects in vestibular reactions, F. E. Guedry and N. Beberman.

Report No. 296, in press. Perceived frontal size as a determiner of perceived stereoscopic depth. W. C. Gogel.

Report No. 298, in press. Behavioral concomitants of cold adaptation: III. Temporal development of behavioral differences. L. J. Peacock and R. A. Marks.

Report No. 299, in press. Heat as a reinforcement for operant behavior. P. L. Carlton and R. A. Marks.

Report No. 300, in press. Effects of variations in ambient temperature on certain measures of tracking skill and sensory sensitivity. R. W. Russell.

Report No. 301, in press. Differences in response latency with different magnitude angular accelerations. F. E. Guedry and G. Richmond.

Report No. 302, in press. Localization of sounds in depth. John L. Fletcher.

Report No. 304, in press. The interacting effects of sodium pentobarbital and two alcohols on the operant behavior of the rat. P. L. Carlton.

Report No. 308, in press. The effect of the extent of movement (control sensitivity) on pursuit tracking performance. B. O. Hartman.

Report No. , in press. Differential satiation effects under fixed-ratio and regular reinforcement schedules. P. L. Carlton.

Report No. , in press. Analysis of abductive and adductive phases of movement in continuous tracking. B. O. Hartman, Marvin Herbert, and W. E. Jaynes.

Report No. , in press. Sound localization in depth and direction under three climatic conditions. Lawrence N. Solomon and Paul D. Coleman.

Report No. , in press. The relative loudness of pure and complex tones. Lawrence R. Deichin.

Report No. , in press. An observer constant in the perception of stereoscopic depth. W. C. Gogel.

Report No. , in press. Heat reinforced operant behavior as a function of prolonged cold exposure. P. L. Carlton and R. A. Marks.

ORDNANCE CORPS

Human Engineering Activities

I. U. S. Army Ordnance Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

1. Vitae
2. Current Projects
3. Bibliography of Published Reports

II. Ordnance Weapons Command, Rock Island, Illinois

1. Vitae
2. Current Projects
3. Bibliography of Published Reports

III. Ordnance Tank-Automotive Command, Detroit Arsenal, Center Line, Michigan

1. Vitae
2. Current Projects
3. Bibliography of Published Reports

IV. Picatinny Arsenal

1. Vitae
2. Current Projects
3. Bibliography of Published Reports

V. Watertown Arsenal

1. Vita
2. Current Projects
3. Bibliography of Published Reports

VI. U. S. Army Ordnance Arsenal, Redstone, Huntsville, Alabama

1. Vita
2. Current Projects
3. Bibliography of Published Reports

VII. U. S. Army Ordnance Arsenal, Watervliet, Watervliet, New York

1. Vita
2. Current Projects
3. Bibliography of Published Reports

I. U. S. Army Ordnance Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

VITAE

Ablon, Leon L., Physical Science Assistant, Private
BA, Alfred University, 1955

Andrew, Dwight K., Research and Development Coordinator, 1st Lt
BA, Dartmouth College, 1955

Azrin, Dr. Nathan H., Social Science Assistant, SP3
[illegible] Harvard, [illegible]

Bacon, Albert S., Social Science Assistant, SP3
BA, University of Virginia, 1954

Blackmer, Raymond F., Electronics Scientist
BS, University of Massachusetts, 1954

B[illegible], William H., Mechanical Engineer Assistant, PFC
BS, Stanford University, 1955

Congleton, Curtis D., Research and Development Coordinator, 2d Lt
BS, University of Kentucky, 1957

[illegible]per, John R., Social Science Assistant, Private
MS, Clemson College, 1956

[illegible]rook, Donald R., Social Science Assistant, Private
BA, Vanderbilt University, 1955

[illegible]ruse, Charles S., Supervisory Engineer (Human Factors)
Maryland Institute School of Mechanical Arts

[illegible]ering, Lawrence E., Engineer (Human Factors)
BS, University of Maine, 1920

Doniez, Ray, Engineer (Human Factors)
ME, University of Cincinnati, 1954

[illegible], Lewis, Psychologist (Human Engineering)
MA, New York University, 1950

Feldman, Leonard M., Mechanical Engineer Assistant, PFC
[illegible], Carnegie Institute of Technology, [illegible]52

Ferrero, Harvey J., Draftsman, PFC
BS, Lawrence Institute of Technology, 1955

Hicks, Samuel A., Psychologist
[illegible] Morgan State University, 1956

Jenner, Robert E., Supervisory Engineer (Human Factors)
MS, Northwestern University, 1954

Katchmar, Dr. Leon T., Psychologist (Human Engineering)
PhD, University of Maryland, 1954

Kurke, Martin I., Psychologist (Human Engineering)
MA, University of Buffalo, 1952

Larkin, Jerome D., Electrical Engineer Assistant, Private
BS, Manhattan College, 1955

Mack, Lois F., Psychologist
BS, Howard University, 1953

Mc Cain, Claude N., Engineer (Human Factors)
BS, University of South Carolina, 1950

Moler, Calvin G., Engineer (Human Factors)
BSE, Davis & Elkins College, 1950

Randall, James I., Supervisory Electronics Scientist
Johns Hopkins University

Reilly, Edward C., Budget Officer
BS, University of Rhode Island, 1953

Rose, Anthony J., Mechanical Engineer Assistant, SP3
BS, Case Institute of Technology, 1951

Sanders, Leonard A., Social Science Assistant, PFC
BA, City College of New York, 1956

Schultz, Duane P., Social Science Assistant, Private
MA, Syracuse University, 1956

Stephens, John A., Engineer (Human Factors)
BEA, Rhode Island School of Design, 1951

Smith, Frank W. Jr., Social Science Assistant, PFC
BA, University of Virginia, 1955

Sova, Bruno L. Jr., Electrical Engineer Assistant, PFC
BS, Worcester Polytechnic Institute, 1955

Torre, James P. Jr., Psychologist
BA, Adelphi College, 1954

Van Huyck, Alfred P., Research and Development Coordinator, 1st Lt
BA, Dartmouth College, 1955

Weiss, Dr. Edward C., Psychologist (Human Engineering)
PhD, University of Maryland, 1954

Weisz, Dr. John D., Supervisory Psychologist (Human Engineering) Director
PhD, University of Nebraska, 1953

CURRENT PROJECTS

A. BACKGROUND RESEARCH ACTIVITIES

Project	Experimenters	Date Started	Estimated Completion
1. R&D on Steering Control Devices in Track-Laying Vehicles	R. E. Jelinek L. T. Katchmar	May 54	Aug 57

This is a laboratory study in which a driving simulator is being constructed which will be used to evaluate driving performance of military personnel using five different types of steering controls. The ultimate goal of this project is to provide a facility which will permit a series of investigations which will be designed to determine the optimum type of steering control and control deficiencies for track laying vehicles.

Project	Experimenters	Date Started	Estimated Completion
2. The Effects of Visual Field on Simulated Driving Performance	R. E. Jelinek L. T. Katchmar	Aug 57	Dec 57

This experiment is designed to determine the requirements of the visual stimulus field for evaluating simulated driving performance.

Subjects will drive (perform the necessary control movements) along a prescribed course under two conditions. The first course condition is defined by the path of a moving spot of light and the second is a motion picture projection of a road. Both conditions are identical in terms of control movements required but differ in the amount of visual information presented.

3. An Evaluation of Selected Rifle Sights Under Two Levels of Illumination	H. F. Pohlman L. T. Katchmar	Dec 56	July 57

This experiment evaluated two experimental rifle sights and the standard M1 sight under two levels of illumination and under conditions of actual firing. The levels of illumination were 1 and 50-ft. candles. The experimental sights had previously been reported to permit the best sighting accuracy under low levels of illumination when evaluated with the aid of static training device.

Ten subjects, using a highly accurate .22 caliber rifle, fired four 10-shot groups at a distance of 100 yards under all conditions of sights and illumination. The results indicate little difference in mean radius accuracy for the three different sights under low illumination. Accuracy was greatest with the M1 sight under high illumination.

4. An Evaluation of the Three Proposed Sets of AAOC Radar Symbols	W. Blair J. Torre L. Sanders	Nov 56	Jul 57

The three sets of symbols under evaluation were the HAWK, NIKE I and NIKE II symbols. Two studies were designed for this evaluation. The first study employed a tachistoscope to obtain recognition thresholds for each of the different sets of symbols under conditions of meaning assigned to symbols and number assigned to symbols. The second study employed a simulated P.P.I. presentation which permitted the control of such factors as number of symbols, the proportion of symbols within a set, and distribution of symbols presented. In any given presentation subjects were required to mark a certain type of symbol or symbols, as accurately and quickly as possible. A total of 30 subjects participated in these studies.

The results indicate that the discernibility of a particular symbol is a function of the "context of symbols" in which it occurs. In terms of performance, the rank order of symbol sets were HAWK, NIKE I and NIKE II.

5. An Investigation of the Use of Graphic Representation of Feeling States for Symbolic Displays	L. Sanders J. Torre	Jun 57	Oct 57

The attempt to aid radar operators in identifying radar targets by the use of symbols requires that a set of symbols be devised which will be easily discriminable, sufficiently different from each other to avoid confusion between symbols, and immediate action symbols be easily identified under conditions of high symbol saturation.

This investigation is an attempt to determine whether there exists within the military population any communality in the graphic depiction of such feeling states as hositility, friend, enemy, etc. If any communality is found to exist the symbols will be used to derive a refined set of symbols which will be evaluated under simulated radar conditions to determine their effectiveness for identification of targets.

Graphic depictions will be obtained from 200 subjects under group testing conditions and 50 subjects under individual testing conditions.

6. The Motivational Effects Of Rest Periods on Performance	N. H. Azrin L. A. Sanders	Aug 57	Dec 57

Characteristically, performance over extended periods of time exhibits progressive decrement. This performance decrement has been variously explained by concepts like fatigue, boredom, and monotony. A number of methods have been discovered which, when applied, appear to eliminate, reduce or forestall performance decrement. One of the many methods used is the injection of brief rest periods.

The present study is concerned with the use of rest periods to increase performance. There is some evidence to indicate that rest periods possess an inherent motivating value above and beyond simply providing time for "fatigue products" to dissipate. The present experiment is designed to (1) investigate the hypothesis that rest periods do possess motivational value, and (2), to explore several variables which may affect this motivational value.

7. The Effects of Noise on a Vigilance Task	N. H. Azrin	Dec 56	Nov 57

Apart from its effects on hearing and communication, noise is generally assumed to exert a detrimental effect on performance, however, in the literature there are reports of no effect, detrimental effects and beneficial effects. To say the least the results are ambiguous.

The present experiment was designed to systematically investigate the effects of various noise schedules, ranging from continuous noise to brief bursts of reponse produced noise, on a task which requires a high degree of attention. The task employed requires that the subject make a response as soon as he detects the stimulus. In order to observe whether the stimulus is present the subject is required to make another response which permits a brief view of the stimulus field. It is this "looking response" which will provide the major portion of the data for this experiment.

8. Physiological and Psychological Effects of Muzzle and Breech Blast	S. A. Hicks J. J. Romba L. T. Katchmar	Aug 55	Continuing

This program represents a coordinated effort on the part of the Human Engineering Laboratory, the Shock Tube Facility of the Ballistic Research Laboratories and the Chemical Corps Medical Laboratory. The program was initiated to determine the effects of blast parameters on various types of performance. Because of the obvious hazards involved the program was initiated on an animal level. The overall program consists of three phases.

The first, or physiological phase, has as its goal the determination of lethality limits in addition to determining the gross physiological damage resulting from sub-lethal blast pressures. Three conditions of exposure have been used: (1) direct exposure to blast waves, (2) exposure in a side chamber and (3), blind flange exposures. Under direct exposure conditions subjects are exposed to a combination of pressure and wind loading which produces body translation. The side chamber permits exposure to normal shock tube pressures but eliminates the factor of wind loading. The blind flange eliminates wind loading and permits higher overpressure durations than could normally be obtained by utilizing the phenomenon of reflected pressure.

Data has been collected on 12 animals. The determination of lethality limits will depend primarily on the limits of the shock tube. In most cases Fastax motion picures were obtained.

The second or Psychological phase, has as its goal the effects of blast on psychological behavior, e.g., learning, retention, motor coordination The first group of animals has been trained on a battery of tests developed at the Wisconsin Psychological Laboratory. It is anticipated that exposure of these animals to sub-lethal blast levels will begin during August. Both single and multiple exposure are planned.

The third phase involves the development of a wide variety of mental, motor and motivational tasks to be administered to operators of artillery weapons before and after scheduled firings. An attempt will be made to scale any observed behavioral changes according to the pressures which are characteristic of particular types of weapons.

9. Development of an Optical Projector for Simulated Radar Studies	R. Donley	Mar 56	Sep 57

Research on current and future radar problems is often limited to or dependent upon the development of adequate electronic equipment. For example, the presently available electronic equipment for research on radar symbols is limited to sine wave derived symbols. An optical projection system is being developed as an interim item which will permit the isolation of those significant display variables which should be further investigated with actual electronic equipment. The equipment in this manner will aid and provide guides for the development of future electronic facilities. The optical projection system will be capable of presenting both static and dynamic displays.

10. Development of Radar Simulation Equipment	J. I. Randall M. I. Kurke J. A. Stephens C. N. McCain	May 56	Continuing

The goal of this development program is to provide a master facility which will permit the investigation of a wide variety of psychological and electronic variables in the display of radar information. In addition to its importance as a research tool, this facility will be capable of simulating for evaluation, complete tactical situations which are anticipated for various types of weapons systems.

At present an electronic system has been developed which is capable of displaying a wide variety of sine wave derived symbols on an M33 scope. Studies utilizing this simulating equipment will begin very shortly.

B. SYSTEMS EVALUATION ACTIVITIES

11. L.A.A. Weapon System (Towed Version)	C. N. McCain, Jr. F. C. Weiss M. I. Kurke	Oct 56	Continuing

This is a continuing program to provide human factors design requirements for the development of this system. The forming of these requirements is the outgrowth of personnel experience with similar systems, literature reviews and controlled experimentation. At present two experiments are under way. The first experiment is designed to determine the least magnification required to detect airborne targets at a specified range. Auxiliary to this will be the investigations of an optimal field of view for the determined level of magnification. The second experiment is designed to investigate tracking efficiency using varying degrees of operator and tracking mount articulation.

This program will terminate with an evaluation of the developed weapon system.

12. Evaluation of Specific Missile Systems			
LACROSSE	L. Estrine C. Moler	Jun 56	Continuing
DART	E. Weiss J. Torre C. Cruse	Aug 57	Continuing
REDSTONE	E. Weiss L. Feldman	Nov 56	Continuing

The details of each of these systems are variously classified from confidential to secret. These programs represent a continuing effort to provide contractors with the necessary specific human factors information to insure operational efficiency of the fully developed missile system.

This type of activity demands that project personnel become thoroughly familiar with the military characteristics and the tactical situations envisioned for the system. Following this, detailed consultations are held with contractor personnel to insure proper cognizance of human factors requirements in the design of the system. In many cases laboratory experimentation is required to solve human engineering problems. An evaluation of component items is performed as soon as the items are available in order to discover any deficiencies. Each of these programs will culminate in an evaluation of the complete operational system. Some of the main factors taken into consideration are:

a. Reduction of error likely in situations encountered in the assembly of the unit, handling of component items, checkout procedures, and possible user abuse of equipment.
b. The efficiency with which trained operators can set up and use the equipment.
c. Environmental factors which might affect the efficiency of the system.
d. Deriving detailed standard operating procedures for the system.

The three system evaluations enumerated is in various stages of completion.

13. Missile Systems:
Contract Monitoring

HAWK	J. A. Stephens M. I. Kurke	Jan 55	Continuing
TALOS	B. Moler	May 57	Continuing
SERGEANT	J. A. Stephens E. C. Weiss	Dec 56	Continuing

The efficiency of any missile system, regardless of type of design, is dependent to a large degree upon the ability of the using personnel to operate the equipment as the designers intended. This man-machine relationship has frequently been neglected in the past, primarily due to the fact that the necessity for such considerations was not urgent in the relatively simple systems then in use. In the extremely complex weapons systems now under development, this "human element" has become one of the most important factors in the design of the system. In order to render the full measure of effectiveness, the human engineering problems must be considered from the initial design concept.

To insure that these vital "human factors" are receiving the attention and design considerations merited by their importance, the Human Engineering Laboratory has been requested by Redstone Arsenal to monitor this aspect of missile development being accomplished by prime contractors.

It is anticipated that human engineering monitoring will become increasingly important as future missile systems are developed.

C. INFORMATION DISSEMINATION — L. Mack, H. Ferrero, J. Hornbeck — Continuing

To keep Ordnance engineers abreast of the rapid advances made in human engineering an activity was created which has the responsbility of disseminating valid human engineering design criteria to Ordnance engineers in a form that is practical and understandable. Even the most engaging and promising work can remain unused unless read and digested by those who plan and develop equipment. Proper emphasis on pertinent material illustrations, photographic layouts, and other publication techniques is employed for best results. Two publications are published regularly, a "Data Report" and a "Newsletter."

D. FIELD LIAISON ACTIVITIES — D. K. Andrew, E. A. Van Huyck, C. D. Congleton — Continuing

The purpose of this program is to gather human engineering data pertinent to Ordnance materiel assigned to combat organizations. The data are gathered from military personnel through questionnaires, interviews, monitoring maneuvers, and other means which lend themselves to this problem. The data obtained through this program are evaluated by the Human Engineering Laboratory and reduced to design criteria which are disseminated to Ordnance design arsenals or other interested Department of Defense agencies.

Current surveys include:

a. Comparison of M59, T113 and T117 Light Personnel Carriers
b. Atomic checkout procedures
c. Field problems in the Arctic.

BIBLIOGRAPHY OF PUBLISHED REPORTS

TM No. 26 (U) — 27 Sep 1956. Human engineering survey of armored infantry vehicle, M59. Evan Charney, Anthony J. Rose and Louis T. Lee.

TM No. 27 (C) — 29 Oct 1956. Driver's position in tanks: a field evaluation of the prone position. Harry F. Pohlmann, Jr., and John E. Leopardo.

TM No. 1-57 (U) — 8 Jan 1957. Systems evaluation of the tank, 76mm gun M41A1. Martin I. Kurke, John A. Stephens, Robert Bell, Ernest E. Fusco and Arthur L. Taylor.

TM No. 2-57 (C)	June 1957. Human engineering comparison study of the ground guidance stations of Corporal missile system type II and type III. Alfred P. Van Huyck, Theodore W. Miller and Bruno L. Sova.
TM No. 3-57 (U)	March 1957. Physical force problems: 1. Hand crank performance for various crank radii and torque load combinations. Leon T. Katchmar.
TM No. 4-57 (U)	April 1957. Human Engineering field survey of 280mm gun and transporters. D. K. Andrew, T. W. Miller and C. B. Lansill.
TM No. 5-57 (U)	In Press. Optical Systems and Aerial Target Detection. Martin I. Kurke and Claude N. McCain, Jr.
TM No. 6-57 (U)	In Press. A study of cold weather organizational maintenance problems. Dwight K. Andrew, Albert S. Bacon and Anthony J. Rose.
TM No. 7-57 (U)	In Press An evaluation of selected rifle sights under two levels of illumination. Leon T. Katchmar, H. F. Pohlmann
TM No. 8-57 (U)	In Press. An evaluation of three proposed sets of radar symbols. Wesley C. Blair, James P. Torre, Leonard A. Sanders
TM No. 9-57 (U)	In Press. Literature Review: Tracking control mechanisms and displays (Light anti-aircraft system oriented). Samuel A. Hicks.
TM No. 17-2 (C)	February 1957. First interim report--Psychological and physiological effects of muzzle and breech blast. Wesley C. Blair.

II. ORDNANCE WEAPONS COMMAND

VITA

Lorenzen, Theodore G., Jr., Ordnance Engineer, BS, Bradley University, 1951

CURRENT PROJECTS

The Headquarters Ordnance Weapons Command, Rock Island, Illinois, coordinates the human engineering program of the Ordnance Weapons Command on all mission items. The actual studies and evaluations of the development items take place at the member Arsenals assigned development support responsibility for the end item. Principal coordination emphasis is being placed on the following systems.

1. Vigilante (U)
2. Little John and Honest John Helicopter Transportable Launchers (U)
3. Octopus (U)

III. ORDNANCE TANK-AUTOMOTIVE COMMAND

VITAE

Carney, William H., Coordinator, Engineering Design Branch, MS, Michigan State University, 1957

Hansen, Alfred A. E., Human Engineering Specialist LLB, Detroit College of Law, 1927

Smith, Daniel F., Chief, Special Engineering Branch, R&D Div

CURRENT PROJECTS

Human engineering analyses were made of the following vehicles:

1. T95, at Detroit Arsenal, Centerline, Michigan

2. S. P. Artillery Vehicle T236, at Pacific Car and Foundry Company, Renton, Washington

3. S. P. 105mm Howitzer, T195, at Detroit Arsenal

4. Air Transportable Armored Multi-purpose Vehicle, at Detroit Arsenal

5. Transporter, Double End, Combat Vehicle, at Detroit Arsenal

6. Truck, Aircraft Servicing, 3/4 Ton, 4x4, at Detroit Arsenal

7. Truck, Tractor, 25 Ton, 8x8, XM-375, at Reo Motors, Lansing, Mich.

8. Truck, Cargo, 5 Ton, 8x8, XM-382, at Detroit Arsenal

9. Truck, Utility 1/4 ton 4x4, XM-151, Ford Motor Co., Detroit, Mich.

10. Truck, Cargo, 10 Ton, 8x8, XM-409, at Detroit Arsenal

11. Truck, Fuel Tank, 10 Ton, 10x4, at Aberdeen Proving Ground, Md.

12. Carrier, Personnel, T113, at Food Machinery & Chemical Co., San Jose, Calif.

13. Tank, T92, at Aircraft Armament, Inc., Cockeysville, Md.

14. Vigilante Vehicle, at Detroit Arsenal

IV. PICATINNY ARSENAL

VITAE

Goldsmith, C. T., Head, Human Engineering Unit, MA, Fordham University

Peters, G. A., Psychologist, MA, Temple University

Seminara, J. L., Psychologist, MA, New York University

Strauss, P. S., Psychologist, MA, New York University

Worms, P. F., Psychologist, MS, City College of New York

Wright, N. L., Psychologist, MA, Fordham University

CURRENT PROJECTS

Human Engineering tasks at Picatinny can conveniently be grouped into four major types:

1. Equipment Design. Based on material available in the literature, the experience of the Arsenal's Engineering Psychologists, and relatively informal experimentation, design recommendations are made to engineers. Upon request of the project engineer, end-item development contracts are monitored to insure that contractors are making proper use of human engineering principles. The equipments considered range from complex missile warhead test and checkout equipment to relatively simple fuzes and timing devices. Currently, seven items are being considered. Where required information is not available in the literature, supporting research tasks are initiated.

2. Supporting Research. The following tasks have been undertaken to provide information urgently needed for design purposes:

a. Radioactive Illuminants. Preliminary studies (TM Nos. 17 and 19) have shown the feasibility of backlighting many Ordnance information displays with self-activated phosphors. Studies are now underway to determine optimum colors, brightness, character sizes and applications. (Wright, Seminara)

b. Control/Display Ratio. An investigation to determine optimum C/D ratio, torque, and control size for setting multi-revolution counters is presently underway. (Wright, Goldsmith)

c. Rotary Knob Torque. A study aimed at determining maximum torque which can be applied to various size knobs is in progress. (Worms, Goldsmith)

3. Equipment Review. The unit is often called upon to evaluate specific designs in terms of the ability of using troops to handle the equipment in the field. These evaluations may be comparative or absolute, and are usually accomplished by means of ad hoc experiments. (See list of published reports for examples.)

4. Systems Analysis. Although a complete man-machine system is considered in every task, some projects appear to be mainly concerned with the effect of several aspects of human performance on system output. The following are current tasks:

a. 3.5 inch Rocket System. Our investigation to determine the output of increasing ballistic accuracy, while decreasing aiming accuracy and time-to-fire, is being conducted. (Strauss)

b. An evaluation of the nature and extent of human errors in artillery accuracy in relation to ballistic and other errors is presently underway. (Strauss)

c. An experimental and analytical study of the effectiveness of anti-personnel mine fields in relation to distribution and visual detectability of mines is currently underway. (Peters)

d. An investigation of the ranging and aiming error of a small caliber weapon system is being conducted. (Strauss)

5. Miscellaneous Activities

a. Human engineering personnel consult with design engineers with regard to optimum design of specific equipment.

b. Effort is being devoted to monitoring the activities of a Human Engineering Laboratory Field Liaison Team. This team is presently performing a field usage survey on atomic weapons for this arsenal.

c. A Human Engineering Bulletin is published periodically to give designers needed technical information in digest form.

BIBLIOGRAPHY OF PUBLISHED REPORTS

PA Technical Report No. 2415 Visual detection of tripwires for anti-personnel mines (Peters, Drum) June 1957

TM No. 10 (U)	Nov. 1956. The analysis of human factors in weapon systems. C. T. Goldsmith
TM No. 11 (U)	Jan 1957. A human engineering evaluation of two safety band assemblies for Rocket Fuze M405. J. L. Seminara
TM No. 12 (C)	Feb 1957. Human Engineering recommendations for the design of the display of a mechanical interval timer. Drum.
TM No. 13 (U)	Feb 1957. Preliminary human engineering recommendations of the design of a timer and associated code wheel device. J. L. Seminara
TM No. 14 (S)	Mar 1957. Design recommendations for the XM77 Adaptation Kit. C. T. Goldsmith
TM No. 15 (S)	Apr 1957. Visual detection of gravel items. J. L. Seminara, G. A. Peters, C. T. Goldsmith

TM No. 16 (U)	Apr 1957. Methodological applications of human factors in operations research. G. A. Peters, C. T. Goldsmith
TM No. 17 (U)	May 1957. Detection thresholds for radioactive self-luminous panel markings at night. J. L. Seminara, C. T. Goldsmith
TM No. 18 (C)	Jun 1957. Sightless aiming of T48 (CLAYMORE) Mines. G. A. Peters, C. T. Goldsmith
TM No. 19 (U)	Jul 1957. Psychophysical investigation of thresholds for alphamerical characters backlighted by radioactive illuminants. N. L. Wright, J. L. Seminara
TM No. 20 (U)	Jul 1957. Ram loading of artillery ammunition by men: II. Experimental ramming. C. T. Goldsmith
TM No. 21 (U)	Jul 1957. Conversion of visible height cover functions to presented target area. G. A. Peters, Gross
TM No. 22 (U)	Jul 1957. Design recommendations for a Nuclear Timer and associated Scroll code device. J. L. Seminara
TM No. 23 (S)	In Press. Design recommendations for the XM86 Adaption Kit. J. L. Seminara
TM No. 24 (U)	In Press. Arming Torque in the T37E4 Mine. P. F. Worms
TM No. 25 (U)	In Press. An evaluation of opening devices for metal containers under arctic conditions. P. F. Worms, P. S. Strauss, G. A. Peters
TM No. 26 (U)	In Press. Human surface area: Estimate for the determination of the lethality of weapons. G. A. Peters, Gross
TM No. 27	In Press. Color coding of equipment design. G. A. Peters, C. T. Goldsmith

V. WATERTOWN ARSENAL

VITA

Ernst, Harry W. Ordnance Design Engineer

CURRENT PROJECTS

Human factors projects have been conducted in the design of the XM33 Launcher and presently on the Vigilante. Both of these projects are classified.

VI. U.S. ARMY ORDNANCE ARSENAL, REDSTONE, HUNTSVILLE, ALABAMA

VITA

Graham, Donald L., Jr., Technical Advisor, Field Protective Measures and Human Engineering, CE degree, Northwestern University, 1937

CURRENT PROJECTS

This arsenal has current and continuing human factors studies involved with the following guided missile projects. In brackets are the contractors or other groups having an active interest in such studies and funded by this arsenal directly or indirectly:

1. DART (Aerophysics Dev Corp - HEL)
2. LACROSSE (Martin Co - HEL)

3. SERGEANT (JPL - HEL)

4. HAWK (Raytheon Corp - Dunlap & Associates - HEL)

5. NIKE-AJAX & HERCULES (BTL - Douglas Aircraft)

6. TALOS (RCA)

VII. U.S. ARMY ORDNANCE ARSENAL, WATERVLIET, WATERVLIET, NEW YORK

VITA

DeTogni, Gino R., Ordnance Engineer (human factors), B.S. in Physics, Union College, 1951

CURRENT PROJECTS

1. VIGILANTE

2. Pivot Chamber

3. Environmental Studies

BIBLIOGRAPHY OF PUBLISHED REPORTS

ORDBG-4, Jan 57, Semi-Annual Report on Ordnance Engineering for Troop Operational Factors at Watervliet Arsenal; G. R. DeTogni.

Quarterly Report, July 1957, Environmental Test of Cannon Components; G. R. DeTogni.

ORDBG-4, Aug 57, Semi-Annual Report on Ordnance Engineering for Troop Operational Factors at Watervliet Arsenal; G. R. DeTogni.

Quarterly Report, July 57, Environmental Test of Cannon Components, G. R. DeTogni.

Quartermaster Research & Engineering Center, U. S. Army
Natick, Massachusetts

I. Vitae

II. Current Studies

III. Bibliography of Published Reports

I. VITAE

Allen, Vernon L., 1st. Lt., QMC, Human Factors Study Group, A. B. University of Alabama, 1955.

Burkhalter, Thomas H., 1st. Lt., QMC, Human Factors Study Group, M. A. Ohio State University, 1956. Area of specialization: Human factors problems in systems operations; engineering psychology.

Dusek, Dr. E. Ralph, Chief, Psychophysiology Section, Ph.D. State University of Iowa, 1951. Area of specialization: Physiological psychology, psychomotor performance.

Fine, Dr. Bernard J., Research Psychologist, Systems Research Section, Ph.D. Boston University, 1956. Area of specialization: Social psychology with emphasis on attitude change, personality and small groups.

Gaydos, Dr. Henry F., Chief, Human Engineering Section, Ph.D. University of Florida, 1953. Area of specialization: Engineering psychology, tactual-kinesthetic perception, apparatus design.

Haggard, Dr. Donald F., Research Psychologist, Psychophysiology Section, Ph.D. State University of Iowa, 1956. Area of specialization: Learning and perception.

Jones, Clarke E., Research Psychologist, Human Engineering Section, M.S. Pennsylvania State University, 1949. Area of specialization: Physiological psychology.

Klein, Dr. Richard M., Research Psychologist, Psychophysiology Section, Ph.D. Boston University, 1957. Area of specialization: Learning, perception, and thinking.

Kobrick, Dr. John L., Research Psychologist, Human Engineering Section, Ph.D. Pennsylvania State University, 1953. Area of specialization: Engineering psychology; apparatus design.

McGinnis, Dr. John M., Chief, Systems Research Section, Ph.D. Yale University, 1929. Area of specialization: Human factors components of systems design, troop attitudes and preferences.

Mendenhall, Robert L., Capt., QMC, Human Factors Study Group, M.S. Oklahoma A & M College, 1956.

Mills, Dr. Allen W., Psychologist, Ph.D. Harvard University, 1957. Area of specialization: Audition; physiological psychology.

Teichner, Dr. Warren H., Chief, Psychology Branch, Ph.D. State University of Iowa, 1951. Area of specialization: Perception, psychomotor performance, engineering psychology.

Wolf, William S., Capt., QMC, Chief, Human Factors Study Group, M.S. Univ. of Virginia, 1950. Area of specialization: Human factors problems in systems operations.

II. CURRENT STUDIES

A. Psychological and psychophysiological effects of environmental factors.

1. Manual dexterity as a function of temperature.
   Dusek, E. R. Started Oct. 1956 - Completed Sept. 1957.

The effects of exposing subjects to low ambient temperatures while they performed manual tasks requiring fine manipulation were studied. Data obtained with the Minnesota Rate of Manipulation Test, the O'Connor Finger Dexterity Test and the Purdue Pegboard Test indicate that manual tasks requiring finer finger dexterity and coordination are especially vulnerable to impairment under low ambient temperature conditions.

2. Skin temperature and pressure sensitivity.
Mills, A. W. Started Apr. 1957 - Completed Sept. 1957.

The effects of low ambient temperatures on the tactile sensitivity of the hand were studied. A preliminary experiment indicated that the minimum detectable pressure on the fingertip increases by a factor of 2 to 3 when the skin is lowered from normal to near freezing temperatures.

3. The relation between EEG amplitude and reaction time and EEG frequency and reaction time in sleeping subjects.
(Tufts University contract) Started Apr. 1956 - Completed Sept. 1957.

The purpose was to investigate the relationship of EEG variables of amplitude and frequency to the sleep-wakefulness continuum, using reaction time to a sound of constant intensity as the measure of depth of sleep.

4. General purpose scales for measuring subjective judgments of warmth and cold and some factors affecting them.
McGinnis, J. M. Started 1954 - Completed 1958.

The purpose was to develop a scale suitable for measuring judgments of subjective warmth and cold in the field or Climatic Chambers under a wide range of climatic conditions. A simple check list was developed and found suitable for group comparisons under various conditions of temperature, humidity, and windchill and for measuring the effects of various types and amounts of clothing, but it is not sufficiently reliable for individual comparisons. Data have been collected and partially analyzed.

5. Effect of distance of reach on tactual-kinesthetic judgment of size.
Gaydos, H. F. Started Apr. 1957 - Completed Nov. 1957.

The purpose was to study the changes in accuracy of tactual-kinesthetic judgment of size, using the method of limits, when the distance between standard and variable stimulus is varied in a horizontal line parallel to (a) the sagittal plane of the body, and (b) the frontal plane of the body. The data indicated that error of judgment increases as the distance between the variable and standard stimuli is increased. However, the error is greater when the stimuli are lined up parallel with the sagittal plane of the body.

6. Psychological factors related to sensitivity to climatic stress.
Haggard, D. F. and B. J. Fine. Started Mar. 1957 - Completed Dec. 1957.

Purpose was to determine the relationship between personality factors as measured by the Minnesota Multiphasic Personality Inventory and subjective judgments of feeling cold as measured by a rating scale. Data are being analyzed.

7. Subjective judgments as predictors of motor performance decrement under climatic stress.
Dusek, E. R., B. J. Fine and D. F. Haggard. Started Mar. 1957 - Completed Dec. 1957.

Purpose was to investigate the relationship between performance decrement in the cold as measured by the Minnesota Rate of Manipulation Test and individual sensitivity to cold when physiological responses such as skin temperature, internal temperature, and heat debt are controlled. Data are being analyzed.

8. The relationship between personality and patterns of finger cooling.
Haggard, D. F. and B. J. Fine. Started Mar. 1957 - Completed Dec. 1957.

Purpose was to investigate the relationship between personality as indicated by the nine scales of the Minnesota Multiphasic Personality Inventory and patterns of finger cooling during the cold pressor test. Data are being analyzed.

9. Genetic factors in subjective cold.
Haggard, D. F. and B. J. Fine. Started Mar. 1957 - Completed Dec. 1957.

Note:--Completion dates given are approximate estimates of the time when reports will be ready to submit for publication. Status of progress is shown as of 1 August 1957.

The differential responses to extreme environments by different racial groups were studied. Negro and white troops were subjected to the same low temperature environments and were required to rate their subjective feelings of cold intensity. Data are being analyzed.

10. Subjective aspects of wet-cold.
    Fine, B. J. Started Mar. 1957 - Completed Oct. 1957.

Purpose was to study the relationship between subjective feelings of coldness and dampness and the physiological responses such as skin temperature, internal temperature and heat debt when subjects were exposed to wet-cold environments. In distinguishing between the effects of different combinations of wind chill, temperature, and humidity, subjective estimates were as good as physiological measures.

11. Relationships between surface skin temperature points at different parts of the body.
    Teichner, W. H. Started May 1957 - Completed Sept. 1957.

The best estimate of the mean weighted skin temperature for the overall body surface is currently derived from the integration of ten separate temperature measurements of different areas of the body. However, the inconvenience of multi-thermocouple harnesses and the labor involved in data reduction make it desirable to attempt to achieve a close approximation of mean weighted skin temperature with fewer thermocouples. An "item analysis" of the ten contributing points indicates that the temperature of the inner thigh seems to follow the mean weighted skin temperature quite closely under various conditions of exposure.

12. Investigation of the characteristics of sounds critical for the aural detection of the enemy.
    (Ohio State University contract) Started Nov. 1956 - Completed Dec. 1957.

High fidelity tape recordings are being made of sounds made by troops in typical field combat maneuvers such as marching over different types of ground surface, advancing through brush, wading in water, etc. These recordings will be analyzed both for the physical properties of the sounds and certain patterns and combinations of noises that would aid in the detection of hostile troops who are attempting to approach in secrecy.

13. Effect on complex manual performance of cooling the body while maintaining the hands at normal temperatures.
    Gaydos, H. F. Started Aug. 1957 - Completed Dec. 1957.

Previous experimentation has shown that hand skin temperature seems to be the primary factor in efficiency of complex manual performance regardless of ambient temperature. The purpose of this study is to determine whether normal efficiency of manual performance can be maintained by keeping the hands warm even though the rest of the body is subjected to severe cold stress.

B. Effects of social and personal factors on soldiers' attitudes and preferences for clothing, personal equipment, and other supply needs.

1. Acceptability of C-rations under sub-arctic bivouac conditions.
   McGinnis, J. M. Started 1956 - Completed 1958.

The purpose was to determine the acceptability of C-rations in general and of specific component items under Sub-Arctic bivouac conditions. A few items were liked less well at the end of the bivouac period than at the beginning, some did not change in acceptability, and most items, including nearly all of the fruit and "sweets" items, were liked better at the end than at the beginning of the bivouac. The overall effect of the bivouac conditions was to strengthen the desire for food and to increase the acceptability of the rations, in spite of the rather monotonous nature of the diet. Data have been collected and analyzed and preparation of a report initiated.

2. The effect of induced prestige on acceptance of footwear.
   Fine, B. J. Started Mar. 1957 - Completed Sept. 1957.

Subjects' preferences for five unfamiliar experimental boots were measured both before and after the boots were identified as belonging to military organizations of high or low prestige value. It was hypothesized that high prestige labels would tend to raise the ratings and qualitative judgments while low prestige labels would have the opposite effect. The general hypothesis was not bourne out but there appears to be a relationship between personality and susceptibility to prestige suggestion.

3. QM human engineering handbook series: V. Criteria used by troops in evaluating QM clothing and equipment.
McGinnis, J. M. Started 1954 - Completed Sept. 1957.

The purpose of this handbook is to make available, in tabular form for easy reference, the relative frequency with which various criteria are used by soldiers in evaluating important families of Quartermaster items of field and garrison clothing and equipment, and to summarize the effects of climate and six major personal variables on the criteria employed. The handbook not only provides guidance to designers, but is also expected to be useful in planning studies involving soldier evaluation of new and standard Quartermaster items and in predicting soldier response to them.

4. Subjective evaluation of foot comfort.
McGinnis, J. M. - Completed 1958.

The purpose was to develop a technique for measuring subjective aspects of foot comfort. Adjectives and phrases considered to be descriptive of important aspects of foot confort were assigned comfort values by approximately 100 men using the method of equal-appearing-intervals and incorporated in a questionnaire designed to furnish both a general measure and a detailed analysis of subjective aspects of foot comfort. Initial validity studies include comparison of results following periods of rest with results following long hikes over hot desert terrain and by comparisons made following wear of boots known to differ in material and/or construction. Data have been collected and analyzed and a report is in preparation.

5. Investigation of differences in preference reactions of airborne and regular troops. (Psychological Research Associates contract) Started 1956 - Completed 1958.

Methods previously employed to determine criteria used by Artillery, Infantry, Ordnance, and Signal Corps troops in evaluating Quartermaster clothing and equipment are being applied to Airborne troops to determine whether or not they use significantly different criteria in evaluating these items than do other troops. Collection of data has begun and a final report is expected during the summer of 1958.

C. Human factors studies dealing with specific clothing and equipment problems.

1. Evaluation of factors in glove design affecting manual performance.
Dusek, E. R. Started Jan. 1957 - Completed Sept. 1957.

The effects of finger and back design of gloves on manual performance were evaluated with a series of dexterity tests. Preliminary analysis of results indicates that the reduction of the number of fingers in gloves leads to some deterioration of performance, but these effects may not be statistically significant. The different glove back designs used in this study did not materially affect performance.

2. Handbook of manual functioning. I: The anthropometry and biomechanics of the hand.
Jones, C. E. Started Nov. 1956 - Completed Dec. 1957.

This section is being prepared to gather together under one cover the tangible results of studies dealing with the anthropometric measurements, the structural form, and mechanical characteristics of the human hand. It is expected that this reference work will be useful to designers of manually operated equipment.

3. Handbook of manual functioning. II: The physiology of the hand.
Gaydos, H. F. Started June 1957 - Completed June 1958.

This section will present a survey of studies dealing with the physiological responses of the hand to temperature changes, prolonged muscular effort, restricted circulation, etc., and their subsequent effects on manual performance.

4. Relationships among several types of handwear and diameter of knob in accuracy of dial setting.
Kobrick, J. L. Started May 1957 - Completed Oct. 1957.

Subjects practiced making settings on a series of ten dials for 20 trials with the bulkiest of four glove ensembles in order to regularize fluctuations in performance due to improvement with practice. Each subject thereafter performed five trials on the same task wearing each of four standard glove ensembles and with the bare hand. This procedure was used for five different knob diameters with each fifth of the subject population receiving only one of the knob diameters. Data are being analyzed.

5. Hand and finger function in relation to varying conditions of the hand.
   (State University of Iowa contract) Started Nov. 1955 - Completed Nov. 1957.

The purpose of this study is to determine the precision of finger manipulation in terms of exactness in patterns of finger movement and application of force as affected by hand fatigue, reduced circulation, trained relaxation, prolonged extension, sustained effort and kinesthetic acuity of the hands. Data are being analyzed.

6. The measurements of the size and force of the foot with reference to fatigue problems.
   (State University of Iowa contract) Started Apr. 1955 - Completed Aug. 1958.

Purpose is to study the effects of fatigue on the strength of the foot. Anthropometric data is being collected on the foot in weight bearing and non-weight bearing positions. Results of this study will be used to evaluate experimental footgear.

III. BIBLIOGRAPHY OF PUBLISHED REPORTS

Allen, V. L. Hand dexterity requirements for the Nike missile system. EPRD Res. Study Rept. PB-9, 1957.

Allen, V. L. and J. M. McGinnis. Subjective evaluation of the Schwartz principle in Army combat boots. EPRD Res. Study Rept. PB-8, 1957.

Dusek, E. R. Effects of temperature on manual dexterity. NRC Subcommittee on Environmental Protection Symposium on Hand Functions in the Cold. In press.

Dusek, E. R., W. H. Teichner and J. L. Kobrick. The relationship between arm-hand steadiness and the position of the extended arm and hand in the median plane. QM R&E Tech. Rept. In press.

Fine, B. J. and D. F. Haggard. Contextual effects in scaling. EPRD Res. Study Rept. PB-13, 1957.

Fox, K. (State Univ. of Iowa, Dr. M. Gladys Scott, Director) The effect of clothing on certain measures of strength of the upper extremities. QM R&D Comd. Tech. Rept. EP-47, In press.

Gaydos, H. F. Intersensory transfer in the discrimination of form. Amer. J. Psychol., 1956, 69, 107-110.

Gaydos, H. F. and E. R. Dusek. Effect of localized cooling of the hands versus total body cooling on performance of a complex manual task. QM R&E Command Tech. Rept. In press.

Gregg, L. W. (Carnegie Inst. of Technology) Changes in the distribution of muscular tension during psychomotor performance. QM R&D Comd. Tech. Rept. EP-50, 1957.

Kobrick, J. L. QM human engineering handbook series: II. Dimensions of the upper limit of gloved hand size. QM R&D Comd. Tech. Rept. EP-41, December 1956.

Kobrick, J. L. QM human engineering handbook series: III. Dimensions of the lower limit of gloved hand size. QM R&D Comd. Tech. Rept. EP-43, 1957.

Kobrick, J. L. QM human engineering handbook series: IV. Dimensions of the lower limit of body size of the Arctic soldier. QM R&D Comd. Tech. Rept. EP-51, In press.

Kobrick, J. L. An apparatus for measuring reaction time during induced muscular tension. QM R&D Comd. Tech. Rept. EP-50, In press.

McGinnis, J. M. Effectiveness of cold weather face masks. QM R&D Comd. Tech. Rept. EP-60, In press.

McKee, M. E. (State Univ. of Iowa, Dr. M. Gladys Scott, Director) The effect of clothing on the speed of movement in the upper extremity. QM R&D Comd. Tech. Rept. EP-48, In press.

Mills, A. W. Finger numbness and skin temperature. J. appl. Physiol., 1956, 9, 447-450.

Mills, A. W. Tactile sensitivity in the cold. NRC Subcommittee on Environmental Protection Symposium on Hand Functions in the Cold. In press.

Mills, A. W. Acoustic properties of the combat vehicle crewman's helmet. EPRD Res. Study. PB-7, 1956.

Nicoloff, C. (State Univ. of Iowa, Dr. M. Gladys Scott, Director) Effects of clothing on range of motion in the arm and shoulder girdle. QM R&D Comd. Tech. Rept. EP-49, In press.

Teichner, W. H., J. L. Kobrick and E. R. Dusek. Effects of Target separation and distance on commonplace binocular depth discrimination. J. Opt. Soc. Amer., 1956, 46, 122-125.

Teichner, W. H. and J. L. Kobrick. Effects of viewing distance with the Howard-Dolman apparatus. J. Opt. Soc. Amer., 1956, 46, 837-840.

Teichner, W. H. Reaction time in the cold. J. appl. Psychol. Accepted for publication.

Teichner, W. H. Manual dexterity in the cold. J. appl. Physiol. Accepted for publication.

Teichner, W. H. Effects of foreperiod, induced muscular tension and stimulus regularity on simple reaction time. J. exp. Psychol., 1957, 53, 277-284.

Teichner, W. H. Cutaneous discrimination of radiant heat. J. exp. psychol., 1957, 53, In press.

Wolf, W. S. Operational analysis of the rough-terrain fork lift truck. QM R&D Comd. Tech. Rept. EP-42, January 1957.

Wolf, W. S., V. L. Allen and T. H. Burkhalter. Operational analysis of protective clothing for guided missile propellant handlers (cold weather phase). EPRD Res. Study Rept. PB-10, 1957.

Wolf, W. S., V. L. Allen and T. H. Burkhalter. Operational analysis of guided missile propellant handlers. EPRD Res. Study Rept. PB-12, 1957.

U. S. ARMY SIGNAL CORPS ENGINEERING LABORATORIES

Fort Monmouth, New Jersey

I. Vitae

II. Current Projects

III. Bibliography of Published Reports

I. VITAE

Griffith, Paul E., Electronic Engineer
BA Carleton College, 1929. Area of Specialization: Communications.

Huebner, Daniel L., Engineering Psychologist
MA The New School for Social Research, 1955. Area of Specialization: Perception.

II. CURRENT PROJECTS

Contract No.	Contractor	Duration
DA-36-039 sc-52648	New York University, College of Engineering	1 July 57 - 30 June 58

Task assignment type contract for performance of human engineering and psychological studies concerning the design of systems being developed for antiaircraft defense. Task assignments classified.

DA-39-039 sc-73253	Dunlap & Associates, Inc	1 Aug 57 - 31 July 58

Task assignment type contract for performance of human engineering studies of equipment and systems. No tasks yet assigned.

DRAFT--For Review & Comment Only

(Reference Signal Corps presentation, page 41)

HUMAN FACTORS ENGINEERING FOR SIGNAL CORPS EQUIPMENT

1. SCOPE

1.1 This Specification covers human factors engineering for Signal Corps equipment. It outlines some techniques and procedures of human factors engineering for use in the design and development of signal equipment and systems. The objective of this Specification is to facilitate the military mission of Signal Corps systems through maximum utilization of the potentialities of the human component of man-machine systems. Consideration is given to operator inputs, environmental conditions, task conditions and operator outputs in terms of overall man-machine system requirements. This includes optimum man versus machine function allocation, minimization of error-producing operator inputs, reduction of conditions producing fatigue and boredom, and simplification of operational requirements.

2. APPLICABLE DOCUMENTS

2.1 The following publications are furnished for information and guidance purposes only:

1. Procedures for including Human Engineering Factors in the Development of Weapons Systems. WADC Technical Report 56-488. AD 79305.

2. Human Engineering Guide for Equipment Designers. Woodson, W. E., University of Calif. Press, Berkeley, 195?. (Copies of publications required by contractors in connection with specific procurement functions may be obtained from or as directed by the contracting officer. Both title and identifying number or symbol should be stipulated when requesting copies.)

3. REQUIREMENTS

3.1 Definition. Human factors engineering is herein defined as the application of human factors principles, techniques and data to the planning and development of military systems, equipment and components. Its objective is to improve and maximize the field operability of man-machine systems, particularly with respect to human factors problems involving speed and accuracy of operation, operational reliability, safety, minimization of operator training and skill requirements, and operation under conditions of stress. Operation is here meant to include all human functions that involve man-machine interaction, at all levels of man-machine system operation, whether involving control, monitoring, installation or maintenance.

3.2 Application of Human Factors Engineering. Illustrative design problems in which human factors engineering is applicable include the following:

1. Operator workload
2. Installation
3. Work space layout
4. Working environment
5. Control units and systems
6. Displays
7. Safety of operation
8. Communication in nets

3.3 Human Factors Engineering in Relation to Development Phases. Table I lists some human engineering considerations and indicates the stage of development at which these considerations are appropriately applied.

TABLE I.

Development Phases	Human Engineering Considerations
1. Preparation of military requirements and characteristics	A. Liaison
2. Design study	B. The Analysis and Allocation of Man-machine Functions Participation in functional analysis Operator decision analysis Allocation of man functions--duties, skills, level of education and training. Human capabilities and limitations Sensory and motor functions Stress--fatigue Morale--motivation Communications Coding, visual, aural, etc.
3. Experimental Phase	C. The Planning of Operational Tasks Operational Planning Link-value layout analysis Pencil and paper mock-ups Consideration of operator training and skills Operational breadboards Operator safety requirements Environmental design--temperature, humidity, noise vibration, shock, dust, illumination, etc.
4. Design Phase	D. The Design of Display and Control Functions Design of Displays and controls "Knobs and dials" Standardization Check Lists Design of operator position Operating instruction Operator classification
5. Evaluation of development model; fabrication and testing of prototype	E. Equipment Evaluation Feedback to design phases

The above table is not intended as a complete presentation of the development phases, but only as an approximation of the relationship of main phases of human factors engineering to the development cycle. The table is intended to indicate the possibilities for integration of human factors engineering into the development cycle.

3.3.1 The scope of the human engineering effort shall be appropriate to the magnitude of the human factors problems involved in the subject equipment design. This shall be interpreted and decided by the USASEL engineers cognizant of the equipment specification, with the corroboration of the USASEL human engineering coordinator. Omission of the human factors engineering requirements of this specification shall be contingent upon demonstration of the omission of the human operator as a link in the subject system, both within the system and as an output link. Most design and development applications will require some phase of the above human engineering activities B, C, and D, that is, the analysis and allocation of functions, the planning of operational tasks, and the design of display and control functions. Some applications will require all five phases. As a minimum, prompt consideration shall be given to the extent of applicability, if any, of the five phases to insure appropriately early integration of human engineering principles into design planning.

3.4 Techniques. Certain human engineering considerations require special attention during early design phases. The employment of the following techniques, when applicable, will help insure the incorporation of design factors involving human performance at stages early enough to obviate to necessity for uneconomic later changes in design.

3.4.1 Man-machine System Analysis. This includes analysis of the relationship of the human operator to the equipment under consideration. The interactions of this relationship define a man-machine system. Operator inputs and outputs are specified in terms of time and accuracy requirements in relation to both equipment and system-time and accuracy requirements. This serves to permit allocation of system functions, such that functions most efficiently performed by machine will not be assigned to human beings, and that functions most efficiently performed by the human operator will be assigned to him, rather than to the machine. This approach requires consideration of the man-machine system as an operational whole in terms of its performance under field conditions.

3.4.2 Operation Decision Analysis. This involves the techniques of stipulating the decisions to be made by each operator in a system. In major systems, mathematical models such as provided by Operations Research techniques may be required. In any case, decision analysis is necessary to equalize requirements for decisions from the various operators, to avoid possible overloading. Decision analysis is also necessary to provide data as to informational inputs required to each operator to enable him to make optimal decisions in a minimum of time. This technique can produce most gain in effectiveness and simplicity of operation when integrated with equipment design planning at early design stages.

3.4.3 Information Analysis. This is the technique in which the operator is considered as an information-handling link in a man-machine system. As a channel having limited informational handling capacities, the operator has certain maximum and minimum input requirements and output capabilities. This approach calls for careful stipulation of sensory inputs and their perceptual organization with respect to output response requirements of the man-machine system. Sensitivities, rate-handling capabilities, environmental interactions and resultant error variances of the man and machine portions of the system are estimated from mock-ups and breadboards, and are adjusted to provide for optimum utilization of the potentialities of both man and machine. Control and display error variances shall be estimated at early stages, in order that operational accuracies not be beyond capabilities of the operator to utilize them. That is, machine and operator error variances shall be proportional.

3.4.4 Link-value Layout Analysis. This is a technique applicable to man-machine and man-man links. It may be used in planning information flow, in laying out work places, and in designing control and display panels and consoles. The importance and frequency of sequential operational sub-tasks are ranked, and total link lengths and interferences are minimized by proper positioning of men, machines and components according to the ranking criteria.

3.4.5 The Use of Mock-Ups. The use of mock-ups in human factors engineering is analogous to the use of breadboard circuits in electronics. They are used to test preliminary designs, and to get performance data for prediction of system performance. The mock-ups may be functioning or non-functioning models, or may be drawings which are two dimensionally scaled. In some cases they may be mathematical models. They may be used for testing sequence of operation, speed of operation, legibility, etc., as well as for comparing alternate design possibilities.

3.4.6 Consideration of The Effects of Stress upon Operation. Great variation in operator performance can be expected under varying conditions of stress. Although almost every operational situation will have some degree of stress associated with it, in particular instances it may be found that the stress conditions likely to be encountered can significantly affect human performance. To achieve the design of man-machine system capable of adequate performance under such conditions, it is essential that consideration be given to possible sources of stress and their effects at an early design phase.

3.4.7 The foregoing techniques are not to be considered as all-inclusive. Other techniques such as time and motion study are importantly associated with these considerations. Not all of the six items may be applicable to a given design.

3.5 Human Factors Engineering Procedures. Operational parameters shall be expressed wherever possible, in terms of explicit quantified values of accuracy, speed, training requirements, portability, time duration of operation, etc., depending upon the specified mission of the system. These requirements shall be so applied as to make fullest possible use of human capabilities in interaction with machine characteristics, operating in a particular system environment.

3.5.1 Man as a Date Processing System. It is required, when considering operational work loads, to consider the operator as an information processing unit having a finite, specifiable capacity. He serves to provide decision or manual control functions in combination. He is subject to input and output handling rate limitations. He is subject to environmental conditions. He is also capable of handling large processing loads if optimally employed. It shall be demonstrated that the operator is optimally employed to the extent that freedom of design permits in the system under development. Total work loads shall not be excessive nor far under capabilities of the operator. Allowance may be made for reasonable short time overloads and underloads, but overload and idle times shall be realistic values.

3.5.2 Operational Environment. Conditions of the operational environment shall be specified to a degree sufficient to insure reasonable expectation of field operation in accordance with military requirements. All design shall be considered in light of actual field operational conditions, as operated by personnel of appropriate level of training, considering wherever applicable, the effects of stress and environmental conditions. For example, if readout accuracy of an indicator is being evaluated, readout time shall be based upon the assumption that the operator has no prior knowledge of the appropriate reading, unless he would be provided this knowledge in the particular operational situation. Likewise, if operability of units is being compared, overtraining of operators shall be prerequisite. If ease of learning of a unit is being evaluated, appropriately chosen untrained operators shall be employ d.

3.6 Reports.

3.6.1 Information concerning the human factors effort shall be incorporated in reports otherwise required by the equipment specification. Except for the Design Plan, specified below, no additional reports with respect to human factors engineering will be required.

3.6.2 Reports shall include, wherever applicable, specification of operational time and accuracy capabilities of designs.

3.6.3 Reports shall, wherever possible, include data showing estimated times for equipment installation, for operation, and for organizational maintenance.

3.7 Human Factors Design Plan. A design plan shall be submitted during the design planning stage demonstrating inclusion of the following, when applicable, into an integrated plan for a man-machine system.

3.7.1 A Description of Operational Function. The design plan shall include a statement of operational function describing, in terms of operational requirements, human factors considerations of the projected system or equipment in its operational environment, and in relation to operationally associated systems or equipment.

3.7.2 Stipulation of Input and Output Requirements.

1. The design plan shall include a stipulation of inputs and outputs of the man-machine system, indicating actions and information required at both sources and sinks in terms of task requirements of paragraph 3.7.2.3 below.

2. The design plan shall include a stipulation of both operator inputs and operator outputs, indicating actions and information required at both sources and sinks in terms of task requirements of paragraph 3.7.2.3 below.

3. Task requirements include the following:

Rate and duty-cycle for information and actions
Accuracy of performance, both instrumental and operator, expressed in percent and absolute terms.
Speed of operation
Decision making
Computation
Tracking
Near-threshold detection
Operation under stress
Interference problems
Operation under temporary overload

3.7.3 Operational Environment. The operational environment of the projected system shall be stipulated, indicating integration of the following considerations into an effective man-machine system.

Number of operators
Other duties of operators
Workspace conditions, field or sheltered
Climatic conditions, natural or man-made
Maintenance accessibility considerations

3.7.4 Instrumentation. Instrumentation design considerations, such as the following, shall be demonstrated to be in accord with requirements indicated in paragraphs 3.7.1, 3.7.2, and 3.7.3 above.

Displays
Control
Lighting
Seating
Temperature
Work-space Layout

3.7.5 Design Plan criteria. Criteria for application of above design plan considerations shall be the optimum use of operator capabilities and the simplification of operational tasks, with the objective of maximizing man-machine system effectiveness with respect to both military requirements and net cost of equipment and manpower.

III. BIBLIOGRAPHY OF PUBLISHED REPORTS

Contract DA-36-039 sc-64647 with Dunlap and Associates, Inc., produced the following reports since the last conference:

Task .08--May 1957. Detection of Aircraft by Radars Subjected to Radio Interference.

Task .09--April 1957. Human Engineering Study of Operating Times for Collection and Reduction of Meterological Data.

Task .10--June 1957. Human Engineering Review of the Landing Assist Radar AN/FPN-32.

KODAK SAFETY FILM

U. S. Army Chemical Corps Research and Development Command
Chemical Warfare Laboratories
Army Chemical Center, Maryland

I. Vitae

II. Current Studies

III. Bibliography of Published Reports

I. VITAE

Davy, Dr. Earl, Chief, Psychology and Human Engineering Branch
PhD, Columbia University, 1952. Area of specialization: Physiological Psychology.

Kolovos, Dr. Ernest R., Physiologist, Captain, MSC
PhD, University of Pittsburg, 1952. Area of specialization: Physiological Psychology.

Goldberg, Marvin N., Biological Sciences Assistant, SP3, United States Army
MA, University California, Los Angeles, 1953. Area of specialization: Physiology.

Roberts, Albert P., Social Sciences Assistant, PFC, United States Army
BA, Queens College, 1953. Area of specialization: Experimental Psychology.

Blanton, James E., Social Sciences Assistant, PFC, United States Army
BA, University of Maryland, 1956. Area of specialization: Psychology.

Shelly, Leon B., Mathematics and Statistics Assistant, PFC, United States Army
BS, Central Michigan College, 1956. Area of specialization: Mathematics and Industrial Arts.

II. CURRENT PROJECTS

A. Directorate of Medical Research	Date Started	Estimated Completion Date
1. The effects of GB in Sublethal Concentrations on Human Behavior	Oct 56	Mar 58

The objective is to ascertain the anticipated reactions and behavior of personnel who might be subjected to low concentrations of GB and what effect this might have on the conduct of prescribed duties of these personnel under these conditions. A second task involves the effects of wearing a gas mask and other types of protective equipment upon the proficiency of troops engaged in standard military activities.

2. Human Factors Engineering Aspects in Design of Field Protective Masks	Jul 56	Jan 58

The Chemical Corps field protective mask of current standard issue is designated as the M9A1. This mask has, on one side of the facepiece, a canister for the purpose of filtering particles of toxic material from the atmosphere before that atmosphere reaches the oral-nasal tract of the wearer. During the past two years the U. S. Army Chemical Warfare Laboratories (CWL) at the Army Chemical Center has developed a new mask now known as the E13. In this mask the side canister has been replaced by two charcoal filters, one on either side of the facepiece.

The M9A1 mask offers a rather high resistance to breathing upon inhalation, thus resulting in user fatigue beyond the extent which would normally result from participation in any given activity. In the E13 mask this resistance has been cut approximately in half. To overcome the interference with speech and the resulting lack of intelligible communication caused by the design of the M9A1, a voiceemitter has been included in the facepiece of the E13. Other innovations incorporated in the E13 include an eyepiece construction which affords wider angle visibility than that of the standard mask. Last June, during the time that the new mask was being tested for leakage, durability, usability in cold environments, etc., we became concerned with finding out how our troops would feel about this mask. We decided to obtain this information at the same time that field tests were being conducted to determine the extent of direct interference of the mask with the execution of typical military tasks such as rifle firing, rocket launching, etc. For these tests fifty masks of each type (M9A1 and E13) were taken to the Dugway Proving Ground near Salt Lake City, Utah. The proving grounds cover a rather large area in the western part of the state and the terrain includes desert and salt flats as well as some rugged areas of the Wasatch range. Before the tests, fifty troops were selected and fitted with one of each type of mask. Each man was shown and allowed to practice the proper method of wearing and carrying both masks. Tests included marching over hill and desert terrain, competitive softball and volleyball, resting in recreation areas, use of weapons, donning mask on signal during a simulated chemical warfare attack, etc.

Wherever possible, half of the subjects wore one mask and half wore the other during the tests. Half way through the tests each subject changed the mask he was wearing. Wherever applicable, the proficiency of task performance, in terms of proper and rapid completion, accuracy, etc., was objectively evaluated by military observers.

3. There are other classified human engineering tasks being conducted by the Chemical Corps which cannot be listed.

III. BIBLIOGRAPHY OF PUBLISHED REPORT

1 April 1957. Some Human Engineering Aspects of the Portable Flame Thrower Gun. Earl Davy.

UNCLASSIFIED

UNCLASSIFIED