Behavioral Science in the Army

A Corporate History of the Army Research Institute

Joseph Zeidner
Arthur J. Drucker

United States Army Research Institute
for the Behavioral and Social Sciences

Printed June 1988

Table of Contents

LIST OF TABLES

LIST OF ILLUSTRATIONS

Foreword

The Corporate History was begun in September 1982 and completed in March 1983. The purpose of this foreword is to note the important scientific developments and progress that have taken place during the four-and-a-half-year interval between the writing and publication.

The research and development (R&D) program strives to increase its responsiveness to the real and important challenges facing the Army. Increasingly, as the Army's principal center for research on the human component in Army activities and systems, the Army Research Institute has continued to expand its study of behavioral science. Military sociology, economics, demographics, and political science have a larger role in the program than was true half a decade ago, and augment the more traditional disciplines such as mental measurement, mathematics, computer science, and psychology. The five R&D areas enumerated and outlined in chapter 7 still serve as the general framework for the applied program: Structure and Equip the Force; Man the Force; Train the Force; Develop the Force; and Maintain Force Readiness. The four endeavors discussed below are representative of current and projected R&D efforts that will, it is hoped, have a positive and lasting impact on Army doctrine, procedures, and policy.

First, "personnel affordability" continues to be the Army's foremost soldier-related problem. How can the Army develop or acquire systems with exorbitant manpower requirements, systems that require personnel with skills largely unavailable in the Army, or systems that are dangerous to train or difficult to operate? At the individual-soldier level the question asked is, "Can this soldier, with this training, perform these tasks on this equipment?" MANPRINT research (integrating manpower and training considerations in the system acquisition process) is designed to ensure that human performance issues are carefully and fully addressed during the development and acquisition of new systems in an effort to ensure that total system performance will be optimized.

MANPRINT R&D has multiple roles: (1) to prove data for estimating human performance, manpower, personnel, and training (HMPT) requirements in new systems design (specifically, basic data on human performance in personnel subsystems); and (2) to develop innovative, refined analytic tools and techniques for making such HMPT determinations. MANPRINT is an offshoot of the concept of reverse engineering of selected weapon systems, addressed by ARI in a precursory effort.

Second, units perform well if leaders motivate the troops and instill a sense of unit cohesion. Maintaining unit integrity in the face of the stresses of combat is largely a function of the bonding of soldiers to each other, the quality of leadership received, and soldiers' dedication to Army goals and values, and to their units. In fact, the difference between winning and losing battles is often the "esprit de corps" (cohesion and commitment) of the units involved. A comprehensive leadership research program at ARI emphasizes creating measures to assess the level of unit cohesion, evaluating relationships between cohesion and unit performance, and developing methods to increase cohesion. The ultimate objectives are to enhance combat group performance and unit effectiveness, and increase readiness.

Third, the Army mission and its necessary organizational policies produce a pattern of demands on soldiers and their families that is different from the demands and lifestyles of nonmilitary families. Can an Army/Army family partnership be achieved in a large volunteer Army with increased numbers of married personnel? (Most service members in today's Army are married and, at any given age, soldiers are more likely to be married than their civilian counterparts.) The answer to this question must take into account the many changes affecting family patterns and gender roles in general. Recently there has been a lessening of the sense of community and the informal networks of supportive social relationships in the Army. The recent Army Family Action Plan (resulting from a real concern for these problems) has delineated a comprehensive family R&D program: demographic analyses of Army families, determination of the relationships between Army families and soldier retention and readiness, and, eventually, development of methods for fostering partnership and a sense of community. The Army hopes that this program will lead to techniques for building family "wellness," a sense of community, and hopes to acquire information on the relationship of family variables and programs to retention and readiness—information necessary for practical policy making and more efficient allocation of resources.

Finally, when not fighting, the Army's most important business is training. General J. A. Wickham, the Chief of Staff in 1987, has emphasized that "We need to develop a comprehensive set of plans, programs, and policies which will strengthen leadership from the squad, crew, and section level to the headquarters of the Army . . . ." Earlier R&D on the measurement of unit combat effectiveness has been frustrated by the infinite variability of conditions of actual or realistically simulated combat, difficulties in observing and measuring unit performance, and the lack of clearly specified standards for mission success tied to established doctrine. The National Training Center (NTC) offers a relatively controlled, partially standardized environment in which the critical tactical missions are trained. Researchers are thereby offered a key for designing performance and effectiveness measurement systems by enabling different units to be evaluated while performing on closely similar missions under comparable conditions. Measurement systems currently under development and validation focus on performance for the 10 most important NTC missions of platoon, company, and battalion task force levels.

Further administrative and organizational changes have taken place. Dr. E. M. Johnson has replaced the senior author as Technical Director and Col. Wm. Darryl Henderson has replaced Col. L. Neale Cosby as Commander of ARI. The three Associate Directors, who also head three laboratories, are Dr. N. K. Eaton (Manpower and Personnel Research), Dr. R. L. Keesee (Systems Research), and Dr. J. H. Hiller (Training Research).

These three laboratories and a basic research office carry out ARI research. Three scientific coordination offices at major commands report to the Technical Director. Offices at the U.S. Army Training and Doctrine Command (TRADOC) and at U.S. Army Europe (USAREUR) coordinate ARI's research with these combined groups. ARI's Director of Basic Research oversees a scientic coordination office in London. Five scientific coordination officers in the United States report to the laboratories, provide two-way channels for research ideas and efforts, and perform liaison activities for management groups in the field and for the laboratories.

Joseph Zeidner
Arthur J. Drucker

Preface

The Army Research Institute for the Behavioral and Social Sciences (ARI) has been in continuous existence since the spring of 1939. Its historical antecedents go back even further, however, to America's entry into World War I. We, the authors, have been intimately associated with this history from 1950 through 1982 as members of the ARI professional staff, one of us having risen from bench scientist in 1950 to Technical Director of ARI and Chief Psychologist of the U.S. Army in 1978, the other starting as a Senior Researcher in 1951 and eventually heading the planning and programming activity of the organization for more than 15 years.

When we were asked to consider writing a history of ARI, our first thought was to ask ourselves, What is the value of a history of any organization, let alone that of ARI? We found a satisfactory answer to the first question in an article by Smith and Steadman, "The Present Value of Corporate History," *Harvard Business School Review*, November—December 1981. Smith and Steadman maintained that corporations or organizations typically accumulate, through the years, beneficial ways of doing things; but they may also become unable to adapt tried methods during periods of change. At such times, managers would do well to look at relevant historical precedents within an organization to find out how it adapted to similar situations in the past.

A corporate history can also be useful as a diagnostic tool and as a way of calling up moments from the past to motivate employees of the present. A company's history contains its heritage and traditions, which managers need to understand if they in turn are to understand the present as a process rather than as an aggregate of happenings.

We thus became convinced of the present value of a history of ARI. We felt that a more systematic and comprehensive account of the organization and its research activities was needed because of its long record of contributions to theory and methodology and its continuing influence on the field.

Our readers can recall, no doubt, many notable moments from psychology's long and rich heritage. One of our favorites is centuries old. Plato, in his

Republic, provided us with one of the earliest written accounts of employing individual differences. He proposed a series of "actions to perform" for use as tests of military aptitude, since "no two persons are born alike, but each differs from each in natural endowments, one being suited for one occupation and another for another." More recently we like Frederick Taylor's pioneering research in the early 1900s and his four basic principles governing people in the workplace: "the scientific selection and progressive development of workmen"; the deliberate gathering of knowledge to find "the one best way" for performing each job; the need for incentives for motivating workers; and the functional division of tasks between management and workers. Taylor's *Principles of Scientific Management* focused on areas of research that concern psychologists today. We would consider our account successful if we could leave each reader with a favorite memory—a concept or effort or commitment, from among five decades of ARI research, that continues to influence research today.

In writing this history, we had three main objectives. First, we tried to highlight ARI's research agenda through the decades, its research accomplishments and their implications for future research, especially into the year 2000. Second, we tried to portray research in the context of the history of the period in which it was being carried out, emphasizing the military's technological environment and the changing needs of the times. At the same time, we outlined some areas of research interest in academia and industry. Third, we tried to provide an organizational account—the structure and management of research and relations with Army proponents. We include lists of scientists who had been or are now employed by ARI and of Army leaders who played key roles; to complete the military/scientific perspectives of this history, we provided descriptions of research accomplished by sister laboratories in the Army and in the other services.

In preparing this history, we were aided immeasurably by the following people: L. Neale Cosby, Edgar M. Johnson, and Frank J. Harris of ARI; Abraham H. Birnbaum and Emma E. Brown, ARI alumni of long service, whose reviews kept us on the right track; Mattie F. Hopkins of the publication staff of ARI for graciously making available all the documents we asked for; Andrea DeLaGarza of Editorial Experts, Inc., for her editorial assistance; Jean Lee, Inga Jackman, and Debbie Leon of ARI for their draft typing assistance; and members of George Washington University and ARI staffs for their constant encouragement.

Joseph Zeidner
Arthur J. Drucker

Introduction

The Army's Soldier-Related Research Organization

The Army Research Institute Today

As one of a half-dozen major military behavioral science organizations supporting the U.S. Army, Navy, and Air Force, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) exerts a large influence on the field of psychology. (For a complete listing of behavioral science laboratories and organizations, see Appendix A.) As of January 1983, ARI employed about 300 scientists and military professionals, who were assisted by 100 administrative and technical support personnel. Included among the 300 professionals are 190 psychologists and 70 scientific personnel of other disciplines. ARI's assigned mission is to maximize combat effectiveness through research in the acquisition, development, training, and utilization of soldiers in military systems; to that end, it conducts basic, exploratory, and advanced research and development. Applying state-of-the-art concepts and methods of the behavioral and social sciences, ARI's staff helps solve current people-related Army problems and makes future problems more manageable.

Complementing the headquarters and research center in Alexandria, Virginia, are 10 field units, each located at an Army installation (one overseas) and affiliated with the local Army command (see Appendix B). Scientific Coordination Offices are based at the Forces Command in Atlanta, Georgia; at the Training and Doctrine Command in Hampton, Virginia; and in London, England.

ARI spends about half of its direct budget of about $40 million (fiscal year 1983) on contracts with universities, industry, and other research and development organizations. The research produced both by ARI's in-house staff and ARI contractors is published in professional journals and presented at meetings of dozens of professional societies. Consequently, ARI's research direction, program, and publications influence the activities of the many universities and organizations under contract to it. ARI has a large aggregate impact on the field today, both in terms of its size and of the dollars spent on research;

to the best of our knowledge, it is the largest employer of research psychologists in the world.

The research lineage of ARI can be readily traced back to the development and administration of the Army's Alpha and Beta tests during World War I, to the testing of more than 9 million soldiers on the Army General Classification Test (AGCT) during World War II, to differential classification during the 1950s, to computer-based training in the 1960s, to human factors and social issues in the 1970s, and to microelectronics applications in the 1980s. While this ancestral tracing may appear to be self-serving, we think it attests to the dynamic accumulation of past research and decisions that have abiding significance for present and future psychological research.

Purpose of This History

We think that the value of an ARI history lies first in understanding the psychological theory and trends surrounding the beginnings of applied psychology, particularly in the military, and in gaining a better understanding of people at work. For example, nowhere but at ARI could one find such a rich data bank of job-related validity studies of ability measures. Analyzing these validity data, Army psychologists have been in the midst of the controversy about the structure and nature of intelligence since the early days of Army Alpha and Beta testing. Over the years ARI has consistently dealt with problems of contemporary society, and thus its history has some importance for behavioral science historians.

We also believe that this history will help ARI make good use of its traditions. Through such study and analysis, we should understand better that ARI's heritage is broad enough to support multiple traditions, any one of which can be brought to the surface of organizational consciousness as needed. How may we manage with integrity the changes required without disrupting continuous research operations? We think this long history and deep-seated traditions can help ARI stay true to itself. Those traditions can guide the organization as it enters the technologically explosive world of the 1980s and let its managers know that the organization survived risky and ephemeral beginnings in poorly defined environments. Managers may then optimistically approach new psychological technologies.

Finally, the broad purpose of this history is to develop a guide for management and employee development for research managers, planners, programmers, and developers today and in the future.

Applications

The uses of a corporate history are diverse. They can enhance the conduct of specific corporate activities, ranging from planning to implementation

and from personnel management to individual development. This history will be of specific value to ARI in the following ways: planning (to ensure that assumptions about the past and present are correctly based); developing management (to provide managers with experience and knowledge of the Institute that are larger than their own); developing proponent acceptance (to help differentiate Institute roles from the roles of other military organizations and to enhance understanding); recruiting and orienting employees (to provide an accessible account that considers key aspects of Institute history); and conducting public affairs (to provide background and context for policies and behavior to lead to more informed public policies and to enhance public understanding of the organization and its mission).

This history, then, can serve a number of different groups: psychologists with a general interest in the history of psychology; scientists with a special interest in areas of emphasis within ARI (such as selection, classification, training, soldier-machine interface, leadership, and microelectronic applications); ARI managers and employees; and proponents and sponsors whose informed involvement is needed in ARI research.

Part 1

Research during the World Wars

Chapter 1

Origins of Applied Psychology in the Military, 1917–1919

Modern military psychology began with the work of Alfred Binet in the early 1900s. His intelligence scale provided the impetus for the ability testing movement. Use of employment tests by government and industry followed and led to testing in the Army during World War I. Robert Yerkes, generally acknowledged as the father of military psychology, experienced both success and frustration in dealing with the Army from 1917 to 1919. One of his biggest successes was obtaining authorization for 130 officer psychologists (nearly 40 percent of the membership of the American Psychological Association in 1917). But he also endured three formal investigations challenging the value of his corps. The Army testing program later had great impact on social policy and federal legislation.

Historical Context

Binet's Legacy

Alfred Binet's work on the measurement of intelligence in 1904 formed the basis for employment testing in industry. The French minister of public education appointed Binet as director of the psychology laboratory at the Sorbonne; his task was to develop techniques for identifying schoolchildren who needed some form of special education. He chose a purely pragmatic course of action by bringing together several short tasks, related to everyday situations, that involved information-processing skills. He hoped that by combining a number of tests of different abilities he could define a child's general potential with a single score. A child began the Binet test with tasks for the youngest age and proceeded in sequence until he or she could no longer complete a task. The age associated with the last task the child could perform became his or her "mental age." In 1912, the concept of the intelligence quotient (IQ), arrived at by dividing mental age by chronological age, was born.

As a practical measure, Binet concentrated on individual differences. His approach for measuring intellectual differences in schoolchildren had momentous consequences in our century, provided the impetus for empirically based ability testing used to rank individuals for a variety of practical purposes, and established theoretical foundations for the study of intelligence over the next eight decades.

Binet used a single score on his test only for practical purposes; he did not mean to imply that the score defined anything innate or permanent, nor did he mean that the score measured "intelligence." Low scores were not to be used to mark children as innately incapable. But subsequently the test scores came to represent a single quantifiable attribute called "general intelligence," and the popular belief that this attribute is inherited and that such heritability is equated with inevitability eventually prevailed.

Matthew Hale gives an integrated account of employment testing using standardized objective tests in the late 19th century through World War I, which we summarize here (Hale, 1982, pp. 3-14).

Employment Testing

As early as 1814, the Army used examinations to test surgeons and prospective Military Academy trainees, as did the Navy at its Academy. A few isolated positions in the federal bureaucracy had testing requirements before the Civil War, and in 1883, the newly formed Civil Service Commission initiated the principle of open, competitive examinations to ensure appointment by merit. Although the model for the competitive examination system was an academic one, the civil service tests were practical ones. Only a few civil service positions were affected at first, but position coverage increased rapidly until 60 percent of positions in the federal government were filled by examination. The federal model, including the merit system and its competitive examinations, was soon extended to several state and local jurisdictions.

During the early 1900s, before World War I, leaders of industry became interested in more efficient management of personnel. Corporations such as General Electric and Westinghouse developed testing programs. By 1910, high rates of labor turnover and industrial accidents helped promote an interest in systematic scientific selection that would deal with turnover, strikes, absenteeism, and accidents. Management had high hopes that selection schemes that would make it possible to select the right man for the right job would solve many of its labor problems (Link, 1919). Psychologists developed tests for industry—Munsterberg (for ship captains), Scott and Thorndike (for salesmen), and Hollingsworth (for clerks and typists). Hollingsworth spoke of the development and tryout of tests for 20 types of work (Hollingsworth, 1915, p. 19). Walter VanDyke Bingham, whose professional career was later to be closely linked to military psychology and ARI, headed a new division of applied psychology at the Carnegie Institute of Technology in Pittsburgh, where he set up a bureau of salesmanship research financed by 27 firms.

Still, most industrial managers remained skeptical, despite the efforts of psychologists such as Munsterberg and Scott. But their cause was not helped

by reports by researchers such as Link, an industrial psychologist who obtained a correlation of .002 between test scores and productivity after 5 years on the job. The tests, he said, could roughly distinguish left-handedness (Link, 1923, p. 110), presumably because they were based upon psychomotor equipment geared to right handers!

Testing in the Army during World War I

The academic career of Robert M. Yerkes began when Professor Munsterberg offered him an instructorship at Harvard in comparative psychology, with half time for research and a salary of $1,000 a year. During his 15 years at Harvard, he served as an instructor (1902-1908) and as an assistant professor of comparative psychology (1908-1917). At Harvard, psychology was regarded as a "soft" science, but Yerkes wished to establish it among the other sciences by proving that it could be as rigorous as physics. His slow academic advancement at Harvard was apparently at odds with his contributions to psychology and the outside recognition he received, for he was quickly perceived as a leader in the psychological profession and, in fact, was elected to the presidency of the American Psychological Association (APA) while still an assistant professor!

According to Gould (1981), Yerkes and many of his colleagues equated quantification with scientific rigor, and one of the most promising fields for objective quantification, Yerkes believed, was in the new and growing field of mental testing. The Army's need to utilize human resources in 1917 was a golden opportunity for Yerkes, now aged 42, to test his ideas with massive amounts of data and at the same time to provide critical help to the war effort.

Yerkes provided a useful chronology of the initial events bringing psychology into the Army in his account of *Psychological Examining in the U.S. Army*, which he edited (Yerkes, 1921, p. 91). Important events of the first 6 months were as follows:

> The pre-official chronology started on April 6, the day the U.S. declared war on Germany. Robert M. Yerkes, President of the American Psychological Association (APA), convened fellow psychologists at Harvard University for a discussion of the relation of psychology to the war. There ensued conferences (April 14 and 19) with the President of the National Research Council (NRC) concerning plans for psychological services, a special meeting of the Council of APA on 21 and 22 April for consideration of service in the war and appropriate action, a plan for psychological examining of recruits in Vineland, N.J., unofficial trial of methods of examining from July 15 to August 15 in Army and Navy stations, with report and recommendations to the SGO (Surgeon General's Office) through the NRC

Robert M. Yerkes

on 1 August. On 9 August, Yerkes was recommended for appointment as Major in the Sanitary Corps to organize and direct psychological examining by the Medical Department of the Army—the first official move by the Army to recognize psychological methodology as a vital facet in the development of the fighting force. He accepted the appointment August 1917 and work officially began.

In January 1918, 132 officers were authorized to work in the Division of Psychology in the Office of the Surgeon General. Names of those assigned to the division until October 1919 are listed in Appendix C; many of them played prominent roles in American psychology.

Uses and Types of Tests

Yerkes recommended the use of tests to select and classify recruits on the basis of intellectual ability. The Army, he suggested, might also use these tests to eliminate the unfit and to identify the exceptionally superior. Because such objectives were considered to be medical rather than personnel matters, development of the Army Alpha and Beta tests by the Committee on the Psychological Examining of Recruits came under the purview of the Army Surgeon General. This committee was composed of Yerkes (as chairman), W. V. Bingham (as secretary), H. H. Goddard, T. H. Haines, L. M. Terman, F. L. Wells, and G. M. Whipple—all eminent psychometricians. Following several weeks of arrangements by the American Psychological Association, the National Research Council, and the Office of the Surgeon General, the committee met from May to July 1917 at Goddard's Training School in Vineland, N.J. Plans called for the development of three types of tests: the written Army Alpha for literate recruits, the pictorial Army Beta for illiterates and for men who had failed the Alpha, and individual examinations—some version of the Binet scales—for failures on the Army Beta.

The Alpha test had eight parts, most of them familiar to test-takers through the years, covering grammar, vocabulary, arithmetic, analogies, common sense, filling in the next numbers of a sequence, and unscrambling sentences. The Beta pictorial items included mazes, block counting, number similarities, what's missing in this drawing, and figure similarities.

Scores on both tests were made available to commanding officers for use in assigning individuals to specific duties, selecting noncommissioned officers (NCOs), and balancing the "intelligence" of military units. Although the test scores were not universally accepted by Army management, they were allowed to play an important role in many decisions. For example, almost 8,000 recruits were recommended for immediate discharge as mentally incompetent, and another 8,000 were assigned to special labor duty.

Yerkes didn't think the Army made enough use of the tests. Certainly, opinions on the value of the tests were divided within the Army. "The Yerkes corps encountered outright hostility in some camps, in others . . . they were treated politely, given appropriate facilities, and then ignored." Some Army officials became suspicious of Yerkes' intent and launched three independent investigations. Additional circumstances underlying conditions of mental testing in World War I are given in Appendix D, taken from Yerkes' own exhaustive account (Yerkes, 1921, pp. 95-99).

By January 31, 1919, Lieutenant Colonel Yerkes had presided over the administration of tests to 1,726,966 men, including 42,000 officers. More than 83,500 of the enlisted men had been given individual examinations in addition to the group test. Yerkes' other accomplishments included the development of an Army grading system to represent a coarse grouping according to ability to learn, oral trade tests to assess job knowledge, job specifications, an officers' qualification card, and other standard forms and procedures for administering the program.

Yerkes also used tests and other evaluative techniques to select potential officers, NCOs, and personnel for special assignments. Civilian and military psychologists serving with Yerkes during World War I performed many other functions, including lecturing on training methods and advising training officers,

At left and above, Administration of Army Alpha and Beta tests during World War I. (National Academy of Sciences photos)

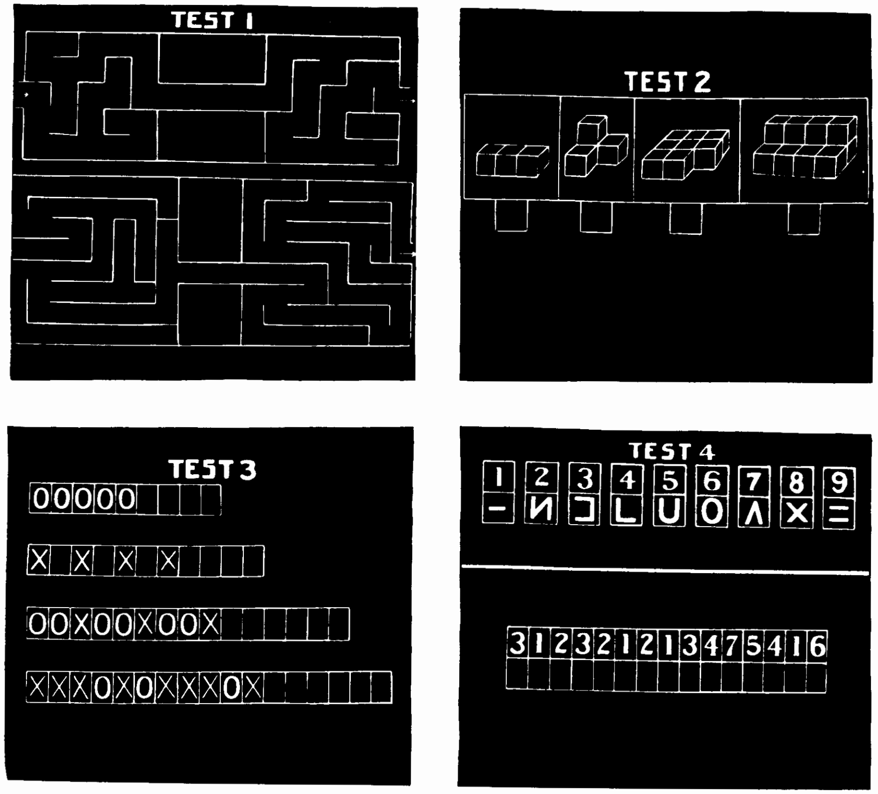
planners, and program directors in development battalions and special training companies. Psychologists assisted in the evaluation of neuropsychiatric patients at base hospitals and in the development of methods and procedures to improve combat effectiveness and morale.

In Yerkes' opinion, mental testing "helped to win the war." He added, "At the same time, it has incidentally established itself among the other sciences and demonstrated its right to serious consideration in human engineering" (Kevles, 1968, p. 581).*

Interest in the Psychology of Mass Testing

As Gould saw it, the major impact of the Yerkes-devised tests—the first mass-produced written tests of intelligence—was not on the Army. The uniform data on 1.75 million men that Yerkes had accumulated from the Alpha

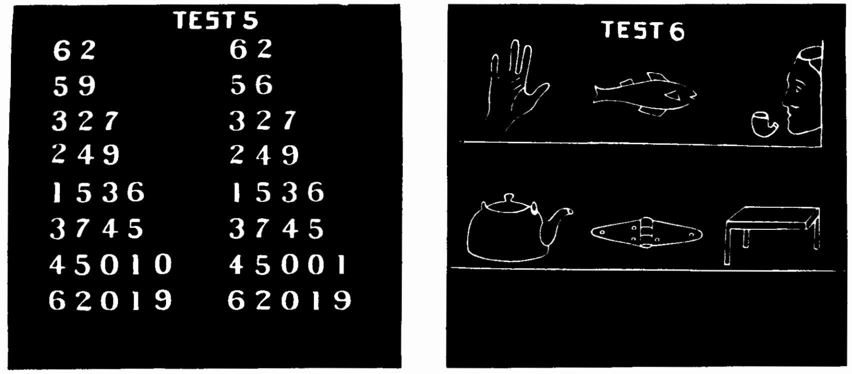
*After the war, Yerkes resumed his academic career at Yale University, where he became a professor in the newly created Institute of Human Relations, and he later became director of the Yale Laboratories of Primate Biology at Orange Park, Florida (later renamed the Yerkes Laboratories of Primate Biology). When the United States became embroiled in World War II, Yerkes served on the Emergency Committee in Psychology of the National Research Council.

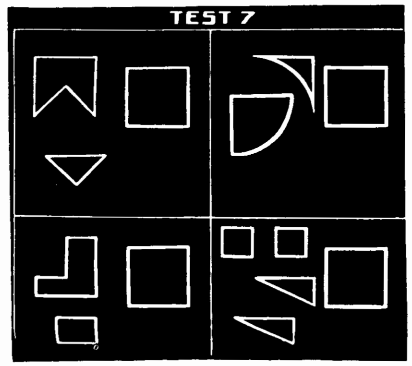


and Beta tests were of considerable interest to many outside the Army. He spoke of "the steady stream of requests from commercial concerns, educational institutions and individuals for the use of Army methods of psychological examining or for the adaptation of such methods to special needs" (Yerkes, 1928, p. 96). Binet's individually administered scales, which often gave markedly inconsistent results even when properly applied, could now be set aside because the new technology of mass testing could rank and screen everybody for almost any purpose (Gould, 1981, p. 195).

Social Significance: The Hereditarian Interpretation

Of profound significance was the interpretation of scores and rankings that Yerkes and his colleagues attached to results. E. G. Boring, a Yerkes assistant who was later a noted psychologist, produced "three 'facts' that continued to influence social policy in America long after their source had been forgotten": (1) the average mental age of white American adults stood at a meager 13 years; (2) European immigrants could be rated by their country of origin—the darker peoples of southern Europe and the Slavs of eastern Europe were less intelligent than the fairer peoples of western and northern Europe; and (3) the Negro was at the bottom of the scale, with an average mental age of 10.41 (Gould, 1981, p. 196). "As pure numbers, these data carried no inherent social message." (Had they been interpreted positively) "they might have been used to promote equality of opportunity and to underscore the disadvantages imposed upon so many Americans." . . . (But) "the tests had been written . . . to measure innate intelligence; and they did so by definition. The circularity of argument could not be broken. All the major findings received hereditarian interpretations" (Gould, 1981, p. 198). To quote Yerkes: "These group examinations were originally intended, and are definitely known, to measure native intellectual ability . . . they are to some extent influenced by educational acquirement, but in the main the soldier's inborn intelligence, and not the accidents of environment, determines his mental rating or grade in the Army" (quoted in Chase, 1977, p. 249).





Blackboard demonstrations for the Army Beta tests (from Yerkes, 1921).

Gould, in his critique of the Army's mental tests, attacks these testing results as having been based on biased item test content; as having been obtained under deplorable testing conditions, dubious and difficult testing procedures, or through faulty summary statistics (inclusion of large frequencies of zero values on the test that were interpreted as zero intelligence); and as having strained interpretations when high correlations with environmental factors were found. Gould noted that "one cannot attribute all these conclusions to some mysterious temper of the times, for critics saw through the nonsense as well. Even by standards of their own era, the American hereditarians were dogmatists, but their dogma wafted up unforgivable currents into grounds of general acceptance, with tragic consequences" (Gould, 1981, p. 222).

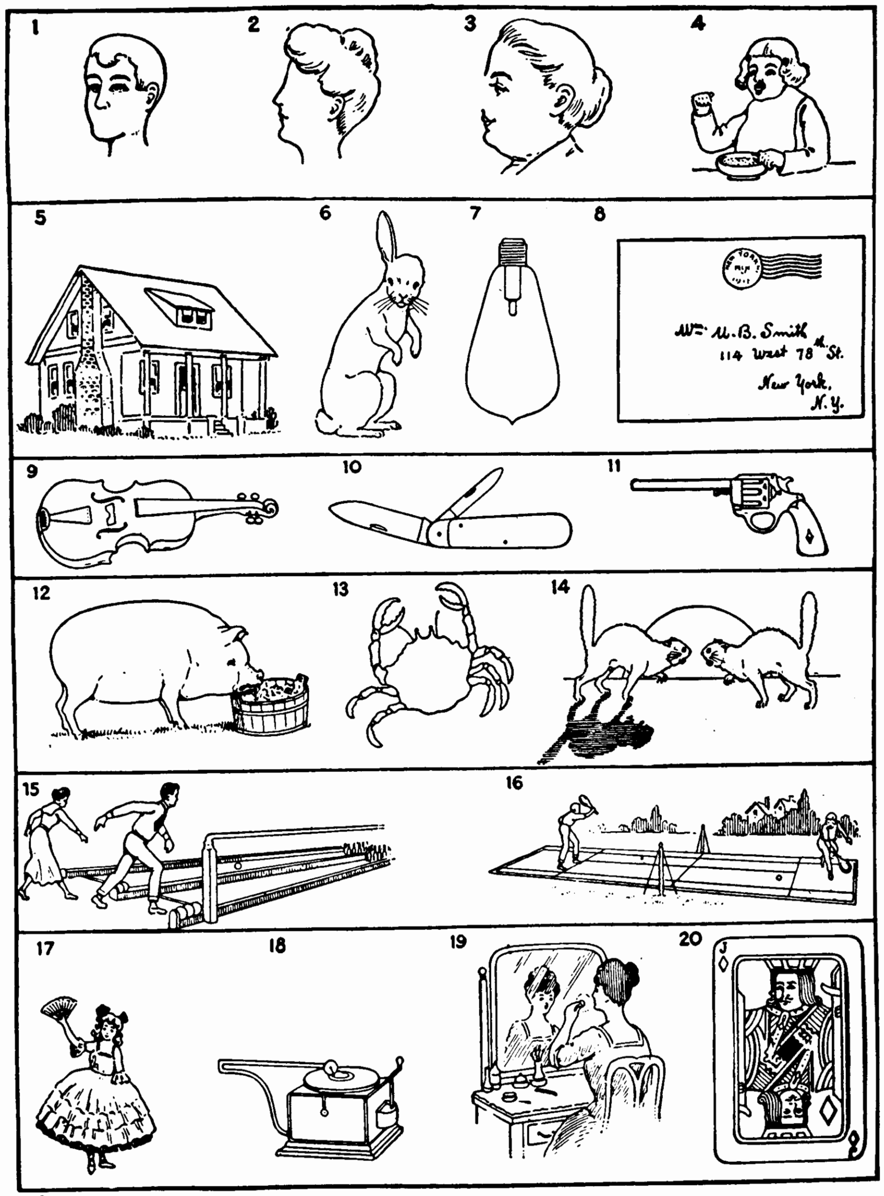
Yerkes apparently developed some misgivings over the figure of 13.08 as an average mental age for white draftees. But he was still oblivious to cultural and educational bias, despite his insistence, and Yoakum's, that "far from being culturally and linguistically based, the Army IQ tests of World War I were culture-free and got right down to the unit characters for intelligence in the blood of the Naked Adam." Moreover, according to Chase, while Yoakum and Yerkes conceded the Army Alpha and Beta tests "do not measure loyalty, bravery, power to command, or the emotional traits that make a man 'carry on' . . . in the long run these qualities are far more likely to be found in men of superior intelligence than in men who are intellectually inferior, i.e., who get low IQ and other forms of 'intelligence test' scores" (Chase, 1977, p. 249).

But one need only examine a few of the Army Beta pictorial test items to see how far Yerkes and his colleagues fell short of achieving culture-free measurement: a tennis court without a net, a phonograph without a horn (both to be drawn in by the examinee), and other objects widely and typically misconstrued by examinees of non-American origins. The tests unquestionably measured American educational and cultural influences, and many recruits were both woefully deficient in education and either too new to America or too impoverished to respond well to the content of the tests. Yerkes opted to accept the figure (Gould, 1981, pp. 222-223).

Political Significance: The Impact on Public Opinion

Yerkes' hereditarian views had a striking impact, both directly and indirectly, upon American public opinion and politics. The chairman of Harvard's psychology department, W. McDougall, wrote in his best-selling book in 1921: "The results of the Army tests indicate that about 75% of the population has not sufficient innate capacity for intellectual development to enable it to complete the usual high school course. The very extensive [IQ] testing of school children carried on by Professor [Lewis M.] Terman and his colleagues leads to closely concordant results" (Chase, 1977, p. 226). How would Professor McDougall have interpreted the post-World War II phenomenon that about 50 percent of college-age students in the United States now attend college?

Chase, writing in the 1970s, was bitterly critical of the use made of the Army Alpha and Beta. He felt the Army would have been better off not administering any IQ or IQ-like tests at all to save many recruits harassment at



Part six of examination Beta for testing innate intelligence

the hands of examiners and the humiliation of being falsely branded as morons and worse. (The mayor of Chicago in 1915 could not pass the 10-year-old equivalent—an achievement exceeded by 95 percent of recruits tested 2 years later.) Chase criticized the " 'blundering' and/or evil authors and public officials who found, in the eugenical interpretations of the Army Alpha and

Beta intelligence score results, the 'scientific' excuses for a half-century of catastrophic educational, immigration and social politics and actions" (Chase, 1977, p. 251).

C. C. Brigham in 1923 claimed that "the Army data constitute the first really significant contribution to the study of race differences in mental traits. They give us a scientific basis for that conclusion." (Brigham, a disciple of Yerkes, was an assistant professor of psychology at Princeton University. Later he was to become the head of the College Entrance Examination Board; he also served on an NRC committee on military classification during the early part of World War II.) In his book on intelligence testing, Brigham's action-oriented conclusions led to advocacy of the hereditarian line as a basis for the restriction of immigration:

> Deterioration of American intelligence is not inevitable, however, if public action can be aroused to prevent it. There is no reason why legal steps should not be taken which would insure a continuously progressive upward evolution. The steps that should be taken to preserve or increase our present intellectual capability must of course be dictated by science and not by political expediency. Immigration should not only be restricted but highly selective, and the revision of the immigration and naturalization laws will only afford a slight relief from our present difficulty. The really important steps are those looking toward the prevention of the continued propagation of defective strains in the present population. If all immigration were stopped now, the decline of American intelligence would still be inevitable. This is the problem which must be met, and our manner of meeting it will determine the future course of our national life (Brigham, 1923, pp. 209-210).

Or as Gould put it, "The Army data had [their] most immediate and profound impact on the great immigration debate. Restriction [of immigration] was in the air and may well have occurred without scientific backing . . . . [Nevertheless] congressional debates for passage [of the] Immigration Restriction Act of 1924 continually invoked the Army data. The act reset the quotas at 2 percent of people from each nation recorded in the 1890 census, [since] southern and eastern Europeans [had] arrived in relatively small numbers before" [1890, they were in effect excluded] (Gould, 1981, pp. 231–232). However, other modern-day scientists have expressed doubt that the Army tests had had as much impact upon immigration restrictions as claimed by Gould and Kamin before him (1974, 1976). Snyderman and Herrnstein, after reviewing old congressional testimony and other sources, concluded (1983) that religious and ethnic biases, as well as economic factors, were probably more responsible than were Army test scores for influencing national policy and legislation on immigration.

Six years after his book was published, Brigham saw matters in a different light. It was now clear to him that the Army data could by no means be regarded as measures of innate intelligence. He admitted, "Comparative studies of various national racial groups may not be made with existing tests" [and] "one of the most pretentious of these comparative racial studies—the writer's own—was without foundation" (Brigham, 1930, p. 165).

Implications: The Impetus to Personnel Testing

One of the more enduring effects of the World War I testing program lies in the impetus given mental testing itself. The Army tests were the first written tests of mental ability to gain respect, and, because they were administered to groups, they represented a convenient means for ranking everyone for nearly every purpose—for children's placement in school, for entrance into universities, for professional certification and licensing, and for a variety of other endeavors.

The early interpretation of the Army test data could be associated with the interpretation of factor analytic results underlying the Spearman theory of general intelligence, or Spearman's "G," and with C. Burt's contention that "G" is inherited.

Most impressive is the tremendous use made of these tests in industry for both employment and educational purposes. The Army's testing program was the first attempt by any large organization, public or private, to measure the capabilities of all its members and to assign them accordingly, or, in the case of officers, to appoint and promote them (Van Riper, 1958, p. 252).

During World War II, several NRC committees championed different approaches to employment testing. W. D. Scott and W. V. Bingham argued for tests of proficiency in or aptitude for a specific trade, while Yerkes held that general intelligence was the best available single indication of a person's occupational usefulness. This issue has not been satisfactorily or conclusively settled to this day. At least for the 1920s, a boom in the development of oral trade tests reflected the Scott-Bingham tradition of skills and abilities measurement rather than the Yerkes tradition of a general measure (Hale, 1982, p. 13).

The ready acceptance of psychological tests in the military during World War II could be attributed to the work done during World War I and the broad acceptance of these tests during the 1920s in industry and academia. A direct result was the creation of new jobs for psychologists in numbers never before realized outside academia—first for personnel and industrial psychologists, who later branched out into more than a dozen related specialties such as organizational psychology, human factors engineering, and applied experimental psychology.

Chapter 2

Refining Selection and Classification Techniques, 1939–1945

World War II placed great demands on the personnel systems of government and industry alike and further increased interest in testing. By that time, personnel management and scientific psychology were no longer unfamiliar topics to the leadership of the Army. In fact, the Army was able to begin a coordinated program for using available psychological tools well before America's entry into the war. One of the earliest actions taken was the establishment of the Personnel Research Section (PRS) to tackle many of the new personnel problems that grew out of the sudden influx of men into the Army. Solutions to immediate problems were sought, and plans were laid for giving research support to what soon became the largest personnel system in history. The Army General Classification Test, which provided an index of learning ability, was used to facilitate classification for training and job assignment. More than 9 million men took one form or another of this test by the end of the war.

The Post-War Testing Boom

After World War I, the National Research Council and the Army Surgeon General were inundated with inquiries for information on tests (Hale, 1982, p. 15). The success of the military program alone could not explain the new-found interest of private industry in the possibilities of testing. American industry was confronted with strikes, with the inevitable difficulties that went along with demobilization, and with poor economic conditions. Psychologists recognized an opportunity for assisting industry with the problems of absenteeism, turnover, and poor industrial efficiency. In 1919, the NRC established a division for anthropology and psychology, the *Journal of Personnel Research* was renamed *Personnel Journal*, and the Psychological Corporation was founded. By 1919, more than half of the members of the American Psychological Association were applied psychologists and 25 of its 400 members were doing research in industrial psychology (Terman, 1919). Henry Link wrote that "the chief problem of employment tests is to determine the value of particular tests when applied to particular tasks. The first step is to test *tests* rather than applicants" (Link, 1919, p. 20). Psychologists cautioned users that tests should be only a part of a total selection process that might include interviews, application forms, reference checks, and personal history forms. The U.S. Civil Service Commission, with the assistance of J. B. Watson and L. L. Thurstone, streamlined its tests and developed new ones, and established a research section headed by L. J. O'Rourke. The postwar boom in testing peaked by 1925, however, possibly because of the upturn in the economy and improvement in turnover, and because of the growing disenchantment of many industrial psychologists with employment tests. When managers and psychologists were forced to admit that the psychological test was something less than the ultimate panacea, testing was immediately abandoned by most companies (Baritz, 1960, p. 74).

The work of industrial psychologists at the Hawthorne Works of Western Electric in Illinois in the mid-1920s was instrumental in introducing a change in the "nature and direction of industrial personnel work and became standard material for students of industrial sociology and human relations" (Baritz, 1960, p. 74). Thereafter, industrial researchers paid attention to social relations within the work situation as well as individual aptitudes, skills, and abilities in determining performance and productivity.

During the Depression, the principal individual skills tested were clerical and typing. Managers concentrated on personnel counseling rather than on selection techniques to satisfy existing employees. When managers did use tests they stressed personality inventories, principally to identify stable and loyal workers. In 1934, the U.S. Employment Service (USES) established an occupational research program that examined psychological aptitudes required for specific jobs and also began a major project of validating the aptitude tests then in use in industry.

Testing in the Army during World War II

The Army Alpha and Beta tests marked the beginning of large-scale mental testing, but the exact military uses of these tests are less well known. In fact, the Alpha and Beta tests were used largely on a permissive basis; that is, organizations could choose whether or not to use the results and to what extent. The interest in military personnel classification hardly survived the Armistice. The Army and Navy both dropped their general testing programs in 1919 and retained only rudimentary personnel classification systems.

The Need for Classifying Military Personnel

World War II placed extraordinary demands on the personnel systems of industry and government alike and rekindled military interest in psychological testing. Military policy makers and civilian psychologists recognized the

need for reestablishing the testing program in anticipation of America's entry into the war. A coordinated program sought to adapt the advances in psychological testing made during World War I. In 1940, the National Research Council, at the request of the War Department, set up the Committee on Classification of Military Personnel. The NRC selected Walter V. Bingham to head the committee. He also assumed the title of Chief Psychologist of the Army.* Bingham, writing in *Science* in 1944, gave a brief account of the committee's early beginnings (Bingham, 1944):

> The Committee on Classification of Military Personnel, appointed by the National Research Council at the request of The Adjutant General in May 1940, has completed four years of advisory service. These years have seen striking changes in the nature and scope of the technical problems involved in classifying and assigning officers and men as the Army has entered on successive phases of planning for the national defense, mobilization, swift expansion, participation in a world-wide war and return of service personnel to civilian employment.
>
> Four months before the Selective Service and Training Act was passed in September 1940, The Adjutant General had asked the committee what steps should be taken to provide aids to general personnel classification and appraisal of soldierly potentialities of recruits and inductees. The question took this form: Should reliance be placed on the standardized vocabulary tests then in use at recruiting stations as aids in sizing up the military suitability of volunteers? Or should use be made of available revisions of Army Alpha, Army Beta and the Binet-Simon Scale? Or had the time arrived to prepare new tests for purposes of screening and initial classification?
>
> It seemed clear that a new general classification test was required, and also an examination which could be given to non-English speaking men and to illiterates. Tests of aptitudes for training in clerical duties and in mechanical occupations also seemed to be indicated. To help in meeting these needs was the chief task of the committee in 1940.
>
> During the summer of that year, The Adjutant General established the Personnel Research Section, called to temporary active duty three psychologists who held reserve commissions, and secured through the machinery of the U.S. Civil Service Commission the appointment of five civilian psychologists classified as personnel technicians. Clerical aid was at first almost non-existent. For several weeks

*Since that time, six other individuals have served as Chief Psychologist of the Army: T. G. Andrews, Harry Harlow, Lynn Baker, J. E. Uhlaner, Joseph Zeidner, and, as of November 1982, Edgar Johnson. Each of the latter three served as Chief Psychologist of the Army and Technical Director of ARI concurrently.

until additional funds were authorized, the chief reliance was on NYA (National Youth Administration) students who came to work on alternate days. Agencies such as the Civil Service Commission, the Bureau of Public Health, and the CCC (Civilian Conservation Corps) helped out. The Occupational Analysis Section of the U.S. Employment Service assisted greatly by analyzing and concisely describing the more important military occupations, by helping to revise and structuralize the Army's occupational code of civilian and military specialties, and by making available for Army use a volume of Oral Trade Questions to help interviewers in finding out whether a soldier was really as well informed about his trade as he claimed to be.

Extension and improvement of the Army-wide testing program has been one of the continuing responsibilities of the personnel research staff of the Classification and Replacement Branch in The Adjutant General's Office.

Personnel Research Section

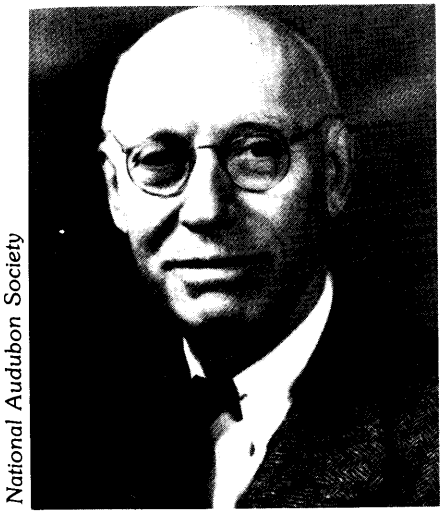
One of Bingham's earliest actions was to merge the activities of the Personnel Testing Section of The Adjutant General's Office, established in March 1939, into the newly formed research organization dealing with test development—the Personnel Research Section of The Adjutant General's Office, ARI's direct ancestor. (See Appendix H for an account of ARI's organizational lineage.) From its modest beginnings, the professional staff consisted in 1944 of 21 officers and 45 civilians, who had the help of 51 clerical assistants and about 50 expert part-time consultants.

Bingham later wrote that his "welcome was in sharp contrast to experiences of World War I, since personnel management and scientific psychology were subjects no longer unfamiliar to officers of the regular Army" (Boring et al., 1952, pp. 22-23). Bingham's committee met, when summoned, over a 7-year period to consider questions related to the work of the Personnel Research Section. It was the "responsibility of the committee to endorse and encourage plans that gave promise of helping the Army toward early victory while putting the brakes on projects that dealt with fundamental questions of great scientific interest but which seemed unlikely to yield usable information without hampering the rapid training of troops" (Boring et al., 1952).*

Under the direction of M. W. Richardson, the Personnel Research Section was presented with new problems that grew out of the sudden influx of larger numbers of men in increased ranges of mental ability, the varied types of backgrounds among the soldiers, the need to select more officer candidates,

*The membership of this committee at the time of its appointment by the National Research Council included W. V. Bingham, H. E. Garrett, L. J. O'Rourke, M. W. Richardson, C. L. Shartle, and L. L. Thurstone.

National Audubon Society



Walter V. Bingham

M. W. Richardson

and the need to determine rapidly and accurately the various degrees of skills and aptitudes among the new personnel. Solutions to immediate problems were sought with a rapidly growing Army in mind, and plans were laid with a view to help manage what came to be the largest personnel system in history. Many developmental tasks were concurrent and overlapping. While measures were being readied for immediate use, work began to devise new and more satisfactory approaches.

Research Outcomes

The contributions of the PRS in World War II have been reviewed by E. Donald Sisson (1948) and are abstracted along with other materials in the following five sections. Sisson's review was based upon his analysis of 346 referenced articles appearing in the PRS report series. Because the authors of these reports were anonymous, Sisson, who himself was a PRS scientist, provided a list of individuals who served on this staff from 1940 to 1946 (see Appendix E).

Classification

The Army General Classification Test, which measured the learning ability of recruits as one basis for personnel classification, was introduced as AGCT-1a and 1b in October 1940. Two Spanish-language versions were issued later—in April 1941 and 1c/1d in October 1941. Each contained 140 to 150 multiple-choice items on vocabulary, arithmetic, and block counting. Standard scores were constructed from raw scores with a mean of 100 and a standard

GCT 1a

31. AGE means most nearly (A) person (B) school (C) bread (D) time

32. A STAVE is made of (A) thread (B) wood (C) jelly (D) grass

33. To SQUABBLE is to (A) float (B) sing (C) dispute (D) speak

34. A THUD is a (A) nut (B) bolt (C) sound (D) light

35. VIOLENT means most nearly (A) modern (B) dead (C) fierce (D) better

36. Bill has 6 dollars, Jack has 8 dollars, and Henry has 4 dollars. How many dollars do they have altogether?
(A) $16 (B) $14 (C) $17 (D) $18

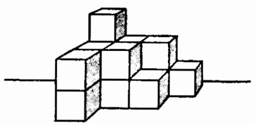
37. A man attended target practice 9 times. He scored 189 in all. What was his average score for each time?
(A) 18 (B) 21 (C) 24 (D) 27

38. Six men went on a trip by automobile. The total expense was $13.44, which was shared equally. How much was each man's share of the total expense?
(A) $2.24 (B) $2.56 (C) $2.92 (D) $3.24

39. Men start work at 8:30 in the morning and quit at 12:00 noon. How many hours do the men work in the morning?
(A) 2½ (B) 3 (C) 3½ (D) 4

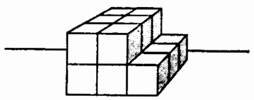
40. A camp has 186 men in three equal groups. How many men are in each group?
(A) 62 (B) 93 (C) 33 (D) 59

41. How many blocks?



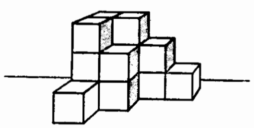
(A) 10 (B) 8 (C) 15 (D) 12

42. How many blocks?



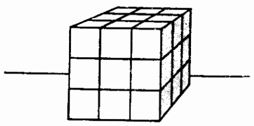
(A) 14 (B) 11 (C) 15 (D) 16

43. How many blocks?



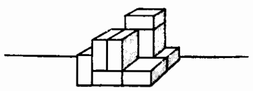
(A) 15 (B) 13 (C) 12 (D) 10

44. How many blocks?



(A) 18 (B) 24 (C) 19 (D) 27

45. How many blocks?



(A) 9 (B) 10 (C) 11 (D) 12

Go right on to next page. Do not wait for signal.

3

16—18810

Sample vocabulary, arithmetic, and block-counting items from AGCT-1a

deviation of 20, then distributed into five Army grades (see Table 1). Revisions in which part scores were recorded for the first time appeared as AGCT-3a in April 1945 and AGCT-3b in 1946. These forms each contained four subtests—reading and vocabulary, arithmetic computation, arithmetic reasoning, and pattern analysis. Equivalence to AGCT-1 was built in. Four

Table 1

Army Mental Grade Groups and Standard Score Ranges

Army grade (mental group)	Standard score range[a]
I	130 and higher
II	110-129
III	90-109
IV	70- 89
V	69 and lower

[a]Percentages of the Army population falling into each mental group varied from time to time with changes in norms. Also, in July 1942, the Group IV lower limit was changed from 70 to 60 to correspond better to the distribution anticipated from operational use. The Army retains this grading system to the present.

forms of each type of AGCT-3 subtest were developed and equated for content and difficulty.

Form 1a was standardized on a population of Regular Army and Civilian Conservation Corps men, the combined group equated to expected recruits in terms of age, education, and area of residence. It was necessary to use this population base because the first inductees under the Selective Service Act had not yet entered the Army. Not surprisingly, the distribution curve of the obtained Army population varied from what had been projected, quite probably because such factors as race, occupational deferments, illiteracy, and the siphoning off of those applying and being accepted for direct commissioning could not be taken into account. By the time form 1b was ready for norming, form 1a had already been widely used for classification. And so, despite differences between the obtained and the expected, norms for form 1b were computed by combined regression of form 1a and 1b scores. Forms 1c and 1d were standardized on the basis of forms 1a and 1b. Form 3a was standardized on a population of 39,000; age, education, race, and geographical location were taken into account.

AGCT was quite successful in selecting men for Army specialist courses, as evidenced by the several hundred validity coefficients obtained, a few of which are shown in Table 2. Since most of the samples for these correlational studies were preselected on the AGCT or on some highly correlated factor, correlations tended to be low, even where academic grades formed the criterion. Validities also tended to be lower against criteria involving personality, such as Officer Candidate School (OCS) graduation, or against success where formal academic background was a major factor. Highest correlations were between reading and vocabulary subtest scores and written examinations, and between pattern analysis scores and criteria involving practical performance.

Table 2

Various Examples of Validity Coefficients for the AGCT

Population	Criterion	N	Mean	SD	r
Clerical trainees					
AAD, administrative	Grades	2947	121.7	11.1	.40
AAF	Grades (weighted)	123	125.9	9.9	.44
Armored	Grades	119	125.3	8.3	.33
WAAC	Grades	199	116.8	12.0	.62
Mechanic trainees					
Airplane	Grades	99	104.8	10.6	.32
Airplane	Grades	3081	418.1	10.7	.35
Motor	Grades	318	88.3	24.4	.69
Tank	Grades	237	116.6	11.3	.33
Aircraft armor trainees	Grades	1907	117.3	10.9	.40
	Ratings	449	112.7	12.1	.27
Aircraft welding trainees	Grades	583	114.8	10.3	.26
Bombsight maintenance trainees	Grades	195	129.1	10.5	.31
Sheet metal trainees, AAF	Grades	764	115.6	10.3	.27
Teletype maint trainees, AAF	Grades	487	123.5	12.1	.20
Radio operator and mechanic trainees AAF	Grades	1055	122.4	11.1	.32
	Code reg speed, WPM	217	117.4	11.7	.24
Radio operator trainees, WAAC	Grades	152	116.2	11.7	.38
Radio mechanic trainees, AAF	Grades	419	108.0	13.0	.49
Gunnery trainees, armored	Grades	66	120.0	12.1	.50
Field artillery trainees, instrument and survey	Grades	68	102.7	6.5	.33
Motor transport trainees, WAAC	Grades	269	111.4	13.6	.31
Tank driver trainees	Ratings	330	87.7	19.5	.16
Truck driver trainees	Road test ratings	421	95.5	20.1	.13

Note. Table adapted from "The Army General Classification Test" by Personnel Research Section staff, 1945, *Psychological Bulletin, 42*, p. 767.

Table 2 continued

Various Examples of Validity Coefficients for the AGCT

Population	Criterion	N	Mean	SD	r
Bombardier trainees, AAF	Grades, academic	40	111.5	18.6	.62
Aircraft warning trainees,	Grades, theory	119	107.1	15.6	.73
plotter-teller	Grades, performance	119	107.1	15.6	.26
Intelligence trainees, AAF	Grades, academic	104	118.9	10.6	.51
Photography trainees, AAF	Grades	431	123.0	11.9	.24
Cryptography trainees, AAF	Grades, phase 1	417	129.9	9.7	.31
Weather observer trainees, AAF	Grades	1042	130.2	12.5	.43
Officer candidates					
Infantry	Grades, academic	103	123.0	10.8	.30
Ordnance	Grades, academic	190	128.2	9.6	.41
Signal corps	Grades, academic	213	128.6	10.1	.36
Tank destroyers	Grades, academic	52	125.8	10.7	.44
Transportation corps	Grades, academic	314	126.4	9.8	.38
WAAC	Grades, academic	787	128.4	11.3	.46
Infantry	Leadership ratings	201	122.6	10.8	.12
Ordnance	Leadership ratings	190	128.2	9.6	.09
13 arms and services	Success vs failure	5186	128.7	10.0	.28[a]
AST trainees					
Basic engineering	Grades, inorg chem	222	126.6	7.8	.21
	Grades, math (trig)	222	126.6	7.8	.16
Personnel psychology	Ranks in statistics	132	134.2	10.4	.25
	Ranks in tests and measurements	130	134.0	10.3	.29
West Point cadets, 4th class	Grades, English[b]	932	131.3	10.9	.40
	Grades, math[b]	932	131.3	10.9	.43
	Grades, mil topogr	932	131.3	10.9	.40
	Grades, tactics	932	131.3	10.9	.29
	Grades, French[b]	167	130.2	11.0	.22
	Grades, German[b]	164	132.4	10.9	.20
	Grades, Spanish[b]	932	131.3	10.9	.19
	Grades, Portuguese[b]	168	130.0	10.3	.12

[a] Biserial correlation
[b] First term

Table 2, from an article by the PRS staff, presents validity coefficients (PRS staff, 1945, p. 767).

The AGCT correlated highly with other well-known tests of mental ability and with education, but showed no significant relationship with age. Blacks scored lower than whites, on the average, but were closer to whites where the races were matched on educational status. Scores for northern soldiers tended to be higher than for southern soldiers of the corresponding race. Study of the AGCT with respect to civilian and military occupations revealed a definite hierarchy and sectional differences within occupations. As a basis for classification counseling, AGCT scores probably were more relevant for occupations with restricted score ranges; those with wider score ranges probably depended more on interests or specific aptitudes. Low AGCT could mean that a high-level occupation should be avoided, but a high AGCT did not necessarily mean the reverse—that such a score was grounds for avoiding any occupation.

Special Mental Tests. As in World War I, there was need for special mental tests—this time to be applied to classification processes. The Non-Language Test for illiterates and Grade V men was standardized against a normal distribution of AGCT responses. An Army Individual Test of general mental ability was valid for predicting Army training success of Grade V men in Special Training Units. Its three verbal and three performance tests had been standardized on a group of native-born literate whites.

The general Mechanical Aptitude Test (MAT) contained mechanical information, mechanical comprehension, and surface development items. Validity studies showed a wide range of correlations, usually lowered by preselection, with course grades and other criteria. As a verbal test, the MAT correlated best with theoretical course grades and motor mechanics, less well with driver performance ratings, and negligibly with radio code receiving speed. Varying results were obtained for clerks, aircraft warning operators, airplane mechanics, basic trainees, and Navy trainees.

The Clerical Aptitude Test, including name checking, coding, catalog numbers, verbal reasoning, number checking, and vocabulary, was validated against clerical school grades but was sometimes inferior to the AGCT, the MAT, and to the Wells Revision of the Army Alpha as a predictor of clerical grade. On the other hand, the General Clerical Abilities Tests, which were used for civilian employees, had an average correlation of .35 with civil service grade and supervisors' ratings but were known on occasion to reach correlations of .50.

Army Trade Screening Tests and Experience Check Lists in clerical, mechanical, and other technical fields were developed to verify skill status in Military Occupational Specialties (MOS). Critical scores were estimated to represent the level of technical achievement attained by Army specialist course graduates. Significant differences in performance were obtained between experienced and inexperienced personnel. (See Sisson, 1948, pp. 583-584 for a full account of World War II classification activities.)

Selection

The initial objective of induction selection was to differentiate those who could learn to be proficient soldiers in a reasonable length of time from those whose learning capacity was unequal to Army expectations. Determination of minimum literacy requirements for induction acceptance and development of mental capacity measures not dependent upon high literacy levels were basic requirements. Tests were developed that would set minimum literacy at the fourth-grade level. Criterion scores were established on the Qualification Test—a verbal measure of general learning ability—for accepting, rejecting, or assigning men to special training. Nonverbal tests, including visual perception, paired comparison, and abstraction items, were used to select illiterates with sufficient mental capacity to absorb Army training. Actually, tests with some verbal content showed higher validity than nonverbal tests against ratings in Special Training Units, biserials ranging from .38 to .72, and various test combinations giving multiple correlations above .60.

Other selection programs applied tests predictive of success in Women's Army Corps (WAC) Officer Candidate School, in highly technical Army courses, in Air Corps basic training, in driving ability, and in the differentiation of troublemakers, neurotics, and normals.

The Women's Classification Test was superior to the AGCT in predicting academic grades in the WAC Officer Candidate School, but neither test predicted leadership ratings. Specialized tests were used to select trainees for highly technical Army courses such as balloon barrage, combat intelligence, military police, medical technician, Air Corps bombardiers, navigators, and weather observers.

Potential predictors of driving ability selected by PRS researchers included a Driver Experience Inventory, a Driver Information Test, tests of visual acuity, night vision, a reaction time test, and several well-known psychophysical tests. A road test was the usual criterion selection—observation of the driver in a standardized situation. Visual acuity was not highly correlated with this criterion, but tests of night vision were higher against a special night road test.

Encouraging preliminary findings were obtained in research efforts to use tests for differentiating troublemakers, neurotics, and normals. The Shipley Personality Inventory identified extreme troublemakers and extreme neurotics. The Minnesota Multiphasic Personality Inventory (MMPI) also showed promise in predicting AWOLs and psychiatric rejects among WAC applicants and selecting Arctic trainees. The criterion in both cases was careful psychiatric diagnosis (Sisson, 1948, pp. 576-578).

Training

With the introduction of the Army Specialized Training Program (ASTP), tests in academic subjects were constructed for all services and used as early selection devices. More than 150 different national achievement tests covering at least eight subject matter fields and seven foreign languages were administered in all basic and advanced courses. One result of the national achievement testing program was greater acceptance of objective testing in college courses.

To validate an aptitude-testing program for Army Air Corps basic training centers, a large-scale study of apparatus and written tests was conducted, with the finding that written tests were generally superior against a criterion of academic success in the training course. The selection battery chosen did include two performance tests, however, which had higher validity against supervisory ratings of Air Corps ground-crewmen in active units but, as expected, the written tests in the battery showed higher validity with academic success.

To test the basic military knowledge required of all soldiers, the Military Knowledge Test was developed and used as a device to determine whether men being redeployed needed refresher training. The test did differentiate among trained and untrained infantrymen (Sisson, 1948, pp. 586-588).

Proficiency Measures

Performance criteria for truck driver trainees consisted of a practical road test checklist with objective ratings on specific items and a general driving proficiency rating. Generally, the reliabilities of road test ratings were as high as those usually obtained for criteria of practical performance. In seeking criteria more reliable than academic course grades for predicting success in Army Air Force (AAF) schools, paired comparisons showed high reliability for small groups of ratees. Five types of on-the-job ratings had been obtained: rank in overall job ability, paired comparisons, and 5-step scales on performance, personality, and overall worth. Except for the personality scale, odd-even reliabilities were high. Intercorrelations averaged about .90.

To validate devices for measuring leadership and personality fitness among officers, pooled independent ratings by a group of "buddies" yielded a highly reliable criterion. This method came into widespread use in several officer programs involving selection, retention, and efficiency reporting. The adequacy of this criterion depended on the agreement of groups of officers familiar with the character and proficiency of the rated officers as to their placement along a continuum of overall competence. Corrected split-half reliability varied between .81 and .91. Greater reliability was obtained as a function of the length of acquaintance with the rated officer (Sisson, 1948, pp. 588-590).

Leadership

The large variety of officer procurement programs during the 1940s was matched only by the variety of measuring devices intended to yield indices of selected aspects of an applicant's background, his learning ability, and his leadership qualities. AGCT was available for measuring learning ability, with those achieving Army Grades I and II eligible to apply for most programs, but more exact discrimination on the basis of such cognitive abilities was felt necessary. Accordingly, the Higher Examination Test was constructed in 1941 to include more difficult vocabulary and arithmetic items than those on AGCT. However, the speed factor in this test appeared to discriminate against older men; consequently the Higher Examination Test was replaced by the Officer Candidate Test. This test correlated highly with the AGCT and with years of education in an unselected population. Validity against success in Officer Candidate School was high—higher than that of AGCT.

Other measuring techniques tried out were rating forms, officer evaluation reports, interview procedures, and other devices, such as projective tests. The interview was a "standardized, objective procedure which breaks sharply with tradition. It is intended specifically to evaluate ability to deal with people. Board members observe behavior and record observations, then check descriptions, integrate these into ratings on specific areas of behavior, and finally evaluate a candidate's ability to deal with people. Objectivity was achieved by defining overt behavior that could be observed and judged during the interview and developing conversational situations designed to elicit this type of behavior." The officer board interview, which was destined to be used in many officer procurement programs over the succeeding two decades, is discussed further in the following chapter. Projective devices included the Rorschach and Thematic Apperception Tests, sentence absurdities, picture absurdities, and Philo-Phobe—all validated against leadership ratings. (The Philo-Phobe is an individually administered interview form for obtaining and analyzing data in four areas: aspirations, emotions, judgment and insight, and ethicomoral development.) Correlations were found to be low. A Preference Inventory containing 100 groupings of activities was developed as a predictor of leadership, and correlations with leadership ratings at OCS were found to be insignificant. A Leadership Test, requiring judgment in leadership situations, was also discarded.

A Combat Adaptability Rating Scale, used in conjunction with an interview, performance situations, and stress situations for officer selection did not prove effective, although reliability of ratings was high. Follow-up studies could not be made of individuals in actual combat because of administrative difficulties, a situation that was remedied in 1951 when PRS sent a team of its research psychologists to the front lines in Korea to conduct a wide assortment of data collection activities relevant to research projects on enlisted classification and performance, and officer selection and performance.

PRS's most successful program in officer selection was that for officers to be given permanent commissions for the postwar Regular Army. A variety of personnel instruments was developed, including a test of general learning ability, a test of general educational achievement, a biographical information form, an Officer Evaluation Report, and a highly structured board interview. All instruments were shown to be valid against rigorous criteria of agreement by fellow officers on each applicant's overall fitness. To select officers who had previously performed outstandingly, scores on the selection instruments were validated against job performance ratings by peers. An index was developed to differentiate on the basis of projected efficiency to select officers likely to remain outstanding in the future. This index was found to be far superior to traditional Army board proceedings for that purpose.

A comprehensive research program on methods of reporting officer efficiency grew out of the investigation of the usefulness of the Officer Efficiency Report as a selection device for retaining wartime officers in the regular Army. Five methods, including a forced-choice technique, were validated against four separate criteria. Results showed a clear superiority of the forced-choice over the other instruments (Sisson, 1948, pp. 590-594).

DA Form 67-1, introduced operationally in 1947, contained forced-choice items. Most officers didn't like such items. The officers could not "control" the outcome, and felt they were being forced to say things they did not want to say. In 1950, Form 67-1 was replaced by 67-2 containing no forced-choice items. But Form 67-1 had produced scores more valid than those obtained with the previous Form 67 and more evenly distributed for better discrimination. Despite the technical merits of the forced-choice item, it did not reappear operationally for purposes of rating officer efficiency. PRS went on to orchestrate development of Forms 67-2 and 67-3, but in 1955 relinquished this activity to the Deputy Chief of Staff for Personnel (DCSPER) as more appropriately management than research. Forced-choice techniques have continued, however, to be used by psychologists in mental measurement and performance evaluation other than for rating officer efficiency.

The American Soldier

An event in military psychology worthy of special note was the publication in 1949 of *The American Soldier*, a four-volume work reporting on an independent analysis of social/psychological data collected during World War II by the War Department. The volumes were entitled *Adjustment During Army Life*; *Combat and Its Aftermath*; *Experiments in Mass Communication*; and *Measurement and Prediction* (Stouffer, 1949).

Research Significance: What the Tests Measure

It is interesting to compare the furor raised by the writings of World War I psychologists concerning the nature of intelligence with that of the writings of World War II psychologists. In bold contrast to the belief of the former that the Army Alpha and Beta tests measured native mental capacity, the latter made no pretense of measuring native ability with the AGCT. Explicitly, the AGCT was to be used as a rough indication of trainability. Or, to quote from

a publication of the Personnel Research Section staff (PRS, 1945),

> . . . intelligence tests do not measure native mental capacity. They measure actual performance on test questions. A test is a fairly valid measure of the native capacities which underlie the abilities tapped by its questions when everyone tested has had equal opportunity and equal incentive to develop the abilities measured. It has maximum validity of this type when everyone tested has had maximum opportunity and maximum incentive over a considerable period of time extending right up to the date of testing. The verbal and arithmetical elements of a group intelligence test should, therefore, possess maximum validity as measures of the corresponding native capacities at the close of the period of elementary education. The decrease in such validity thereafter appears to be greater than has been generally supposed.

Thus the Army psychologists' World War II position was that the test scores represented nothing more than an index of measured abilities at the time the test was taken, a position that prevails among most contemporary psychologists.

From 1940 to 1945, the AGCT, in one edition or another, was used throughout the Army; some 4,000 persons were given the test daily. Not only were the research results used by psychologists for years to come, but new uses are still being found to this day.

Implications: New Directions for Research

During World War II, PRS psychologists examined almost every type of selection device that could be standardized and then subjected each device to vigorous empirical evaluation. Cognitive tests, psychometric tests, personality tests, biographical inventory tests, psychomotor tests, and sensory tests were tried out for different kinds of selection and classification programs. Interviews, essays, ratings, performance-based measures, and assessment techniques, all accompanied by vigorous attempts at obtaining reliable and relevant criterion measures, were also used as selection tools. The data coming from these investigations proved to be the best extant on ability testing for training and employment. Such data provided the standard of quality for industrial psychological research and pointed to new directions for such research.

The transition from broad classification to differential ability testing was gradual. The AGCT-3a was the first manifestation of a battery of tests. The earlier AGCT tests were predominantly verbal, including items on arithmetic reasoning, vocabulary, reading comprehension, and spatial relations, and were scored as a single test. As early as 1941, research and operating experience indicated the need for supplementary tests for use in classification. As described earlier, specific tests such as Mechanical Aptitude, Clerical Speed, Radio Code Learning, and Automotive Information were introduced at various times to supplement the AGCT in classification. By the fall of 1947, 10 such tests (later to make up the Army Classification Battery) had been in use for classification; however, interpretations of the meaning and appropriate use of the test scores varied widely, and it was not possible at the time to make available sufficient data on validity and interrelationships so that even technically trained personnel could make optimum use of the tests. Work was begun on a continuing program to determine the combinations of tests that were valid for various groupings of Army Military Occupational Specialties (MOS).

The use of psychological tests during World War II for purposes of initial screening for service began soon after induction became effective. Wartime screening for mental abilities passed through a number of phases, each characterized by psychological testing procedures. For example, screening tests were used only to select men who were at very low mental levels, a practice that continued after the war for the full range of mental abilities.

Of greatest significance was the aggregated success of World War II psychological research in such diverse areas as selection and classification, training, leadership development, large-scale measurement of attitudes and values, and diagnosis and treatment of emotional problems. The psychologist's demonstrated ability to provide practical tools and techniques for application to people in the workplace was the key factor in the postwar demand for psychologists, both in terms of additional numbers needed and in the number of subdisciplines.

More specifically, in 1939, APA had 618 members; by 1950, the number of members was 6,735, a growth of nearly 11-fold! The World War II experience led for the first time to significant employment opportunities for psychologists in government agencies (federal, state, and municipal), industry, research foundations, health services, marketing, and many other pursuits, as well as in academia. World War II was the coming of age for psychology.

Army Air Corps Research Program

This chapter has concentrated almost exclusively on the birth of Army research organizations—principally the Personnel Research Section in The Adjutant General's Office. During the 1940s, Navy and Air Force programs also proliferated in organizations antecedent to today's Naval Personnel Research and Development Center (NPRDC) and the Air Force Human Resources Laboratory (AFHRL)—both sister laboratories to ARI. Since the AFHRL was a direct descendant of the Army's aviation research program, it merits special mention.

In 1941, the Civil Aeronautics Authority Committee on Selection and Training of Aircraft Pilots urged the expansion of Army's program in personnel research, which had begun in 1939, to include aviation personnel problems. The resulting wartime research activities in aviation are best remembered by the older behavioral scientists today as the Army Air Corps "Aviation Psychology Program." Its director was John C. Flanagan, who gave many of his staff their professional starts in psychology with opportunities for making research contributions in several psychological areas: selection and classification of aircrew personnel; proficiency evaluation; instructional procedures in flying training schools; flight operational procedures; individual reactions to combat; individual differences; evaluation of education and training effectiveness; and equipment design.

Throughout the war the most extensive aviation research program was on the problems of the selection and classification of air crews. "Stanines," which were weighted, single-digit standard scores of the Air Crew Classification Battery, were validated against success in training and in combat, along with other operational and experimental tests. An early decision was made to use a screening test, the Army Air Force Qualifying Examination, for preliminary selection of men to be trained for air crews. On the basis of a battery of printed and apparatus tests, weighted predictive scores were determined separately for pilots, bombardiers, and navigators.

On July 26, 1947, the National Service Act, while providing for unification of the services under a Department of Defense, created an Air Force separate from the Army. Beginning in 1947, research directed at Air Force selection and personnel management (as well as later programs reflecting more comprehensive approaches to human factors problems) was the province of Department of Air Force research elements such as AFHRL, the Air Force Aerospace Medical Research Laboratory, the Air Force Office of Scientific Research, the Aerospace Medical Division, and the Simulation Systems Project Office.

Part 2

Research following World War II

Chapter 3

The Psychology of Individual Differences, 1946–1959

Army leadership in the early 1950s considered various means of strengthening and expanding existing programs of behavioral research, particularly in areas that required ready applications. New organizations with missions in training research and human engineering were established. ARI's research activities were largely a continuation and refinement of World War II efforts. Its mission was to enhance performance of soldiers through better selection, classification, assignment, and utilization techniques, and it chose to do so through the application of state-of-the-art solutions to old problems. By the late 1950s, ARI had initiated the first comprehensive attempt to broaden its programmatic objectives in an area critically important to the Army. The research program on image interpretation and surveillance systems served as a valuable prototype for ARI in later years and set the stage for a systems approach to military research.

The Industrial Testing Environment

If the Army and Navy were quick in 1919 to drop their general testing programs, in the 1920s potential test makers jumped at the opportunity to make civilian application—and profit—from such activity. By 1947, 560 commercial tests, applicable to a large number of different occupations, were offered the public, and there were many takers. At least one government agency—the U.S. Employment Service (USES)—was not to be left behind in this rapidly growing technology. In a display of notable initiative, USES announced it would make standard tests available at no cost if companies would report their results to the agency. In 1949, according to Baritz, about 300 companies did use these services (Baritz, 1960, p. 156).

The use of tests in private industry continued to grow steadily through the 1950s and into the 1960s. In 1947, National Industrial Conference Board surveys conducted by Scott reported that 26 percent of a sample of "best-known" companies gave intelligence tests for selection and promotion (Scott, Clothier, & Spriegel, 1961). From 1947 to 1953, growth in the use of tests of all types by these companies increased from 66 to 75 percent. Clerical tests were the most commonly used, followed by tests of intelligence, mechanical ability, personality, and interests.

Both state and industrial testing programs grew rapidly after World War II. A modification of the Social Security Act of 1939 provided the initial impetus by requiring states to employ merit systems for employees in the Social Security program. This requirement was also applied to other federal grant programs. The federal public assistance and public health programs brought all but two states into the merit system by 1949. By the 1960s the majority of states had comprehensive merit system programs that were not limited to federally funded programs. During the 1960s and 1970s, with the passage of the Civil Rights Act of 1964, Title VII, and as a result of various presidential executive orders during the Johnson and Nixon administrations, interest in establishing objective programs of employment and maintaining records of hiring and promotion decisions became a necessity rather than an alternative.

Selecting Management Personnel

During the postwar years, a significant trend in psychological testing was seen in the increase of the use of tests to select management personnel. In 1983 white collar workers accounted for nearly 53 percent of the total adult work force, and as much as 70 percent of industry's annual payroll. The Bureau of Labor Statistics estimated that the white collar work force would grow to 55 percent by 1985, and some believe it could reach 90 percent of the total U.S. work force by the year 2000. The trend toward white collar work began its rapid growth immediately after World War II and with it came the enormously increased demand for managers. The use of psychological testing for the selection of managers became the hot new issue in the late 1940s and has continued to this day to dominate a major segment of industrial test activity. Highly selected and trained managers were seen as the key to ensuring productivity. (These managers would in time direct their attention to human resources development, to new technologies, and to environmental design considerations.) Still more firms sprang up whose sole purpose was to develop and apply tests to identify the large numbers of managers required by this transformation in American business and industry. A common approach used by these new firms was to supplement conventional aptitude-based selection batteries with personality tests and biographical inventories. As Hale reported, L. L. Thurstone helped develop a comprehensive battery of tests for Sears Roebuck that aimed at identifying potential managers from within the company itself. By the end of 1950, the battery had been used to test 10,000 employees (Hale, 1982, p. 29).

Scott reported that in 1953 44 percent of a sample of well-known firms used personality inventories, such as the Minnesota Multiphasic and Bernreuter

Personality Inventories (Scott et al., 1961, p. 566), a figure that a *Fortune* survey put at 63 percent a year later (Whyte, 1954, p. 117). According to Hale (1982, p. 30), many professional psychologists and personnel managers had long questioned the use of these inventories, which came under open attack by the mid-1950s following publication of such books as *The Fallacies of "Personality" Testing* (Whyte, 1954). By the mid-1960s, such books as *Brain Watchers* continued to attack personality tests (Gross, 1962).

Hale (1982, pp. 30-31) also noted that personnel managers in several leading corporations were beginning to look for improved ways of assessing managerial potential. One method attracting a good deal of attention was the multiple assessment technique applied by the Office of Strategic Services (OSS) during World War II (USOSS, 1948). This method was based upon a "holistic" concept, that is, a "complex of personal characteristics is more predictive of progress than any single characteristic." In 1956, American Telephone and Telegraph initiated an evaluative study of the assessment center approach in manager selection. Eight years later, the assessors "were clearly able to identify those more likely to advance in their organization" (Bray & Grant, 1966). The assessment center technique became very popular in industry until about 1,000 companies used some variation of it by the early 1970s. These centers had become "one of the more phenomenal success stories of applied psychology and organizational psychology and personnel administration" (Hinrichs, 1978, p. 596).

New Research Areas in the Military

In 1957, the Department of Defense (DOD) initiated a series of planning studies of the research on human behavior required to meet long-range military needs. In retrospect, the recommendations resulting from this effort influenced the services' projected agendas. The general approach was to define research areas relevant to future military needs "ready" to advance during the next decade. The description of these promising, ready research areas constituted a selected review of several new and significant but small demonstration programs initiated in the 1950s (Smithsonian, 1960). Our brief outline of these efforts is intended to give a notion of the rapidly changing military programs, particularly in the mid- to late-1950s, and follows Bray's summary of the larger report (Bray, 1962).

Human Performance in Systems

In the late 1950s, human functions were increasingly thought of as part of a soldier-machine system—soldier and equipment brought together for a common purpose and linked by a flow of information. The nature of systems then and now is such that a measure of military effectiveness can be obtained only by looking at a system as a totality rather than by analyzing the components or subsystems separately. Added to this systems orientation is the increased use of automation, which might either restrict or expand some of the classical functions soldiers serve. Among the expanding functions of the person in automated systems is that of information processor. In this context, the person obtains information; perceives temporal, spatial, and abstract configurations in it; and classifies and integrates it for his or her use and for input to other systems and components or to other persons. Experience showed that although automation was successful in replacing or aiding a person, it frequently produced problems of its own. Automation, even while it replaced humans, increased the need for understanding effective human performance.

Systems designers and users needed information about humans as information processors. The 1950s saw the development of techniques to simulate systems or subsystems and to test critical operations through the use of test beds as a check on simulation. It became common to look at simulation not only as the key to improving models of human functioning in systems, but also as the key to improving systems design to increase human performance.

One new aspect of research was measuring the performance to be expected of people under standard reference conditions. Although military conditions and personnel cannot be standardized, expected human performance can be estimated through use of standard reference conditions where variability is known. Still, research difficulties in estimating expected levels of performance abounded; for example, dealing with the large number of variables affecting performance, measuring performance in useful terms, and generalizing from one task to another. Researchers began to develop systematic taxonomies of tasks so that they could generalize results. One type of taxonomy dealt directly with intellectual standards for defined classes of tasks important to military systems. A second, more theoretical type attempted to improve classification based on common effects and interactions of different variables when these effects and interactions were generally known for many tasks.

Decision-Making Skills. Another area brought into the laboratories was the examination of cognitive skills, particularly as the skills related to making complex decisions. In decision making, a person receives information, integrates it with other stored information, and generates alternative solutions to a problem. In making a decision, he or she chooses among the alternatives available and creates new alternatives or actions. Efforts in information-processing research proliferated.

Research on decision making also proliferated because of the recognition that decisions would have to be made more and more rapidly, would need to take into account a wider range of information, and would have to be made at lower echelons in the hierarchy, often in isolation from main military situations. Consequently, a period of rapid acceleration in the development of theory of decision processes was begun in the early 1950s. Such studies included models of cognitive processes, decision making in gaming situations, and the

measurement of aptitudes and decision styles as determinants of problem solving.

Team Research. Although military establishments are characterized by extensive and expensive efforts to train effective teams, there had been little programmatic research on teams within the military sector. State-of-the-art knowledge was not lacking, because such research was common in group psychology, interpersonal relations, and social perception in industrial settings. It was recognized that scientific progress in team functioning would hinge on how well appropriate and generalized measures of team effectiveness could be developed.

The Adaptation of Complex Organizations to Changing Demands

A second major area concerned complex organizations. The essential problem here, from the military point of view, was how to adapt its complex organizations to changing demands. Until the 1950s, workers in organizations were thought of as machines, and motives were accorded little importance. With the general trend in our industrial society toward humanism, the importance of each individual and of securing his or her active participation in the pursuit of organizational goals was emphasized. Later, game and information theorists dominated the scene and emphasized decision making, the communication of information, and a problem-solving view of the role of individuals in organizations. In addition to relating research on systems and teams, scientists began to call for research on organizational goals, management strategies, incentive systems, and coordination and control.

Persuasion and Motivation

A third area that may have had more attention in the 1950s than it does today concerned the processes of persuasion and the nature, development, and stability of attitudes. Concepts of attitude were poorly defined, although useful technology for attitude assessment existed. Studies examined the relationships among attitudes, motivations, cognition, and personality, but no clear understanding emerged. One major finding of attitude research in World War II was that the American soldier was motivated less by ideology and training than by his desire not to "let his buddy down." This finding suggested the desirability of a combination of field studies, using attitude survey techniques, with laboratory studies of two-person interactions in response to persuasion in simulated situations. But despite a call for systematic research in this area, little work was done.

Expanding Psychological Research for the Army

In the summer of 1943, for various reasons including the need to obtain personnel, Personnel Research Section (PRS) moved to New York City. Overcrowded conditions in wartime Washington had made it almost impossible to recruit full-time personnel, and the supply of qualified consultants was far greater in New York than in Washington. In the spring of 1947, PRS returned to the Pentagon and continued to pursue the research program that had characterized its wartime activity.* (For an account of physical location shifts and geographical expansion of ARI from 1951 to 1983, see Appendix F.)

The needs of the Army for broader applications of psychological knowledge resulted in the creation of a number of significant new research groups. These included the Human Resources Research Office (HumRRO) of the George Washington University, established in 1951; a Department of Psychology established in the Walter Reed Army Institute of Research in 1951; the Human Engineering Laboratory (HEL) at the Aberdeen Proving Ground, established in 1953; and the Human Resources Branch, established at the Climatic Research Laboratory in Lawrence, Massachusetts, in 1953. HumRRO is worthy of additional comment in our history because of its close association with ARI.

Human Resources Research Office

During the years immediately prior to 1951, the Army staff considered various means of integrating, strengthening, and expanding the existing program of research in the behavioral and social sciences. Professor Harry Harlow, serving as chief of the Army's Human Resources Research Program while on leave from the University of Wisconsin, was largely responsible for the recommendation that "a major contract be awarded to a recognized educational institution to provide for the formation of the Human Resources Research Office (HumRRO), which would have primary responsibility for conducting research in the areas of training methods, motivation and morale, and psychological warfare techniques." This recommendation, included in a staff study, "An Integrated Program in Human Resources Research," was approved by the Army in June 1951. The leadership of ARI (then PRS) preferred at the time to limit its research scope to the personnel measurement area—its area of recognized expertise. A contract between the Army and the George Washington University created this new organization in July 1951. The mission of HumRRO remained essentially unchanged until 1955, when the responsibility for psychological warfare was dropped from its mission. The improvement of the performance of individuals and units primarily through training and education became the dominant theme in HumRRO's research and development activities.

In 1963, HumRRO was included in the list of Federal Contract Research Centers (FCRCs), published originally by the National Science Foundation and

*For convenience, in discussing the work of this period, the organization will be referred to as ARI whether or not the work was actually conducted by PRS or its successors. See Appendix H for specific names and dates.

accepted by the Congress and the Department of Defense. While HumRRO was part of the George Washington University, its entire effort was devoted to the Department of the Army under a single contract. In 1967, the contract was modified by mutual agreement to allow for multiple sponsorship, and HumRRO began a modest program of diversified sponsorship. In 1969, HumRRO left the university and began operations as an independent nonprofit corporation; at that time, its name was changed to Human Resources Research Organization. As sponsorship by other government departments increased, HumRRO requested removal from the list of FCRCs, and its contractual relationship with the Army ended in 1972. During this entire period, Meredith P. Crawford served as president of HumRRO. Appendix G describes HumRRO's major research areas during its formal association with the Army (Crawford, 1974).

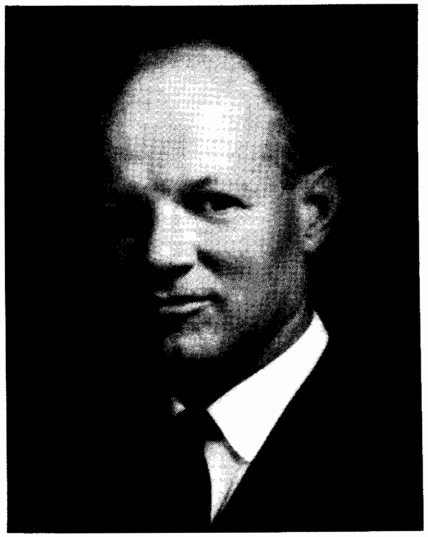
The Army's Personnel Research Program

Military psychologists' scope of effort had already expanded considerably several years before the DOD prospectus on human behavior research began in 1957. Army psychologists after World War II had much unfinished and new business to take up: the continuation of previous research, the investigation of new concepts, and new military personnel applications suggested by the growing state of the art.

Historically, ARI's research activities had been largely those of industrial psychology. This trend was natural, because ARI pioneers had been essentially industrial psychologists, steeped in the tradition of the psychology of jobs and the world of work. The methodological mainstay of industrial psychology—testing and test development—became ARI's mainstay during this period—to predict success in training, success in total job performance, or success in critical aspects of jobs, tasks, or functions. As a case in point, ARI worked intensively on general mental ability testing for screening enlisted personnel, first for the Army alone, then from 1950 for DOD and the other services. Similarly, from World War II until the late 1950s, ARI was heavily engaged in both the methodology and substance of differential classification.*

During this period, ARI moved even more vigorously into the world of work while taking full advantage of methodological developments such as operations research, including cost-effectiveness concepts. ARI emphasized mission output, took greater advantage of sophisticated computer capabilities, and began to add systems analysis to its stock of techniques (Uhlaner & Drucker, 1967, p. 40).

*The scientific leadership of ARI in the late 1940s included Donald E. Baier (Chief Scientist), Harry Harman, Charles I. Mosier, Edward A. Rundquist, and Erwin K. Taylor. Scientific leaders in the 1950s included Hubert E. Brogden (Chief Scientist), Edmund Fuchs, E. Kenneth Karcher, Samuel H. King, J. E. Uhlaner (Research Manager), and Joseph Zeidner. Additional scientific personnel are listed in Appendix I.



U.S. Army photograph
Hubert E. Brogden

Cost Effectiveness and Systems Analysis

The results of this expanded thinking led in the mid- to late-1950s to the development of a research program designed to improve total mission output in a work setting, whether it be a simple job, a portion of a job, jobs in the aggregate, or a group of interrelated jobs in conjunction with sophisticated equipment. There was much less preoccupation with "finding the best man for each job." With increasing shortages of skilled human resources, military or civilian, selection often had to take a back seat. After all, industrial and personnel research psychology had classically concentrated on work methods and on human interface with equipment and relationship to the work environment.

With the methodologies and computer equipment available, ARI began to ask research questions that took into account real-world variables. How could military effectiveness in a systems setting be improved? How could military mission effectiveness be improved, assuming one could realistically measure such effectiveness? As a matter of fact, much of this new effort borrowed psychometric theory that had been applied to criterion development and now applied it to systems output measurement. For example, if the Army provided sophisticated equipment such as stereo to the image interpreter at a known cost, was stereo worth its dollar cost in terms of speed, accuracy, and completeness gains, if in fact there were any gains? What would be the effect on the measured output? In short, the thinking at ARI was to approximate the world of work at least in part in a systems setting, where interaction effects could be examined systematically and trade-offs evaluated from a cost-effectiveness point of view.

It was the criterion concept in new dress. If one were going to put more money and time in training for a given level of performance, could one utilize

personnel of lower ability levels? It was crucial to attempt research where a mix of different kinds of training and ability levels of personnel was evaluated and where different mixes were studied in terms of expected utility, cost matrices, and trade-off considerations. Military objectives might be specified in terms of time and cost of training.

Human Performance Experimentation

Under its Human Performance Experimentation domain, ARI sought principles applicable to many Army systems. To enhance human functioning in those systems, ARI studied general behavioral functions common to many Army systems, such as vigilance required of system monitors, efficient electronic communication in combat operations in a modern tactical environment, and ability to perform effectively in night operations. To do the research, ARI scientists obtained parameters and variables from the military systems under study, simulated these in the laboratory, used special program equipment for data input and reductions, and checked out the experiments in the field.

Studying Jobs in the Aggregate

In its Selection Research domain, ARI studied jobs in the aggregate, attempting to determine how to make optimum use of enlisted personnel of lower mental ability. The utility of Armed Forces Qualification Test (AFQT) scores in measuring the potential value of young people for performance in military jobs had been demonstrated over and over again. As one descended the AFQT scale, it was harder to find ways of training men in a reasonable period of time to a level of performance at which they could function without close supervision.

Another effort typifying the study of jobs in the aggregate was the use of human resource models in personnel resource allocation. A sequence of computerized simulations of personnel systems was developed. In such models, sequences of normally distributed random numbers were generated and then transformed so that they had the statistical characteristics of scores on the variables represented in the model for the input population. Particular operations were then applied to these simulated personnel samples, the optimal allocation was performed, and the criterion value was calculated.

Manned Systems Research

In its manned systems research, ARI emphasized the enhancement of systems output as it related to the person's role in small Army systems. It was in this domain that the challenge of conducting integrated human factors research was finally accepted. ARI's Surveillance Program was illustrative of this research. Such manned systems research was characterized by an integrated approach that could involve all the critical human aspects in the soldier-machine interface. Fundamental to much of the systems output, and particularly human performance within those systems, was better, more accurate, and more timely decision making. Based upon the greater capability of measuring output then at hand, this approach brought together psychometric theory, probability theory, and soldier-machine interface knowledge. The approach used the computer as a major partner and considered cost in a total value (not solely economic) sense.

Manned Systems Research dealt with a rational means of improving decision making. The feasibility and usefulness of using expected cost estimates as a way to control the information produced by a facility for image interpretation were investigated. That approach employed realistic systems concepts and the means for implementing an expected cost matrix. The decision maker's judgments and experience first had to be made explicit in the form of probabilities and value indices in the construction of a problem. When a given problem was formulated, the decision could specify a course of action that was best according to well-delineated and measurable criteria. Such efforts became vehicles for making the products of manned systems research most useful for military planners, decision makers, and designers.

By the end of the 1950s, ARI had started to emphasize the interdependent aspects of military human factors problems, interrelating these aspects in broad research approaches. Once the focal point (as in selection and classification research), the soldier came to be seen as a link in the soldier-machine-computer system. The researcher no longer simply asked, Is soldier A better than soldier B? but rather, For a given cost, do the products of the developed system meet the military's requirements? The greater complexity of such a research approach was believed to meet more fully the military user's needs. Several programmatic efforts are described in the following paragraphs.

Induction and Recruitment

Congressional legislation had provided the basis for procedures to screen input quality so that persons lacking military trainability might be rejected. Successive forms of the AFQT met the requirements in the form of an overall screening measure. The concept of a common instrument to be used in screening inductees and enlistees for all the services had originated in the late 1940s, based on the recognized principle that the basic mental abilities required for initial enlistment and induction were common to all the services. Such a common screen had the advantage of providing an objective basis for the equitable distribution of human resources.

Development of successive AFQT forms had been in accordance with the direction of the Armed Forces Examining Station Policy Board, Department of Defense, and in close coordination with representatives of policy and operating agencies of the services. In these developments, the Army, in its capacity as executive agent of the board, had overall responsibility, with the Navy,

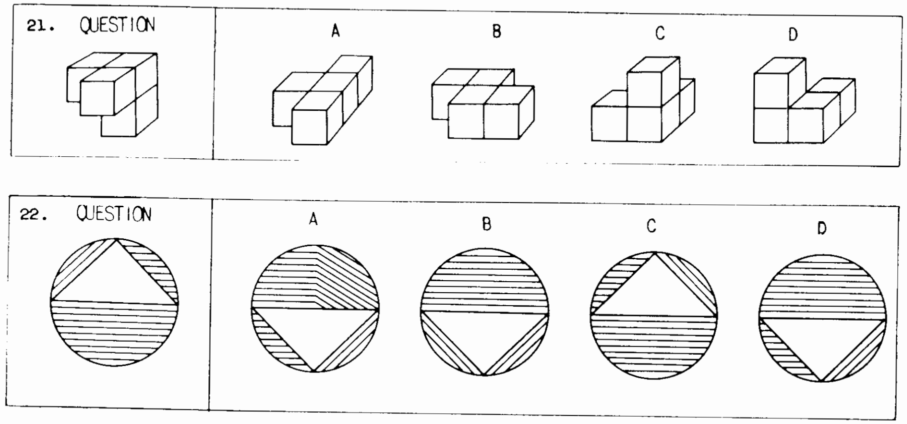
30. The tie was not appropriate.
A) attractive
B) expensive
C) necessary
D) suitable

31. He was bewildered.
A) angry
B) anxious
C) confused
D) disgusted

32. Food supplies were abundant on the island.
A) available
B) limited
C) plentiful
D) scarce

37. If a boat carries 24 times as much as a plane, how many planes are needed to carry the goods from 6 such boats?
A) 204
B) 144
C) 6
D) 4

38. If railroad fares are increased 20%, how much more will you pay on a $15.00 ticket?
A) $3.00
B) $2.00
C) $1.50
D) $ .75



Sample vocabulary, arithmetic, block-counting, and spatial items from AFQT-1a

the Air Force, and the Marine Corps contributing substantial efforts. In July 1960, new Forms AFQT-7 and AFQT-8 were introduced for operational use. Following the research design for previous forms, experimental test items in four content areas developed by the separate services were administered to 3,000 armed forces personnel for item analysis and item selection. Final forms were then administered to standardization samples representative of the mobilization population as a basis for conversion of test scores to percentile scores. AFQT-7 and AFQT-8 correlated substantially with the preceding operational forms (r = .89 to .90) and were satisfactory alternate forms for screening (Bayroff & Anderson, 1963).

One related research effort concerned proper disposition of induction failures. Those who deliberately sought to conceal their mental abilities to avoid service were identified by tests. There was also a need to identify those who met induction standards but whose overall usefulness to the Army was submarginal. Identification prior to induction was the ideal; but as an intermediate goal, means were sought for making such identification (to be followed by separation action) early in basic training. Research was also undertaken to deal with the identification of marginal persons who could successfully complete basic training. Embedded in this effort was research to develop performance utility standards that would permit determination of the ability level at which the marginal person's contribution began to exceed the costs of achieving and maintaining the contribution—an early indication of cost-effectiveness analysis in personnel research.

Although the Army was in a peacetime situation, planning for research usually projected full mobilization. Women and physically limited personnel were examined as untapped human resources who might contribute effectively to the military mission in time of war. Based on analyses of jobs and job requirements, a list was prepared of MOS judged suitable for enlisted women (Sternberg & Greenberg, 1958). The information, together with the results of a census of aptitudes appropriate for Army jobs present in the civilian population eligible for WAC service, provided the basis for assessing the potential impact of utilizing WAC personnel in an operating situation. This was ARI's first venture into research considering women as a new source of personnel available to the Army.

Enlisted Selection and Classification

ARI's experience in classification research had led to the conclusion that the most efficient classification would likely result from measuring not only technical skills and abilities, but such personal factors as motivation, interests, and attitudes, particularly for combat classification. ARI was determined to step up the quest for measures of factors not yet provided for in the Army Classification Battery (ACB).

In 1949, ARI organized initial classification measures into aptitude areas comprising combinations of tests for various MOS. The resulting Army Aptitude Area System for differential classification was a major innovation for military personnel operations. When compared to the single measure on the AGCT used during World War II, differential classification met more personnel training requirements. Using a single overall measure of general mental ability, only general differences among men could be identified. As a result, men with high scores would be assigned to jobs demanding special ability, while men with lower ability were assigned to nonspecial jobs. Using Aptitude Area Scores, however, classification would be based on demonstration of individual skill and ability combinations deemed necessary for a particular position. The result was the fitting of available human resources to the jobs needed in a more efficient manner because many more potential skills and abilities could be utilized across available human resources (Zeidner, Harper, & Karcher, 1956). The Aptitude Area System introduced differential classification to the world of military psychology and established it as a major innovation in classification procedures.

In addition, research on differential classification provided a continuous flow of useful data on the validity of ACB measures for both training and jobs. Analysis was directed at providing a basis for closer matching of available aptitudes to training and job requirements. Men qualified for assignment to training in critical technical specialties such as missile maintenance and operation were in short supply, whereas surpluses of qualified personnel had been found in less critical areas. Accordingly, research was undertaken to reexamine aptitude requirements for critical Army jobs and to develop improved procedures for allocating available ability resources to meet the need in critical areas. For the benefit of operational Army interest, effort was next directed toward identifying training courses and jobs for which selection was made on the basis of aptitude areas in which shortages existed, but which could be adequately filled by men with aptitudes in areas of plentiful supply without undue reduction of job effectiveness (Helme, 1960).

Closely related to this operational problem was that of assigning and allocating personnel to combat units. As a result of the relatively high standards set for school training in technical courses, relatively lower mental category personnel had been allocated to combat units. A feasible system of assigning men to combat units was hence developed to maximize combat effectiveness. The method required the simultaneous consideration of numerical personnel requirements, input in terms of measured aptitudes, the validity of classification measures (the aptitude areas), and the relative importance of different MOS with respect to the Army's mission. The projected solution encompassed programming of mathematical computations to arrive at optimum allocation of personnel, both to combat units and to the rest of the Army (Boldt & Seidman, 1960).

Some special needs, however, could not wait for the completion of the above generalized programs. The identification of individuals capable of absorbing and retaining electronics skills was one immediate need. Extensive validation research on experimental predictors was instituted to help develop an electronics selection battery. An opportunity to assess test validity for electronics personnel working under widely varied conditions was afforded by collecting predictor and criterion measures on trainees at Signal Corps schools, the Air Defense School, and the Ordnance Guided Missile School, and on personnel assigned to Ordnance and Signal MOS, including men serving at Nike sites (Helme & White, 1958).

Officer Selection and Leadership

Leadership requirements of a modern army are never completely satisfied. During the late 1950s, research to develop means of early identification of potential officer leaders was a major thrust of ARI. Two approaches were taken: One concentrated on the selection of combat officers; the other continued research to identify special facets of leadership and special abilities peculiar to combat, administrative, and technical jobs. Both phases of the research utilized problem situations and ratings as criterion measures in the development and evaluation of predictor measures. (Later, in the 1960s, a most comprehensive assessment-center type of performance evaluation was to be used.)

At the same time, maximally effective measures were called for to select men to be trained in officer procurement programs such as Officer Candidate School (OCS), Reserve Officer Training Corps (ROTC), and the U.S. Military Academy. It was hoped the selection measures would enable the Army both to maintain the high caliber of the officer corps and to reduce attrition in the training courses. Researchers found it necessary to cope with some elusive operational factors that tended to reduce the effectiveness of selection procedures developed with respect to training success: the inclination of the OCS to fail the same number of cadets no matter how refined the selection processes, and whether or not to accept at face value for research purposes the reasons cadets and officer candidates gave for resigning (Parrish & Drucker, 1957).

Also, as the Army reduced to peacetime status, ARI directed its efforts toward developing a new officer efficiency report, working toward objective rating standards that would minimize criterion and rater bias and that would be acceptable to raters and ratees alike. Results of a comprehensive program of rating research will be discussed in the next section.

During the late 1950s, ARI also worked to develop techniques to identify, early in their Army careers, enlisted men capable of becoming good noncommissioned officers (NCOs) in the combat branches. Research proceeded through a study of characteristics of NCOs who were effective leaders and who were able to motivate their followers to effective action as a basis for the development of experimental predictors. A major effort was devoted to the development of situational tests of leadership for use as criteria of effective NCO performance, for the validation of selection measures, and for discriminating real differences in NCO leadership operationally. These tests had to be easy to administer and yet yield objective scores indicating leadership level (Medland, Hammer, & Frankfeldt, 1962).

Combat Prediction

Because of the great emphasis the Army had placed on individual combat soldier and officer performance, ARI had for a number of decades emphasized noncognitive research. Most significant was a concern with the development of possible predictive measures of successful combat performance from the point of view of an individual's will to fight as a vital adjunct to the cognitive capabilities required in such situations. The finding that combat performance could be predicted through noncognitive measures was turned into operational use in 1958 with the introduction into the Army Classification Battery of two new tests, the Classification Inventory and the General Information Tests, used to comprise two new combat Aptitude Areas, IN and AE. Aptitude Area IN, designated for use in classifying to combat specialties in infantry, proved very promising in terms of its potential for differential classification when compared with the Aptitude Area it replaced. Aptitude Area AE, designed specifically for classifying to combat specialties in Artillery, Armor, and Combat Engineer branches, also proved very promising when compared with the former Aptitude Areas and Aptitude Area IN.

The research behind IN and AE involved experimental testing of approximately 5,000 enlisted combat arms personnel—2,000 in actual combat (Korea), 1,000 in Arctic maneuvers, and 2,000 in both a training and a later overseas garrison/maneuvers situation. Still another 2,000 men in a training status were tested in supplementary studies. These data furnished both predictor and criterion rating scores for the research (Willemin & Karcher, 1958).

ARI continued to pursue the objective of determining what makes fighters and to improve techniques available to select men with fighter potential. After the ceasefire in Korea in 1953, continuing the combat selection effort required the creation of an effectively realistic, albeit simulated, combat situation. It was generally acknowledged that the U.S. Army Ranger course was the most rigorous infantry training situation available. As a first step in translating the rigors of Ranger training into combat-type situations for combat selection research, an ARI psychologist enrolled as a full-time trainee to gain first-hand information and insight through actual field participation. Eight psychological requirements of Ranger training appeared best for combat simulation: situations inducing extreme fatigue (lots of outdoor exposure, sleep deprivation, equipment carrying, and cross-country movement); unstructured situations; conflict situations; acceptance of training as real combat; lack of direct knowledge of personal progress; inability to leave the course voluntarily; utter dependence upon teamwork; and the need to observe and retain military information. Reactions typifying nonsuccessful as opposed to successful Ranger trainees were malingering; lack of social responsibility; expressions of martyrdom when volunteering; unauthorized withdrawal (in tactical exercises); hostility; fear of injury; uneasiness over unknown situations; psychotic-like reactions; failure to assume the assigned combat role; and inability to pay attention or follow instructions (Peres, 1959, pp. 27-35).

Visual Measures for Day and Night Performance

ARI's earliest research objectives in the area of night vision were to devise techniques for assignment of special military jobs requiring night vision abilities and to determine the effectiveness of the Armed Forces Vision Tester being considered by the Surgeon General for use in the induction physical examination. During World War II, several combat units had illustrious successes because their commanders had insisted on intensive training in darkness.

Experience in Korea had shown that one third of all engagements took place during hours of darkness; Army training programs were modified accordingly to reflect this emphasis. Following Korea, night movement and combat became standard tactical training procedures, especially as necessary conditions for many of the Army's modern weapons and surveillance systems. Because it was found that the wide ranges of night vision ability could not be reduced by training, the exploitation of individual differences through research was given wide recognition.

In 1955, a requirement had been set forth for an effective, simple test of night visual acuity to enable the Army to capitalize on individual differences. Accordingly, ARI conducted research consisting of a basic examination of individual differences and the development of instruments to test night vision. This research eventually produced the Army Night Seeing Tester (ANST) and a body of pertinent information.

During research phases, it had been determined that night seeing ability depended mainly on brightness contrast sensitivity and line resolution factors. This finding was taken into account in instrument-development phases. Interestingly, little relationship could be found between daylight seeing ability and night seeing ability, but ability to see at different low levels of illumination was correlated (Uhlaner & Zeidner, 1961).

A decade later, night operations research was being addressed through field-laboratory techniques to develop quantifiable and reliable measures of human performance as it affected systems output. A program involving highly specialized experimental methodology conducted in the field under night conditions was established by ARI at the Combat Development Command Experimentation Center (CDCEC), Fort Ord, California. Operational data useful as a basis for establishing procedures and for improving search and scanning performance in night operations were obtained. In fact, ARI developed a mobile automated on-line data recording system to provide rapid feedback of findings to military users as well as a data base on search behavior for more exhaustive analysis (Banks, Sternberg, Cohen, & DeBow, 1971).

Selection of Army Aviators

When the Army first began to develop its own aviation capability following World War II, selection of personnel to be trained as Army aviators posed no special problem. Many pilots in the Army Air Corps remained in the Army after the formation of the Air Force. But this supply of experienced human resources was eventually exhausted, and it became necessary to train men who had had no previous flying experience. A high failure rate among trainees with resulting loss of lives, equipment, time, and money was soon noted. In 1955, ARI began developing a program to select fixed- and rotary-wing pilot trainees.

The Air Force had done exhaustive research on fixed-wing pilot selection, so initial ARI research was limited to modification and adaptation of Air Force selection batteries and follow-up studies to determine their effectiveness. The same approach was not successful in ARI's rotary-wing selection research. Most of the helicopter pilot applicants entered aviation training as enlisted men who had received appointments as warrant officers upon completion of the Warrant Officer Candidate Aviator Course. However, the later leadership performance of many of these warrant officer pilots was considered unsatisfactory; as a result, the training program was expanded to include intensive training of the type given in OCS. Attrition tended to be considerably higher than in officer pilot courses because of the requirement for enlisted trainees to emerge as officers as well as pilots.

To reduce attrition among helicopter trainees, ARI conducted extensive research to improve selection instruments. Both Navy and Air Force pilot selection tests were less effective in the Army rotary-wing situation. More than 40 tests and measures appeared promising enough to be incorporated into experimental batteries for comprehensive validation. Included were background predictors, four types of personality and motivational measures, four Air Force psychomotor tests (apparatus tests), and a variety of cognitive tests and measures (Zeidner, Martinek, & Anderson, 1958).

Recommendation of a six-test provisional selection battery resulted from validation studies involving numerous experimental measures. The resulting Flight Aptitude Selection Test Battery (FAST), for both fixed- and rotary-wing use, provided the Army with a solution to the "double hurdle" problem of leader-pilot prerequisites that many of the earlier applicants had not been able to satisfy. "The most effective single test for predicting overall success in training was in fact a self-description instrument . . . . Results with this test furnished empirical evidence that success in training for Army Aviation requires a variety of attributes—motivation, personal adjustment, leadership attributes, as well as flying skills" (Drucker & Kaplan, 1966, pp. 29–32). Later revisions of FAST are still in use in Army aviation programs.

Language Aptitude and Proficiency Tests

Improvement in the selection and classification of linguists in the Army had come about through tests of foreign language ability. ARI worked jointly with the Army Language School to develop and improve the Army Language Proficiency Tests. In all, 65 such tests were developed. (See Appendix J for a list of the languages covered in the language proficiency testing program in 1962; that appendix also cites many other operational testing programs to which ARI made a research contribution.)

Army language proficiency tests in Russian and Mandarin Chinese were constructed to serve as prototypes for additional language tests. The evaluation of their effectiveness was conducted in three steps: experimental test materials were administered to Army personnel possessing varying degrees of ability and experience in the two languages; scores were compared with performance on simulated interpreter and translator tasks; and those portions of the experimental tests that proved to be most effective in predicting how well a person would perform on the simulated tasks were retained to include in the prototype tests.

The validity coefficients of the final form of the prototype tests were .77 and .79, respectively, for parts I and II of the test in Russian and .75 and .79, respectively, for the test in Mandarin Chinese. The criteria used for part I of both tests were the respective interpreter work samples scored on the speaking and understanding parts. Cutting scores recommended indicated three potential levels of performance: suitable for emergency use only, satisfactory for most interpreter and translator jobs, and very successful for most interpreter and translator jobs.

Many Army linguists had to handle assignments requiring a high fluency level in an obscure foreign language and hence had to learn from scratch. It had been previously determined that language proficiency was a capability that existed differentially in individuals regardless of the language. Accordingly, qualification for assignment to the Army Language School was in part determined by tests of aptitude for learning a foreign language. Thus, ARI constructed the Army Foreign Language Aptitude Battery to meet the need for an objective standard in selecting foreign language trainees.

Psychological Factors in Image Interpretation

The Army's critical need to improve the combat intelligence capability of tactical units through more effective use of sensor systems such as radar, infrared and television images, and moving target indicators prompted the initiation of ARI's manned systems research in image interpretation in the late 1950s. This program served as a valuable prototype for ARI in later years and set the stage for a systems approach to research. This area was in fact the first comprehensive attempt to broaden programmatic objectives by including the total performance of individuals within a systems context. Systems efforts on image interpreter teams and on their information-assimilation and decision-making skills were measured for accuracy, completeness, and time required for decision. Field and laboratory efforts were combined, and real-time computer simulation was brought in for the first time. Overall, ARI researchers were concerned with determining the common and unique psychological factors required to interpret imagery material from the various media as a basis for the development of both performance standards and selection methods for image interpreters. Researchers also charted the individual's potential contribution to image interpretation in terms of abilities and aptitudes, and the utilization of human resources that would best meet the need for accurate intelligence information from conventional as well as from nonconventional imagery material. Specific research areas were image interpretability, real-time and near-time interpretation, soldier-computer interaction, change detection, mensuration-location, training, keys-references, and resources management. Primary users were trainers and trainees, developers of doctrine, and systems developers-designers. Research findings were used to help enhance the performance of the human component in current systems, provide developers with design specifications for future systems, and determine areas needing further research (Zeidner & Birnbaum, 1959).

Selected Research Findings

The Dollar Criterion

Industrial psychologists, when they stopped to think about it, were not happy over their choice of criteria of industrial efficiency against which to validate selection devices. All too frequently, they tended to choose those indices that were most immediately available—frequently not those most desirable.

The problem caught the attention of two members of ARI—Hubert E. Brogden and Erwin K. Taylor, who recognized and emphasized the need for a common metric for subcriterion variables, such that the measures obtained would reflect the contribution of the individual to the objectives or the overall efficiency of the hiring organization. Brogden and Taylor proposed a general rationale for converting production units, errors, and time of other personnel consumed into dollar units on a cost-accounting basis to give direct face validity to the criterion. Each criterion scale could be shown to be directly oriented toward the objective of the organization to ensure that validation analyses could be interpreted as estimates of the degree to which predictors contributed to this objective. Units on the scales would be equal, and scales would be comparable, one to another; they could then be combined into a direct weighted sum with a rational basis for such combination.

In developing the dollar criterion, it is critical to trace the exact nature and importance of the effect of each variable on the efficiency of the organization. "Its usefulness lies in the possibility provided of obtaining an early estimate of the relative importance of the various criterion elements, and a selection of those elements of most importance in arriving at a practicable approximation to a measure of the total effect of the individual on the efficiency of the organization" (Brogden & Taylor, 1950, pp. 141-142). To trace the effects of accidents, for example, an evaluation of the cost of repairing the resulting damage would be required, including time of other personnel lost because of personal injury.

In the larger and more generally applicable sense, the use of dollar units for the criteria of all jobs provides a common denominator that makes it possible to compare an applicant's potential contribution in each of the several positions for which he might be hired, as in selection and classification operations.

In many validation studies, criterion ratings have to be employed in evaluating all aspects of performance on the job as substitutes for direct observations of effectiveness. A tempting approach is to have the ratings themselves made in terms of the monetary value of individual differences in the area being measured. But the rater then has the dual responsibility of evaluating performance and of assigning a monetary value to that performance.

It is better, perhaps, in the tracing process, to determine the continua on which criterion behaviors occur and to have raters evaluated in terms of these behaviors. Predetermined dollar values could then be centrally applied to the ratings, which could then concentrate more on recording observations and less on value judgments (Brogden & Taylor, 1950, p. 154).

Ratings as Job Performance Criteria

ARI capitalized on years of research to establish methods for obtaining reliable and valid ratings appropriate for use as job performance criteria. Repeatedly it was found that a large general factor dominated the rating even where concerted attempts had been made to measure different aspects of job performance by using a number of specific rating scales. In one study, even "contextual suppressors" were tried (Uhlaner, Goldstein, & Van Steenberg, 1952). In predicting combat performance, the attempt was made again to delineate different aspects of combat proficiency, and, as before, researchers had to settle on how good an individual's overall performance in combat was (Severin, 1952). ARI had also found very little difference in validity between ratings by raters classed as "hard" and those called "easy" and hence stopped worrying about such differences (Browning, Campbell, & Birnbaum, 1952a & b). The intelligence of the rater had been found to make little difference, except possibly where raters were in the lower portion of the distribution on mental ability (Chesler, Brogden, Brown, & Katz, 1952).

Empirical evidence had been accumulated, moreover, that raters agreed more in their evaluations of job success when they had had more opportunities to observe the individual performing on the job; in other words, peer ratings have superior validity over cadre ratings (Kaplan & Willemin, 1956). Research also had demonstrated that fellow trainees or fellow workers on the job are generally in a better position to observe the performance of another. Obvious? Perhaps, but ARI researchers went further in discovering that in the basic training situation, even a period as short as 3 or 5 weeks is sufficient to enable the rater to make the gross judgment required. Equally obvious was the finding that the rating based on the judgments of more than one rater was better than the single rating. This was true to the extent of a rating validity difference of .53 for single ratings compared to an average of 10 ratings with a validity coefficient of .84 (Karcher, Winer, Falk, & Haggerty, 1952). Since little improvement could be expected beyond 10 ratings, the decision of how many raters to combine became a matter of administrative convenience. These

finding were capitalized upon quite readily to derive a criterion of combat effectiveness.

Measuring Combat Performance. Because the promise of "objective" criteria for predicting combat performance was fruitless, combat performance in Korea was measured largely by means of ratings. Combat officers, NCOs, and other ranks in Korea were told, "Assume you are a squad leader picking men from your squad to go with you into combat. Select the one to whom you would be most willing to trust your life if you had to depend upon him in actual combat." The following question was next asked concerning every man studied: "How well did /X/ do in combat?" The replies ranged from "He was one of the very best men in the outfit," to "He was not a combat soldier; his outfit would have been better off without him." Those were, in fact, the extremes used at opposite ends of the 7-point criterion rating scale employed for data collection in Korea. NCOs placed about 800 men out of three regiments, or 15 percent, in the last category.

Leadership Ratings

ARI based 11 years of leadership research—from the late 1940s to the late 1950s in OCS, ROTC, West Point, and in Officer Retention and NCO selection programs—on early evidence that leadership ratings could be useful for selection purposes. Several noncognitive predictors were shown to correlate consistently with later performance-in-training evaluations made by associates and peers. On the other hand, just as consistently, cognitive selectors for officer training or commissioning did not predict leadership evaluations very well in either combat or noncombat assignments. Thus, during this period, the criterion usually used in leadership prediction consisted of refined and controlled ratings that apparently could reflect better the overall leadership requirements of the officer or leader job (Drucker, 1957).

Overall ratings emerged as the only type of measure that could readily encompass an extensive range of job requirements, as ratings of specific leadership traits were shown to be essentially duplications of ratings on scales of overall leadership effectiveness. The most successful and therefore most frequently used predictors of leadership were self-description questionnaires, evaluation reports of prior or current leadership performance, and standardized board interviews. Tests measuring cognitive abilities and educational background were used mainly to identify the top one fourth of the Army's enlisted input as the group eligible for officer training or commissioning.

In the board interview, management usually reserves the right to "see the man" before making final selection. But to make this procedure work in Army officer selection, that is, add to the predictive efficiency of a given battery without undue overlap with other predictors, it was necessary to restrict board members to certain aspects of the applicant and withhold from them any information about the applicant that would normally be available through other aspects of the application process. For example, cognitive test scores, which in all probability would have been used in a go/no-go determination of eligibility of the candidate to *apply*, would have been withheld from board members as nonrelevant for selection! It was a great notion in theory, but probably went quite unappreciated by board presidents.

Evaluation report forms used in the OCS selection battery contained training scales of officer potential, leadership, and character. Those used in selecting ROTC Distinguished Military Graduates for direct commissioning contained a series of overall evaluations on the qualities of adjustment, cooperation, initiative, judgment and common sense, behavior and manner, force, and overall ability (Brogden, Osburn, Machlin, Loeffler, & Reuder, 1952).

Numerous research programs produced a body of evidence to the effect that ratings on Army leadership performance could be successfully and usefully predicted by a number of testing devices: Ratings of performance in leadership training situations correlated up to .50 with later leadership effectiveness ratings, both in combat and noncombat assignments (Haggerty, 1955, p. 13). Self-description questionnaires could predict leadership ratings made by peers and tactical officers in the training situation to the extent of .40 correlation (Parrish & Drucker, 1957, p. 15).

Standardized board interviews, one of the few interview procedures with demonstrable validity in operational use, were found to correlate .30 with later Officer Efficiency Ratings, and .40 with peer and tactical officer ratings in the training situation. Evaluation reports of performance indicative of leadership potential, although not always possible to obtain, correlated around .35 with peer and tactical officer ratings (Parrish & Drucker, 1957, p. 15).

As a result of research in the late 1950s, peer ratings of leadership potential were instituted in Basic Combat Training in 1961, along with selected ACB scores and the commander's judgmental review, to identify enlisted men showing the most promise as NCO material. Those selected were sent to a special training course and thereafter served as acting NCO training cadre in Advanced Individual Training.

Implications: Beyond Selection and Classification

In the post-World War II period, ARI research activities continued to be steeped in the tradition of the psychology of jobs and the world of work. For the entire period, ARI immersed itself in testing and test development to find better predictors of success in training and on the job. It was a time for integrating the vast amounts of research data that had grown out of the war and for extending the data in breadth and depth. Out of this period came a sense that the limits of selection and classification technology and its methodological disciplines had been reached. The foundations for research efforts in new directions during the next two decades had been laid.

While ARI continued its mission, the Army took steps to expand behavioral research into areas such as training, human engineering, social psychology, and physiological psychology. The Army's interest in finding new applications for emerging techniques of behavioral science attests to the success of ARI's program during World War II and the following years.

The ARI leadership, however, decided to stay within its own area of expertise—the measurement of individual differences—a decision that was later seen to be restrictive. With little delay, other organizations, including a number of federal contract research centers, undertook the new areas of research. A direct consequence was the fractionalization of research so that no one organization was responsible for researching the whole person in a real-world context. Thus one organization became concerned almost exclusively with selecting a person, another with training, another with the equipment used, and still another with motivational and adjustment factors.

The Beginnings of a Human Factors Program

And yet, by the mid-1950s, ARI had begun to move more vigorously into the world of work in a more comprehensive sense, using new technologies and methodological developments. In the area of surveillance research, and the image interpretation system in particular, ARI began to conduct an integrated human factors system program.

Initially, the military sponsor community did not fully accept ARI's new perspective because of perceived problems of overlap (inherent in the fractionalization of the established system) and potential jurisdictional disputes with other research groups over mission rights. Also, there were difficulties with the concerns of the general staff proponent in ARI's chain of command: The Adjutant General feared the dissipation of what was once fully dedicated support for ARI to other elements within the Army. Indeed, there were even problems convincing scientists within ARI, many of whom had traditionally worked in the measurement area, that a broadening of specialization was desirable.

The highly successful program in image interpretation, the results of which were constantly being implemented in developing systems, served as an excellent prototype program for ARI. Image interpretation research set the stage for a systems approach to research; it was the first comprehensive attempt to broaden programmatic objectives by examining ways to improve systems performance as a whole, in which human functions were increasingly thought of as part of a soldier-machine system.

Information requirements, inputting information, decision making, task allocation, techniques and procedures of work, equipment utilization, training, and individual differences now all became of parallel concern and hence matters for investigation because these types of variables all potentially contributed to systems performance. ARI no longer felt itself limited to the measurement of the individual differences in isolation from all other measurements, and thus began to discard the narrow view of its mission and to move into areas that went beyond selection and classification.

In a similar vein, under the Human Performance Experimentation program, ARI sought principles applicable to many Army systems. Common behavioral functions were studied to enhance human functioning in a number of those systems—research on vigilance required of monitors in systems, on the ability to communicate electronically, and on the ability to function at night was incorporated into the larger ARI program.

New Partnerships

ARI soon learned that it would have to include in its research a different mix of scientific skills, including expertise in experimental psychology, learning, motivation, operations research, measurement, and computer science. By the end of the 1950s, ARI had fully acknowledged the potential of a new concept—multidisciplinary research. ARI recognized the need not only for scientists of broadened disciplines but also for military subject matter specialists—experts in the particular military system of operation under investigation. ARI also recognized the need to develop a new type of delivery system for its research products. The conventional procedures used to implement new paper-and-pencil psychological tests would not do. In short, a new type of partnership was formed with the military to develop coherent research programs and to help transfer research findings into operational use.

This new interdependency helped ARI win recognition as the Army's principal soldier-oriented research laboratory. From this point on, ARI did research for the Army as a whole, not only for the personnel management system. Such program diversification soon led ARI to a new general staff organizational affiliation.

ARI recognized that new research methods would be required. For one, it turned to the laboratory as it had a decade earlier in night vision research. This time, however, the laboratory focused on the computer to permit the real-time experimentation and simulation research that could not have been done before.

As ARI entered the 1960s, it did not reject its psychological and industrial heritage of personnel measurement, but recognized that its mission had to be more compatible with the changing Army, changing technology, and changing expectations of soldiers at work. The broadening of mission eventually met with greater acceptance by military sponsors, and prospects for the organization brightened.

Clearly, not to change was not a viable option.

Part 3

Research during the Vietnam War

Chapter 4

Impact of the Vietnam War: Expanding the Research Charter

The war in Vietnam was the longest in U.S. history. More than 2.5 million soldiers served in the war zone during years of active conflict; 300,000 were wounded and 58,000 gave their lives. Vietnam produced bitter divisiveness, dissent, and confrontation in American society over U.S. policy in the war. The Army's total manpower requirements were difficult to meet; suitable soldiers for conventional and guerrilla conflicts needed to be found, trained, and assigned to units for short tours.

In the late 1960s, the Army also needed to prepare for the prospect of an all-volunteer force and the possibility of using soldiers with lower mental abilities. The Army leadership initiated a number of social reforms in response to societal changes and the lessons learned in Vietnam. Programs were quickly implemented to deal with new leadership concepts, race relations, drug abuse, discipline, morale, and motivation. Project 100,000 was established in October 1966 to accept recruits in all services on the basis of lowered mental standards and largely from the socioeconomically disadvantaged segment of society. New methods of selection, assignment, and training were devised and evaluated to make better use of these "new standards" personnel.

To cope with rapid modernization and changing doctrine and tactics, scientists also began applying more sophisticated technologies, such as computer simulation and computer-based instruction. Army behavioral scientists were given a broadened charter to explore weapons systems development and utilization, civil-military relations, and a host of social issues.

A Unique and Complex War

The immensely powerful and sophisticated U.S. military forces fighting in Vietnam were confronted with a unique, complex war. In addition to waging conventional battles against highly motivated, well-trained regular units, the forces had to conduct modern air and sea warfare, counter jungle guerrilla tactics, engage in pacification programs, assist in "rural construction," and in general support the needs of an agrarian society.

During the early phases of involvement in 1962, the strength of U.S. military forces rose from about 1,000 to more than 11,000 soldiers. By mid-1966, U.S. forces had risen to 276,000, more than 60 percent of whom were Army personnel. A peak of 549,000 was reached in mid-1969, when the first troop withdrawals occurred, and a gradual reduction continued from that time on. Eight countries provided military assistance, including combat troops, military medical teams, and advisors, to the Republic of Vietnam. Forty nations provided economic, technical, and humanitarian assistance.

Vietnam produced unparalleled divisiveness and dissent in American society. The war unleashed the same devastation as past wars, but it had its own unique methods of destruction. Although modern technological systems such as the helicopter gunship were able to clear large areas with awesome firepower, the individual foot soldier was transformed into an incredibly destructive mobile arsenal in his own right. As the war escalated in size and intensity, the aim of both sides increasingly appeared to be destruction. Watching television, the American public witnessed daily the horrors of battle even as it was being waged, and this experience undoubtedly heightened personal viewpoints on the war.

Peter Bourne, in his book on soldier stress in Vietnam, writes that it was the political, social, and psychological aspects of the war that captured the interests of Americans (Bourne, 1970). An increasingly sophisticated public began to question the relationship of the war to broader social changes and forces within society, and many began to empathize with the antiwar movement. The American public was conditioned to the war through a slow process of incremental escalation in which U.S. commitments progressively edged upward. At the same time, the public hoped that America was dedicated to the humanitarian and democratic goals of the "other war" of the Vietnamese people, once victory, so close at hand, was won. Many people, Bourne believed, were confronted with the need to reduce the tension-producing dissonance of the war by rationalization; they were able to support the war. Persons who were able to tolerate this dissonance were the ones who protested the war.

Soldier Motivation

Surprisingly, antiwar sentiment in the United States appeared to have little effect on the motivation of soldiers in Vietnam, if good combat performance, very low incidence of psychiatric casualties, and low frequency of disciplinary actions were any indication. Bourne reviewed and then rejected, for Vietnam, the traditional determinants of combat motivation. The traditional view was that the fighting quality of a nation's army was a direct reflection of the national character. A related view was that the soldier's commitment to any war comes from a sense of patriotism and a belief that the fighting was for a just cause. Professional soldiers favored the view that esprit among the troops came from discipline, training, indoctrination, and organization. Social scientists during World War II identified the "primary group" of troops as the critical social structure in the maintenance of morale and motivation. The social intimacy typical of small units produced personal relationships and a group allegiance that was seen to override any identification with the larger organization or concerns with ideological goals. In Korea, while the face-to-face contact of the primary group remained significant, a dyadic relationship or "buddy system" was also seen to be critical in maintaining motivation. Bourne found a contrast in Vietnam; many of the social phenomena of earlier wars appeared to have little significance or were absent (Bourne, 1970, p. 41).

> The single most important policy decision in altering social behavior in Vietnam is the rotation system, which guarantees each soldier that he will return to the U.S. at the end of twelve months, thirteen if he is a Marine. His entire conceptualization of the war and his involvement in it revolves around this issue. The war became a highly individualized and encapsulated event for each man. His war begins the day he arrives in the country and ends the day he leaves. He feels no continuity with those who are with him but rotating on a different schedule. The universal objective is the personal DEROS—date expected to return from overseas—a day known exactly to each man from the moment he arrives in Vietnam (Bourne, 1970, pp. 41-42).

Aside from the emotional effects of the rotation system, individual arrivals and departures broke down the traditional solidarity of the small unit. Forming close ties was risky, given the likelihood of casualty in combat. With survival the paramount concern, a soldier was able to dismiss the controversy over the war in the United States; he was not even concerned about the war's eventual outcome.

Nevertheless, American soldiers in Vietnam were conscious of a vaguely defined but deeply felt sense of Americanism. Their allegiance and beliefs allowed them to justify being in Vietnam. But when asked to define Americanism by specifying what made America different from other countries, many soldiers tended to focus on material possessions, leisure activities, personal aggrandizement, and a commitment to "looking out for number one." This viewpoint, in part, was found more frequently among soldiers from lower socioeconomic backgrounds—a characteristic of a high percentage of combat soldiers.

The Sixties' Environment for Psychological Research

Personnel Psychology in Academia

In the mid-1960s, personnel psychology was a composite of various specialties such as selection and recruitment, classification and placement, job analysis, job evaluation, organization, morale, proficiency measurement, training and development, human engineering, accidents and safety, pay and satisfaction, and separation and retirement. Social science research was rapidly expanding into industrial human relations, organization, and motivation. Computer technology, simulation, and mathematical modeling were beginning to appear, along with man-machine systems, communications systems, organizational dynamics, and automated learning. These advances were changing the face of personnel research, and some of these developments became new specialties. As a result, personnel research began to add new languages and to report findings in newly established journals (Cowles, 1967).

Still, most personnel research lagged behind techniques. Selection research methodology tried to accommodate motivational and social variables along with cognitive and skill ones, but against single or global measures of job success. Meanwhile, employers hinted at their dissatisfaction with classical validation models based on simple or even multiple correlations. Some researchers looked ahead to more powerful computerized multivariate techniques but saw these as events of the somewhat distant future.

Guion and Gottier, who summarized validity studies in personnel selection in the mid-1960s, found that only one third of studies in a sample of the literature typically included predictive validity. Cross-validation had been performed even less often. The few significant validities for noncognitive measures had generally been obtained with tailor-made instruments for the particular situation in which the inventory was used. Guion and Gottier concluded that such research-based selection tests were better tools than "standard" (commercially available) instruments (Guion & Gottier, 1965).

Old measurement research problems such as rater format, devices to increase interview validity, and moderator variables were still prevalent in the literature. The state of the art tended to be summarized and heralded by academic sources: Most textbooks on individual psychology, human factors engineering, and decision theory approaches had been prepared by academic personnel psychologists. A relatively new academic emphasis on programmed learning and automated learning was stimulated in part by the need to make teaching and learning more effective in the face of a teacher shortage.

Academic researchers in the industrial setting had concluded that there was no simple relationship between pay and productivity, or pay and satisfaction, but had developed a better appreciation of the complexity of human factors in the workplace. New approaches and more disciplines were being called upon to examine complex relationships involving multiple variables measuring motivation to work, job performance, and job satisfaction. Psychologists were now interested in needs and satisfactions, response styles, expectations, frustrations, and conflicts; sociologists, in social, community, and cultural factors; human factors engineers, in good and bad performance in man-machine systems; and economists, in pay plans and personnel benefits. Yet researchers conducting studies of factors in job success or job satisfaction, as with use of measures of interests and values in predicting managerial success, still did not use cross-validation and were seemingly content with low *N*s. Nor did they worry unduly over documentation of their work (Cowles, 1967, p. 7).

The mid-1960s also saw sporadic but nongeneralizable contributions to theories of motivational factors in the workplace. Herzberg's two-factor theory of motivators as differential sources of satisfactions and dissatisfactions was being challenged (Herzberg, 1966). For example, college students ranked perceived importance of five motivators, but results gave no evidence of two independent factors spelling out job satisfaction and job dissatisfaction (Burke, 1966).

Most employment-oriented social psychological studies by academic research workers involved organizational behavior and theory. A typical study by Jerdee raised the question: Is attitude variability a function of group or individual variability? From sampling attitudes of 190 employees representing 38 work groups in three manufacturing plants, he found group differences in attitude insignificant when compared to individual differences. The author concluded that the appropriate unit for study of such attitudes is the individual, not the group (Guion & Gottier, 1965).

Personnel Psychology in Industry

By the mid-1960s, industry recognized that few or no changes had been made in the validity of aptitude tests for a long time. Although the need for more adequate analysis of the criterion was generally acknowledged, industrial psychologists had not yet faced the question of how and to what extent one was expected to identify all of the factors affecting the quality of on-the-job performance and turn as many as possible into measures that could become predictors. Somehow, the job situation, the job market, and the value system used by management had to be taken into account. Further, researchers could still see no good way of removing portions of test variance attributable to economic or social disadvantage, to "equivalent" experience, or to lack of appropriate job experience.

Industry had become quite disenchanted with the lack of success in the measurement of personality factors per se, although such factors had long been acknowledged as important in selection and in quality of job performance. In an attempt to explain more noncognitive variance in the job situation, researchers were entertaining the notion of including personality measures of the individual in relation to the organizational climate. They apparently thought such a notion was at least the start of an answer to those who feared that psychometric advances in the workplace were being held back by indiscriminate use of linear aggregative statistics.

Other broader scopes of research design were in the air; for example, one design proposed to interpret scores adapted or adjusted to the kinds of individuals to whom the scores were being applied, and not to just one standard applicant. Some consideration also was being given to the possibility of applying predictors differentially to the behavior of different subsets of individuals. Other researchers were proposing that by combining studies of organizational effectiveness with concepts of individual differences, more of the total work performance situation could be considered. And some researchers were showing interest in augmenting aptitude test scores with training, which could later be compared with scores not so augmented.

Industry had not yet gone beyond recognition of the problem of aptitude testing of the culturally deprived, the disadvantaged, or minority groups; needed research approaches had still not been clarified to any great extent. The "invasion of privacy" issue was just beginning to surface, however; opponents of testing were charging measurement psychologists with asking individuals to testify against themselves. At first the issue seemed to be mainly in the selection, transfer, or upgrading of executive personnel, particularly in situations using paper-and-pencil techniques to measure personality and motivation. It would be a few years before the problem finally spread to all levels.

Industry still clung to the hope of using objective, observable employee behavior as criteria for selection. But such criteria could work only in organizations that had stated organizational goals and where objective evidence existed that reflected these goals. An example of one such success was reported—the 1-year retention criterion for validating tests to select employees for overseas employment in an oil company (Edgerton, 1967, p. 17).

The Military's Technological Challenges

Several prominent technical concerns challenged all of the service laboratories in the 1960s: the selection, training, and utilization of individuals who were mentally marginal; the search for improved measures of proficiency, especially needed for selection and training research; the application of computer simulation to manpower planning, cognitive functions, and systems design; and the development of programmed instruction or "teaching machines."

Personnel Research in the Navy

By the mid-1960s, the composition of the Navy's enlisted classification tests had changed considerably as compared with World War II tests. The overall validity of tests for assignment to about 70 schools had been raised. By adding a Naval knowledge test, a biographical information blank, and a Navy activities preference blank (for occupational interests), the median intercorrelation was lowered, although explained variance was not improved. The new battery yielded an increase of approximately 5 percent in the number of recruits eligible for assignment, without any loss of validity.

Computer-assisted assignment of recruits (COMPASS) was developed to improve efficiency of procurement and processing of recruits. In November 1965, this computer technology was applied to the complex problem of matching workers and jobs at the school-assignment level. Such optimal assignment had not been practicable prior to the advent of the computer.

Like the other services in peacetime, the Navy was finding retention a problem that defied the development of instruments by which the Navy could identify the "career-prone individual" with any reasonable degree of certainty. "It appears that one question concerning the enlistee's interest in reenlistment for a career is just as good as an elaborate questionnaire in predicting career potential" (Fields, 1967, pp. 19-37).

To replace the earlier practices of developing achievement tests and evaluating training effectiveness, a mid-1960s aim of Navy training was to develop a theory of training technology that could be applied widely in planning, designing, and executing Navy training programs. Many objectives seemed possible: increases in proficiency, skills, or levels of knowledge; reduction of training time; reduction of training complexity; reduction of failure rates; development of techniques to facilitate shipboard training; and redefinition of training objectives and standards in relationship to demands of Navy jobs. The Navy was also concerned with transfer of training, programmed instruction, identification of relationships between individual differences and effectiveness of training, job simulation, methods for validating training programs, establishment of relationships between content and methods, and measurement methodology for research. The Navy started a large program of experimental training to cope with the increasing need for personnel of high intellectual caliber. Could the potential pool be expanded by lowering aptitude qualifications and reducing complexity of training? Another practical effort was the development of short curricula for training persons who would stay in the Navy for only one enlistment.

The Navy also developed a method to measure and predict human contributions in a total system context known as Techniques for Establishing Personnel Performance Standards (TEPPS). This method proposed to identify the personnel and equipment functional units a system comprised; state the contribution of each person and piece of equipment to system operation; determine performance standards for each directly related to system effectiveness requirements; and test effects of deviations from performance standards on system effectiveness.

In the Navy's research effort on electronics maintenance, the fundamental assumption was that the tasks had to be performed to fulfill corrective maintenance requirements and to identify training and proficiency variables that contributed to improved performance. The research strategy was to have project teams develop specific tools in their areas of responsibility and combine these tools into an integrated model, which ultimately could be used to establish trade-offs between equipment design and personnel training and point to the most feasible ways to improve the maintainability of electronic equipment.

In applying the computer to personnel planning and management, the Navy emphasized reducing the burden and increasing the accuracy of personnel planning and control. Navy researchers were also interested in the way computer simulation models could be used to investigate personnel performance considerations in the early development cycles of new weapons systems, especially with respect to soldier-machine interaction.

Personnel Research in the Air Force

Selection for pilots and to some extent for navigators and bombardiers, during World War II and for about 10 years thereafter, had depended on both paper-and-pencil and apparatus tests. By 1952, the apparatus tests had been dropped because they were too expensive, even though they added some validity to selection batteries. By the mid-1960s, the Air Force had decided to take another look at apparatus tests to see if the state of the art had advanced to the point where such tests could again be used cost effectively. Encouraged by the results of a thorough review of the problem, the Air Force set out to develop a moderately portable piece of apparatus embodying 23 different tests of perceptual and psychomotor functions in 19 areas identified as critical to performance and behavior related to aircrew success. The machine was electronic, used computer tape, and was completely flexible in permitting test order of any sequence (Ritter, 1967, pp. 49-55).

Research on the prediction of human social behavior, particularly human reliability and unreliability, also occupied Air Force scientists. Research to identify factors associated with unadaptive behavior (usually resulting in discharge for "unsuitability") was favorable, leading to the adoption of more stringent enlistment criteria, which in turn markedly reduced the number of enlisted personnel discharged for unsuitability or substandard performance. A sharp decline in unsuitability attrition was also achieved as a result of the program implemented in 1961 to identify potentially unreliable personnel prior to assignment to high-risk jobs, such as nuclear weapon handling.

The development of historical data files, an activity of the Personnel Research Laboratory for many years, formed the empirical base for many studies. The laboratory could well congratulate itself because it was able to respond to Air Force needs as a result of the foresight of the "data-savers," records management regulations notwithstanding!

In the mid-1960s, the Air Force was conducting a comprehensive and ambitious research program in occupational structures. Objectives were to develop methods for collection, analysis, and reporting of information descriptive of Air Force jobs; methods of organizing jobs into specialties, career ladders, and broader management categories; methods for evaluating the capability of personnel to perform jobs in their career ladder or utilization field; and methods to determine the appropriate grade levels for officer and airman jobs. Task inventories were prepared that permitted accurate and reliable collection of detailed information concerning tasks done at each skill level in each specialty in a career ladder. Next, researchers prepared a set of computer programs

to be applied to data collected through the task inventory procedures. The combination of the task inventory and the computer offered a powerful new tool to evaluate individual capabilities. Air Force researchers looked for a major breakthrough in the collection of performance evaluations at the task level, to allow for a more objective procedure for determining grades for officer and airman positions. An occupational research byproduct of the job inventories was assistance in constructing and validating Air Force specialty knowledge tests, used for upgrading airmen.

Scientists developed a multiple regression technique for "capturing policies" (predicting manpower management choices) of human decision makers. The technique enabled the researcher to determine the unique or interactive value of several quantified variables in accounting for the predictable variance of the criterion. The computer was to treat the sample of decisions as a dependent variable to be predicted; the empirical information on which these decisions were based was used in various combinations to form the predictor variables. This method was used in studying the proper grade level for Air Force officers and for the capturing policy of selection boards.

In the 1960s, scientists had adapted modern mathematical modeling techniques to meet immediate operative needs. For example, the personnel awaiting training systems (PATS) determined the number of workdays lost in waiting time by pipeline personnel between entering the Air Force and finally being given on-the-job assignments. A large number of variables were "cranked" into the model: the many heterogeneous sources of entrants, variable training periods, types and sequences of training, varying lengths of time before shipment out, and differing quotas. The model showed quite clearly where the pipeline flow could be increased at various points and also showed where some of the flow might be decreased.

Project 100,000

In August 1966, Secretary of Defense Robert McNamara stated, "The poor of America have not had the opportunity to earn their fair share of the Nation's abundance, but they can be given an opportunity to serve in their country's defense, and they can be given an opportunity to return to civilian life with skills and aptitudes which for them and their families will reverse the downward spiral of human decay." He said he had no desire to convert the military into a universal military training establishment or to encroach upon other agencies that were charged with "War on Poverty" actions. Instead, the armed services were to fulfill an obligation to help improve the nation's young workforce, so long as military missions would not be impaired or degraded.

As a result, Project 100,000 was established in October 1966. Its goal was to accept 40,000 persons during the first year and 100,000 the second year. Ninety-five percent of these were accepted on the basis of lowered mental standards; the remaining 5 percent were men with remedial physical defects. Thereafter, the services expected to continue accepting about 100,000 men a year. About 11 percent of all persons entering the enlisted ranks would be coming in on the basis of mental standards lowered to accommodate them. Those who entered below the 1 October 1966 established standard of the particular service would be counted as a "new mental standards" soldier.

The Project 100,000 personnel accepted initially could be described statistically as follows: They had an average age of 20 years (like all other recruits); 40 percent were nonwhite (as opposed to 11 percent for other recruits); 38 percent had been unemployed prior to service; 57 percent had not completed high school (compared with 23 percent for other recruits); and their median reading ability was 6th grade (as compared with 10th grade for all other recruits at the time). These entrants were best in "hands-on" skill training but had difficulty in technical training that required comprehension of written material. They did not appear to cause undue disciplinary problems. Most were motivated, wanted to learn, and wanted to complete their military training.

Using All Ability Levels. Professionals and the lay public had shown much interest in testing lower ability individuals, especially those who came from disadvantaged backgrounds. But the use of tests for selection purposes in schools and industry had the reputation of discriminating against lower socioeconomic groups. To professionals involved in testing for military service, these new entrants offered a challenge. The policy of accepting only the best applicants had now become one of accepting and putting to work persons of all ability levels, an approach that changed the emphasis of testing from selection to classification. The tests used for selection or for promotion had to be free of cultural bias and as valid and consistent between services as possible. Finally, the Armed Forces Qualification Test (AFQT), or whatever test was used to screen applicants initially, had to be a valid and suitable instrument for these recruits.

The Department of Defense policy had been to avoid clustering these new entrants within restricted groups of MOS or career fields, especially to avoid an overconcentration in ground combat jobs. In DOD as a whole, more than 60 percent of new standards personnel were assigned to training (schools or on-the-job training) in noncombat MOS, where there had been a good dispersion into a variety of soft-skill areas.

Aptitude test scores were the key factor in assigning soldiers to training. The attrition rate in advanced training had generally been moderate and tolerable. However, for some courses, new standards personnel who had met the minimum aptitude score requirements suffered an attrition rate of 50 to almost 100 percent. An example was their 75 percent attrition rate in the Army's power generator operator-mechanic course. It was recommended that each "high attrition" training program be analyzed to determine an appropriate course of action.

Problems in Testing "New Standards" Recruits. In 1967, the Naval Personnel Research Activity in San Diego conducted a program to develop and evaluate test instruments specifically designed for new standards recruits.

A major goal of this program was to minimize or overcome, if possible, the effects of problems and factors that operated against the valid assessment of the new standards personnel (Thomas, 1968, pp. 15-20).

The Navy, like the other services, had traditionally been concerned with identifying and classifying recruits of average or above-average intelligence—those likely to perform well if given academic training for a job specialty. Items in the operational tests had been designed to provide maximum discrimination around the middle of the distribution of talent. As a result, the tests were relatively ineffective at discriminating among new standards recruits. Also, the tests were designed to predict academic trainability and to measure aptitudes important for success in school. Most new standards personnel did not score sufficiently high on these tests or possess the verbal requirements needed to qualify them for schools; they were likely to go directly to on-the-job training in the fleet following recruit training. They could be useful to the service to the extent that they would perform well on the job. Moreover, it appeared that the operational tests had a built-in disadvantage for predicting job performance, not only for the new standards recruits but for enlisted personnel in general. The wide range of differences among new standards recruits on factors related to education, cultural background, and motivation presented a different challenge because of the possible confounding of factors operating within the group.

The Navy administered 11 experimental instruments, of which 7 involved cognitive abilities, and 4 were designed to tap biographical, attitudinal, and interest factors. The questionnaire items were deemed to be valuable for gaining insights into the composition of the new standards group and for assessing characteristics that could be important to job performance, given the requisite skills.

Several problems specific to new standards recruits were encountered. Many items in the operational tests proved to be quite difficult for most new standards recruits. Items in the experimental instruments were, accordingly, designed to improve test sensitivity to differences in performance among lower aptitude persons. As a group, the new standards recruits varied considerably in reading proficiency and use of language. Tests that required extensive reading would be less likely to yield valid assessments for individuals with poor reading skills. Written test instructions were used, but the test administrator always read them aloud.

The questionnaires used pretested words and avoided terms that might pose difficulties. This approach was not possible, however, with standardized interest measures because changes in wording could affect score interpretation. To solve this problem, a special glossary was prepared to accompany this instrument.

To determine the tests that should be used for new standards personnel, one portion of the Navy's research effort involved interviewing supervisors of low-mental-ability recruits (Category IV on the AFQT) who entered the Navy between 1964 and 1966. The research found that most of these recruits were assigned to jobs involving machinery operation and repair, service and supply (e.g., stockroom and laundry), maintenance work (e.g., cleaning and painting), and to jobs such as helpers and messengers. Apparently, the kinds of tests needed would assess the characteristics that supervisors used to rate their workers—tests that revealed attentiveness, perseverance, ability to follow instructions, and what one supervisor called "common sense."

The danger was also present that some lower aptitude recruits might react negatively to all tests, expect to do poorly, and exert less than maximum effort. Research had indicated that persons from lower socioeconomic classes tended to view tests as devices to keep them from doing well; even those with good scores would sometimes feign dullness because they were accustomed to poor performance or had low aspirations.

To help overcome these tendencies, new standards recruits were not singled out for study but were included along with all recruits in what appeared to be a routine test administration. Different formats and methods of presentation were also tried as a departure from traditional paper-and-pencil tests to lessen test anxiety, increase interest, and contribute to a greater display of effort. Introductions to the tests were made less forbidding. In general, the attempt was made to make failure a less obvious option.

Another major problem was test "fairness." Did a test contain items that were equally difficult for all individuals, regardless of cultural background? It had been generally conceded that the AFQT and most of the Navy's operational tests were biased on this count. The use of a "culture fair" intelligence test, for example, might provide information on what portion of low AFQT performance could be a reflection of cultural impoverishment rather than low innate ability. But would a culture-fair intelligence measure, if available, be a valid predictor of success on the job? Eventually, the issue of culture fairness was muted by a shift to a more technologically oriented definition of fairness.

Biographical Information and Attrition. The Naval Personnel Research Activity constructed a 183-item biographical information form to learn about low-mental-ability Navy personnel and to discover how they differed from other recruits. It was hoped that subgroups could be identified for whom prediction of recruit and on-the-job performance would be higher than for the total group (Swanson & Rimland, 1968, pp. 25-29).

The form was administered to 7,500 incoming recruits at the Naval Training Center in San Diego, including 1,150 personnel with AFQT percentile scores ranging from 10 to 30 (Category IV). The instruments were rather broad, covering economic background, family situation, parental education, level of education, work experience, academic courses taken and performance in them, extracurricular school activities, social experiences, activities engaged in and skills acquired, self-perceptions of abilities, and attitudes related to general outlook on life and work.

One striking finding of the research was that most of the recruits, regardless of AFQT category, completed recruit training—nearly 98 percent of Category I through III recruits and nearly 94 percent of Category IV recruits. Among the Category IV group, the percentage discharged before completing recruit training was nearly twice as high for non-high school graduates as for high school graduates. The data for the various Category IV subcategories showed a progressive increase in attrition rate with decrease in AFQT score. But even for the lowest subgroup of non-high school graduates, attrition was less than 12 percent. Considerable effort had been put forth to keep attrition low, since existing performance standards were to be retained; marginal personnel were to be trained with others insofar as possible. Results were to be monitored on an individual basis.

Some recruits had reading problems, which tended to hold them back. Remedial reading training, a 6-week course, was set up for about 20 percent of Category IV recruits, after which they returned to regular companies to finish training.

Clearly, most Category IV recruits were successful in recruit training, although at considerable expense, especially for the lowest AFQT group. Later research was devoted to assessing on-the-job performance of these recruits and recruits of similar mental levels.

Training and Utilization. Within the Army, accepting recruits with lower mental abilities was not unique. Mental standards had been even lower during World War II and the Korean War. The Army's research effort in Project 100,000 was unique because it was designed to create a vast bank of information by name, background, and performance on each individual brought into the service under the new standards. Project 100,000 thus became a sociological experiment of considerable magnitude and far-reaching impact, even to the extent of assisting these personnel to become productive citizens after service. The problem was the inevitable conflict in training: Instruction had to be paced to accommodate both the slow learner and the fast learner. Courses were revised to include more training aids, more hands-on and practical training, and less lecture, theory, and written material; also, more practical and fewer written tests were given, primarily to improve instruction for all trainees. Army research and development faced the challenge of determining how many of each mental group the Army could accept, train, and utilize without wasting the Nation's limited talent and without degrading training, enlisted leadership and skills, and the resulting operational capability of the Army (Crain, 1968, pp. 228-235).

A special focus of the research, directed at trainability of these recruits for military tasks, deserves examination. In one important project, relationships between aptitude and learning performance in a wide range of laboratory learning tasks provided results of unusual consistency. Several tasks, ranging from simple monitoring through rifle assembly to complicated verbal chaining and principles learning, were administered, and every possible effort was made to maximize the learning opportunity for the low-aptitude subjects. All training was continued to a criterion standard of performance. Three aptitude groups were examined, each maximally different from the others: The high-aptitude groups had AFQT scores of 90 to 100; the middle group, 45 to 55; and the low group (consisting of new standards recruits), 10 to 20.

Results were completely consistent in demonstrating large differences among the aptitude groups in learning performance on all eight training tasks. Low-aptitude subjects were slower to respond, requiring more training time to reach criterion (and in some cases never reaching it); such persons needed more guidance and repetition of instruction; and varied decidedly more as a group than middle- and high-aptitude subjects. Even in the simpler motor tasks, no reversals on any trial were found. Although learning conditions favored the low-aptitude group, thus minimizing differences between groups, AFQT level was a highly successful predictor of large and practical differences in learning performance on the laboratory tasks (Caylor, 1968, pp. 11-13).

After 8 weeks of basic training, this same relationship, though somewhat attenuated, was found between AFQT groups and the Army-administered composite performance tests covering fundamental Basic Combat Training content in both motor skills and cognitive areas. Routine peer judgments of leadership potential at the end of basic training were about as highly related to AFQT grouping as were initial classification test scores. In a comparison study of performance in Advanced Individual Training (AIT) in the simpler combat support MOS, AFQT was again solidly related to school performance. In another longer range follow-up study of recruits throughout their first Army tour, a highly correlated measure of aptitude predicted Army success, as measured by Army data, even with the high-quality input of 1961 recruits. Considering the many factors involved in the criterion behavior, 50 minutes of generalized aptitude testing provided substantial predictive leverage. The AFQT was shown to work surprisingly well.

Distinguishing between recruits of true low general aptitude and those of higher learning ability whose test scores were depressed by functional illiteracy was a general problem. Considering the low reading and arithmetic accomplishments of most Project 100,000 personnel, it was no surprise that these recruits had difficulty in training courses that demanded a far higher level of these skills for course completion. Potential remedies were substantial literacy training or training and assignment programs minimizing such requirements.

Army training officials realized that Project 100,000 and Category IV personnel typically made lower passing scores on their intermediate and end-of-course tests; in other words, they learned and retained less yet made the minimum passing grade to qualify for the MOS. Thus in terms of MOS qualification, the Army was satisfactorily training most of these personnel.

In conclusion, from a technological viewpoint, the Project 100,000 experiments provided important groundwork for consideration of the issues surrounding culture fairness and the production of culture-fair tests. This issue was later to be debated in terms of a more widely accepted technical definition of fairness—differential prediction accuracy. The experiments also forced military psychologists and personnel officials to reappraise the kinds of aptitudes that typically had been identified and measured until the mid-1960s and to search for predictors that would relate to on-the-job performance. Finally, the experiments provided a much clearer focus on enlistment standards for military service in both DOD and Congress.

The Quest for Good Proficiency Measures

From the earliest beginnings of psychological measurement, a paramount concern has been the adequacy of criterion or proficiency measures for previously tested or trained individuals or groups. Such proficiency measures are also invaluable in developing psychological constructs of judged relevance for analysis of selection, training, and system design variables. S. Rains Wallace, while serving as head of the Personnel Performance Psychology Area for DOD, Research and Engineering, addressed the Military Testing Association in 1965 on personnel performance evaluation. Wallace said that he had derived little pleasure in finding that high validities could be obtained by correlating one paper-and-pencil test with others, and hence he pushed for the development of on-the-job, simulated, and "contrived" performance measures as possible alternatives. His arguments, here summarized, are still strong (Wallace, 1965):

> The nature of proficiency measures determines how human resources are selected, classified, trained, maintained, and assessed. If the measures are irrelevant to the jobs, the wrong persons will be selected, or they will be classified incorrectly, or their training will be inefficient or wasted. Therefore, the decision on which proficiency measures to use entails a decision on the kind of person to be trained for the job.
>
> The most important of human tasks involved in national defense are likely to be needed under conditions of extreme difficulty or stress. Such conditions may degrade performance or even preclude some performance entirely. If measures were developed based on performance obtained in the controlled conditions of the laboratory, persons may be selected and trained who will perform well only up to a point where their performance is crucial.
>
> Few would defend statements that military performance measures are adequate or that performance deficiencies can be spotted through paper-and-pencil tests. Such tests are reliable and are easily and inexpensively constructed and administered, but they still are flawed by high verbal loading and cultural and education biases. Advances in paper-and-pencil test construction may have created a state of complacency about how well the evaluating job can be done; but the record for validating paper-and-pencil tests as performance tests

has not supported such complacency. There are no shortcuts to obtaining good performance measures for validation purposes.

Wallace proposed a broad, three-way classification of performance measures: on-the-job, simulated, and contrived performances. The on-the-job approach measures performance on job aspects in real-life situations. The first advantage of this approach is its relevance, if indeed most job aspects can be examined. A second advantage is that factors that normally improve or degrade performance—motivation, stress, forgetfulness—are present. It is best if the measures are made a part of routine operations. The results will form a built-in system for making longitudinal studies, which are crucial in determining training strategies and realistic assessments of strength. If better methods were devised for observing, measuring, and evaluating real-world situations, a better understanding of human behavior would result.

Situations are often encountered, however, in which on-the-job performance measures are impossible to obtain or are undesirable when they are obtained. Some complex systems are so expensive to operate that practice and its concurrent opportunity for measurement are held to a minimum. And some high-level tasks, such as leadership or management, are so nebulous, diffuse, and long term that they seem to defy application of any kind of measurement. Thus, simulation may have to become the basis for proficiency measurement.

The greatest asset of the simulation method of proficiency measurement is that it can be controlled. Much of the unsystematic or systematic-but-contaminated variance involved in on-the-job performance can be removed. Simulation, like on-the-job measurement, is better than paper-and-pencil tests in its quality of realism, which admittedly is based more often on face validity than on any real understanding of what has been simulated or of how performance on aspects of the simulation is related to performance on the job.

When cooperative efforts are directed toward a better understanding and utilization of simulation techniques, a third type of proficiency measure will probably begin to receive attention—contrived performances, thus named because their nature is not determined by samples of or analogies with real-life tasks. Contrived performances are irrelevant performances, but they are so because the investigator planned them that way rather than because they were uncritically adopted. These measures are designed to test hypotheses about the transfer of training, the nature of degradation imposed by stress or obsolescence, the qualities required for success in training, and the existence and basis for individual differences in performance changes under varying conditions.

Computer Simulation in Human Factors

During the design and development of soldier-machine systems in the early 1960s, soldiers were regarded as one component of a larger system in

their ability to perform a variety of actions that depended on perceptual or intellectual capacities. As top Army leaders pointed out, a major problem in devising soldier-weapons systems was how best to specify precisely what the functions were so that function allocation between soldier and machine could be made appropriately. Equally important was finding a way to represent complex, interacting relationships involving human behavior and a changing environment.

The system model had to be able to predict or generate instantaneous values of composite behavior while the system was being studied. Also, the model had to be able to show the relative contributions of component behaviors and their separate relationships to the composite behavior. The model had to have a structure of sufficient generality that behavioral predictions were possible in a changed system environment, together with changes in the systems components and their configurations.

To be useful for analyzing complex systems, computer simulation models had to be elaborate enough to account for known mechanisms that played a part in producing behavior. Adopting this research strategy implied that knowledge and understanding would increase faster if the scope of explanatory efforts were expanded than if narrow measurements of isolated fragments of behavior were pursued. But computer simulations could not guarantee fast or easy solutions to the problems of human factors research; such solutions could only guarantee a means for elaborating conceptualizations of behavioral phenomena and for testing the hypothesized processing mechanisms (Gregg, 1962, pp. 241-246).

One major limitation of computer simulation in 1962 was the cost in time and money in developing software for experimentation. Once a commitment was made to a particular model and its associated software, departures from it were made only with the greatest difficulty.

Within 10 years, using computer simulation, researchers could consider a large number of variables simultaneously in terms of the character of their interaction and the structure of specific situations and could introduce and consider, within the analysis, random effects and events; researchers could study the nature of the effects of varying loads and contingencies on system performance and could also accumulate data for a larger number of cases than was convenient by other methods.

Computer simulation allowed for an assessment of the effects of changes in personnel policy, equipment, and resources assignment rules that was impractical by other techniques. Simulation provided a relatively inexpensive method for developing quantitative insight into possible problem areas and into the relative benefits to be obtained from the various solutions. Finally, the method allowed testing of alternative hypotheses on system design and operation and offered a better understanding of the actions of a system.

In July 1971, the Naval Personnel Research and Development Laboratory hosted an entire symposium on computer simulation as it related to manpower and personnel planning. Many topics were discussed: state-of-the-art simulation, including gaming, analytic, and soldier-machine models; use of a simulation test bed through which investigations of alternative staffing concepts, maintenance and work policies, training concepts, and equipment design characteristics could be evaluated; development of a digital simulation model tailored for planning and allocating maintenance manpower; and development of soldier-machine simulation models that complemented one another (Siegel, 1971).

All of these models had the general purpose of providing a basis for predicting soldier-machine performance, but each applied to a system of a different size. Two models considered intellective, psychomotor, and social interactive processes to a greater extent than the other models presented. The logic and structure of a simulation model developed to assess the effects of gamma radiation on human performance in modern weapon systems had an internal structure that considered both intellective and psychomotor performance. A manpower management planning tool was operational and yielded a multiplicity of outputs, all of which were expected to be of value to those concerned with manpower size, mix, and cost trade-off problems.

Simulation Issues. Complex problems often demand complex analytical techniques. Such has been the case in attempts to understand organizations, forcing development of increasingly sophisticated methods of observation, description, and analysis. A delineation among four such methods—analytic models, machine simulation, soldier-machine games, and free-form games—was made by Shubik and Brewer (1971). A good analytic model, they found, was usually quite abstract and poor in the number of variables explicitly considered, but rich in terms of ease of manipulation and clarity of insight. Certain forms of warfare had been well characterized by game-theoretic, analytic models in which two-sided or more-than-two-sided combat was explicitly considered. Analytic models, however, were usually too restricted to solve an actual operational problem directly. But because the model was normally clean and clear, it could provide insight on potential difficulties, indicate where additional measurements were most needed, and identify and order important omissions.

Machine simulations, on the other hand, frequently involved many variables. But simulations and the "simulators" responsible for their design, implementation, and operation were much harder to control than analytical models. Not only were there fewer discernible scientific standards available to evaluate a computer simulation versus a mathematical model, but there was little or no general agreement among professionals as to which standards were pertinent. Simulation was usually an extremely expensive pastime, validity problems were difficult to solve, and making many general observations was risky.

Soldier-machine simulation usually, but not always, involved a digital computer. Some roles in the modeled system were played by people, because people cost less than software. But where human factors were important in the analysis of the situation—how people behaved and what motivated them—the people clearly performed a quite different function.

Soldier-machine simulation was also expensive, but could be worth the effort. A common property of success seemed to be that if, early in the research, someone asked one or two reasonably well-defined and -understood questions, the answers, when they eventually came, were recognizable by the principals. Very frequently in a large-scale simulation, answers may have been there, but they had passed unnoticed because no one knew how to recognize them.

In free-form gaming, computer equipment frequently was not used; instead, individuals operated in a scenario. Of the four types of work described, free-form gaming was the least amenable to technical control, and costs were relatively low. Therefore, with low levels of expenditures (both absolute and relative), a few additional pennies spent on this type of game certainly would do no harm and might even have stimulated more serious scholarship (Shubik & Brewer, 1971).

Programmed and Computer-Based Instruction

By 1960, programmed instruction was starting to grow rapidly, and it was difficult to keep up with progress. The method had evoked widespread interest because it promised techniques that would substantially increase the rate of acquisition of learning materials with less instructional effort than conventional means. Also, many manufacturing and publishing firms started to see commercial possibilities.

Actually, programmed instruction, whether or not it involved hardware, is a teaching method that can be traced back to Socrates, if one considers the three active ingredients of the technique. First, active participation by the student is required to respond to each step. Second, the student is informed immediately as to the correctness of an answer. Third, each student may proceed at his or her own pace.

A healthy skepticism about programmed instruction emerged as early as 1961; many of its claims were being disputed. Some well-controlled studies failed to support the conclusion that automated teaching was superior to conventional teaching. Also, when researchers allowed students to proceed at their own rates, no significant differences were obtained between a teaching machine and a programmed booklet, or between responding and not responding. There was no difference when a complex machine, a crude machine, and a programmed booklet were used. Nor had there been any long-term studies on the effectiveness of teaching machines. The question of retention as a function of quickness of learning had not been answered and much of the research that had been conducted had used the ubiquitous sophomore as the subject. A catalog of research needs emerged; for example, determinations had to be made as to whether this kind of learning was best for the slow student, the mediocre student, or the superior student, or whether it was equally good for all. If not, programs had to be prepared to fit the needs of each group. The entire problem of size-of-step and when and where the step size should be varied needed clarification. If programmed instruction were a training technique with certain standardized features, would it not be possible to consider the use of certain existing psychometric procedures in the study of its efficacy (Bishop, 1961, pp. 237-239)?

Cost and Training Effectiveness. Ever since Bishop's review in 1961, individualized instruction and the use of computer-based instruction (CBI) to facilitate training have continued to increase at a rapid rate, both for civilian education and for military training purposes. Use of CBI has been a popular way to try to increase the cost effectiveness of educational and training systems. High-quality instruction has been possible with CBI because it can reduce instructor variability. Training can be distributed to students, rather than students being distributed to instructors. Updating of instructional materials can be facilitated by centralization. Technological advances in microelectronics have promised further cost reductions in computer hardware. Similar advances in software and in simplifying the student-computer interface have all stimulated growing technological interest in CBI (O'Neil, 1981, p. 2).

The military services have supported research in CBI since 1960. However, no comprehensive analysis was available on the cost effectiveness of CBI in military training until Orlansky and String's (1979) comprehensive review. This research examined 30 CBI studies completed between 1968 and 1979, reporting effectiveness data; but only 8 studies also provided cost data.

Orlansky and String outlined four methods of instruction. Conventional instruction referred to instruction by lecture, discussion, demonstration, and tutorial. Students would proceed together at the same pace; differences in achievement would be reflected in end-of-course grades. In individualized instruction, students would proceed at their own pace. Mastery of each lesson would be set as a condition of progress. The amount of time to complete the course might be selected as the principal criterion of progress, but the same level of achievement would generally be sought for all students. In computer-assisted instruction (CAI), all instructional materials would be stored in the computer. The student would interact in real time via the terminal and display system. The computer would be capable of diagnosing student performance, prescribing lessons, maintaining progress records, and predicting individual course completion dates. In computer-managed instruction (CMI), self-paced instruction might take place away from the computer. The computer could score and interpret tests and advise a student of the next step—to take the next lesson, an alternate lesson, or remedial work. The computer could also manage student records, instructional resources, and administrative data.

Skill training at U.S. military schools of all services was estimated in FY 1979 to cost $3 billion a year. In FY 1977, DOD had spent an estimated $12 million a year for research and development on the use of computers in military education and training. A wide range of subject matter was covered in the Orlansky and String survey—knowledge, theory, and hands-on performance skills; electronics maintenance; recipe conversion; vehicle repair; and fire control. The eight studies that reported cost data had been limited to expenses incurred during the experiment and were incomplete with respect to costs of program management, maintenance and repair, instructional support, and other factors important in determining life-cycle costs.

Ideally, training effectiveness should have been measured by how well course graduates performed specific jobs in operational units. However, all studies had used student achievement at school as a measure of effectiveness. Data on length of time required for students to complete a course (generally less for CAI and CMI than for conventional instruction) should have been treated as a measure of the cost of instruction rather than as a measure of its effectiveness. The same argument could apply to academic attrition rate. Attitudes of students and instructors to CAI and CMI were qualitative in nature; it was difficult to relate such data either to the cost or to the effectiveness of instruction.

Comparisons of alternative methods of instruction had been limited. Generally, CAI or CMI had been compared with conventional instruction. Only a few comparisons of CAI and CMI with individualized instruction (without computer support) had been found. Time savings found when CAI or CMI had been compared with conventional instruction may have been due to a combination of self-pacing, computer support, and revised and possibly reduced amounts of course materials.

Military research studies showed that student achievement at school with CAI had been about the same as that with conventional instruction in most comparisons and superior in about one third of the comparisons. The differences in achievement were not thought to have practical significance. Student achievement with CMI had been about the same as that with conventional instruction—inevitable findings because students had been held in CAI and CMI courses until they had achieved the standards established previously for conventional instruction.

CMI, compared with conventional instruction, may have increased the rate of student attrition for administrative reasons, as found in four Air Force Advanced Instructional System (AIS) courses over a 4-year period. Student attrition did not appear to have increased with CAI, but this finding had been based on tests of limited duration.

Students in the experiment almost always preferred CAI or CMI to conventional instruction. In the few studies reported, instructors had been almost always *un*favorable to CAI and CMI in comparison with conventional instruction. However, little attention had been given to the role of instructors and to how they should have been prepared for the use of computers.

CAI and CMI in military training had saved about 30 percent of the time (median value) needed by students to complete the same courses given by conventional instruction. The amounts of time that had been reported as saved varied widely, but this variability had received little research attention. Most of the results on CAI had come from experiments of limited duration, with limited amounts of course materials, and with relatively few students. Where CMI had been used for extended periods (up to 4 years), the initial time savings had been maintained or increased. Some data had been found where the same course had been given by conventional instruction, individualized instruction, and either CAI or CMI. Individualized instruction had saved student time; however, the addition of computer support to individualized instruction had not increased the amount of student time saved much beyond that which had been achieved by individualized instruction alone.

Cost-effectiveness studies of CBI had been relatively few. For CAI, the PLATO (Programmed Logic for Automatic Teaching Operations) system was judged to be not cost effective in two evaluations. Although substantial amounts of student time had been saved (19 to 89 percent in eight courses), PLATO IV was found to be not as cost effective as self-paced instruction because of high communications and maintenance costs in one evaluation, and not as cost effective as programmed instruction because of greater development and operating costs in the second case. For CMI, it was estimated that the Navy system had avoided costs of $10 million in FY 1977 and that the Air Force had avoided costs of $3 million in FY 1978. Both estimates had been derived by translating amounts of student time saved into dollars avoided for student pay and allowances because of the reduced training times. These estimates were incomplete because they had not considered the other costs of providing CMI at these installations or compared these costs with the costs of alternative methods of instruction for the same courses.

Orlansky and String (1979, pp. 15-17) made several recommendations for future CBI operations:

> Improve current methods for measuring performance on the job in areas related to technical training.
>
> Evaluate alternative methods of collecting reliable data on the costs and effectiveness of instruction in military training.
>
> Develop and initiate data collection programs on the costs and effectiveness of alternative methods of instruction.
>
> Bring up to date the *Integrated Department of Defense Plan for R&D on Computers in Education and Training* (Department of Defense, 1975). Provide exploratory and advanced development to develop objective measures of performance on the job, compare student achievement at school with performance on the job, develop methods to measure the quality of course materials and delivery of instruction, and conduct studies on relative contributions of self-pacing, course revision, computer support, and other factors to amount of student time saved by CAI and CMI.

> Collect data on the costs of instruction for courses and course segments given now by CAI or CMI for military training. Project costs for CMI systems for the 1980s.
>
> Determine factors that account for the large variations in the amounts of student time saved by CAI and CMI, such as quality of courseware, instructional strategies, types of subject matter, and amount and type of guidance provided by instructors.
>
> Determine the extent to which observed increases in student attrition are due to CMI and to other factors, such as a change in the quality of students.
>
> Determine systematically the attitudes of instructors to computer-based and other methods of instruction so that remedial actions can be taken.

The Army's Research Response

It was popularly supposed that the Army's involvement in Vietnam accelerated its need to regroup on social, organizational, and institutional fronts as well as on tactical ones. In fact, it was tempting to attribute outright drug abuse, racial disturbances, and deteriorating cohesion and unit stability to the growing exigencies of Vietnam. But it was equally tempting to say that in fact all America was experiencing social turbulence—in its entire social structure down to the family unit—and that the Army couldn't expect to remain free of such influences. Nevertheless, the war in Vietnam was at least a catalyst for the eruption of many Army manpower and personnel problems.

The fighting in Vietnam was first perceived as a guerrilla operation, albeit a large one. It was soon realized that having a combat capability in the usual sense of the term was not enough. Total manpower requirements appeared most difficult to meet. Personnel suitable for conventional, guerrilla, and jungle conflicts had to be found and trained. Certainly, the Army's personnel allocation system was hard pressed to meet this need in the face of increasing sophistication of weaponry, demand from field units for more discrete MOS, and quick rotation (short tours) due soldiers with vitally needed special skills. Prospects of the impending volunteer force (to be implemented in the early 1970s), which foreshadowed lags in vital civilian-acquired skills and the general caliber of college graduates, were not encouraging.

The war in Vietnam did precipitate a change in emphasis for Army behavioral science. All facets of its research program took new or altered directions: in the content or substance of the research conducted; in the management of that research; in a new role (or a newly acknowledged official role) for the behavioral scientist as an "expert" providing technical advisory services; and in the desire by Army leadership for quick-turnaround projects for which results would be known in a year or less.

Not only were weapons undergoing modernization, but their operational uses—principally their tactical deployment in the Vietnam environment—were changing at the same time. One research area concerned new techniques for utilizing surveillance systems. For now, emphasis was on sensing rather than on firing at enemy forces, since frequently they couldn't be found. Interest also increased in such topics as the relations between civilian populations and the military, restoring stability to political systems, and aiding in the pacification process. Research in the manpower and personnel arena also heightened. Problems included the utilization of marginally able soldiers and the full range of social issues—not only drug abuse and race relations but disobedience among troops, lack of motivation, and disruptive secondary allegiances. Much stress was placed on a new breed of junior combat officer who could carry out a modern, enlightened form of leadership.

The charter for behavioral scientists initiated in the late 1950s neared its end by the early 1970s; in its essence it was to research the totality of the problem, not only the whole person, but people in systems within their mission-defined environments. Planning new doctrine for future forces as well as for systems development needed to address human factors in the broadest sense. Behavioral scientists accepted the three new research thrusts during this period: systems development and utilization; stability operations or civil-military relations; and social issues.

But the old charter was not ready for the scrap heap. As the war in Vietnam wound down, the Army was forced to plan and bring about force reduction—to determine who should be released while maintaining quality and readiness. Research answers were needed quickly.

Emphasizing the Soldier's Contribution to the System

In 1963, The Army's Chief of Research and Development acknowledged that human factors and human factors engineering had advanced from population stereotypes, knobs and dials, and after-the-fact modification of equipment to a concept of system design. He believed that Army research and development had entered a stage that sought to capitalize on the unique contributions that humans could make to the system. People have always been a critical and costly commodity. By 1968, Army leadership was emphasizing that the number of personnel and the skills needed to operate and maintain each competing system must be considered for all proposed concepts for materiel systems. The Army also asked experts to help estimate the training requirements of competing materiel concepts so that cost data could be developed for purposes of comparative systems analysis. Moreover, the contribution of the soldier to systems performance could be evaluated only in a realistic environment; once development began, human factors data were needed on

a continuous basis so that designers could consider all areas of manpower involvement (Besson, 1968). Trade-off practices, in which hardware, personnel, and logistical functions are matched or balanced to meet "real world" operational goals, had become a familiar concept, if not yet a common practice.

Conceptual development of new materiel items begins with a review of the military mission of that item and a detailed analysis of the functions that the new items must perform. The result is identification of soldier-machine-environment relations and the interactions among them judged critical to success of the final product. Some Army leaders were disturbed because human factors scientists could not provide an adequate systematic methodology for allocating functions between soldier and machine. They strongly believed that human factors research and development should be able to emphasize the difference between soldiers and machines, particularly the uniqueness of the soldier. General William W. Dick, Chief of Army Research and Development in the early 1960s, charged human factors scientists:

> . . . It is because man is so complex that the behavioral sciences have had comparatively such a late start. It is because of man's complexity that we tend to think of machines as the constants and human factors as the variables in the man-machine system model . . . . As automation proceeds, the human will become even more significant, since the jobs left for humans to do are the jobs that the machines cannot do. What will remain are the jobs that man can do better, that which he can contribute uniquely, to the system (Dick, 1963, pp. 5-7).

Stability Operations

Given the Army's research capabilities and past achievements in selection, classification, and use of personnel, plus weapon and equipment design improvement from human factors engineering research, Army Chief of Staff General Harold K. Johnson in 1965 recognized some qualitatively different requirements for research that could contribute to the role of the Army in stability operations: "We have noted the nature of stability operations and the inevitability of Army involvement in them. Therein rests the Army requirement for reliable data on the causes and symptoms of instability—for an understanding of the events which precipitate instability—(or) better still, an understanding of those factors which promote stability" (Johnson, 1965, p. 86). Elsewhere in this chapter is a description of a specific role assigned to ARI in stability operations—development of special devices for selecting and evaluating special warfare troops. Development of these devices required that ARI scientists try unconventional approaches that would eventually satisfy unconventional requirements for selecting the Army's ambassadors, agrarian advisors, peacemakers, interpreters, and other personnel.

The paramount requirement that the Army placed on the social sciences, however, was to gain an understanding of factors that would promote stability. Such research sought to analyze social systems through real-world simulation using modeling, case studies, and other forms of experimentation. The Army's social science research on underground movements, counterinsurgency activities, and the political-military aspects of the U.S. advisory role overseas was heavily concerned with the attitudes being instilled in foreign peoples, that is, with the role of the political and military leaders and with problems of communism among people of differing cultural backgrounds. A good example was a report by the Special Operations Research Office (SORO), *A Short Guide to Psychological Operations in the Republic of Vietnam—1965*, which described research on the human factors motivating Vietnamese peasant farmers, their attitudes toward their government, and toward the Viet Cong insurgents.

E. W. Gude, a social scientist with SORO, in examining the genesis of social conflict as it might relate to stability operations, found little previous research on the problem of social conflict. He believed that social science represented only a small portion of the professions that could make a contribution. Journalists, diplomats, and military officers all had roles to play. What could social science do that an experienced soldier, diplomat, or journalist could not do? "Social science attempts to systematize common sense by more rigorous methods of data collection and analysis than is reasonable for the soldier, diplomat, or journalist . . . by working on real-world problems that are like those of concern to operators, the social sciences are avoiding the serious threat of having research consigned to trivial matters" (Gude, 1965, p. 93).

Although social science uses the case study as a major technique of analysis, Gude found that not enough systematic, descriptive case studies of social conflict situations had been completed to provide a basis for extensive comparative analysis, nor had the studies been undertaken with adequate conceptual frameworks or with research designs providing for maximal quantitative analysis. A conceptual design would have provided information on important theoretical aspects of conflict situations, whether or not the particular condition was important in the single case. Also, quantification was an important aspect of the design because it would have facilitated comparative analysis and application to manual and machine modeling. Gude's conclusions on research of this type were as follows:

> Improved understanding of social conflict is not a reactionary objective of those solely opposed to change. Its primary objective is to sensitize people in power and out of power to the implications of alternative actions. The dynamics of social processes are such that one cannot simply prevent revolution or change. One can . . . make change orderly and with a minimum of unhappiness for the people involved . . . . To refuse to investigate a problem because the potential is present for misuse of results is of course to eliminate the possibility of good and desired utilization. To assume problems will go away by themselves or that we already know all there is to know about social conflict is an abdication of leadership and responsibility (Gude, 1965, pp. 94-98).

The new emphasis within the defense establishment on the social science aspects of counterinsurgency had led to accusations from several sources that the military had left the areas of legitimate concern. Counterinsurgency was a word that had conveyed to many the notion that the Army was planning to suppress the rights of free people. Stability operations carried a certain implication that the Army was dedicated to preserving the status quo. Was this a proper role for the Army? General Johnson said yes. Stability operations had the objective of establishing, maintaining, or restoring a climate of order within which government, under law, could function effectively; General Johnson maintained that the U.S. Army had been engaged in stability operations for more than 100 years. "Today the Army can be considered a professionally competent organization, complemented with a variety of intellectual skills. In short, the Army has acquired a professionalism and expertise that permits it as a group to take a broader view of the role the Army can fulfill in carrying out the policies and governmental actions of this country" (Johnson, 1965, p. 84).

Nevertheless, the stability operations as an area of research was later withdrawn from the Army repertoire as a result of congressional admonitory action. The Army's research in this area, despite the positive views and arguments of its leaders, was perceived as improper involvement in the affairs of other countries. Portions of the research that dealt with achieving a better understanding of peoples in Southeast Asia who were receiving U.S. assistance did continue for a few years in support of ongoing programs.

Social Issues

Social goals in the 1960s and early 1970s included improving the quality of life, reducing alcohol and narcotic addiction, reducing interethnic and interracial conflict, reducing crime, and minimizing the alienation of youth from society. National defense policies were not considered a thing apart; they were and are influenced and affected by national policies, just as national policies are affected by defense policies.

A requirement had been developing so auspiciously for the military to assume responsibility for programs that seemed to be strictly sociological in nature that critics asked: Is DOD becoming a sociological lion? And is DOD turning into a welfare society? The latter question was raised because, starting in the 1960s (as described earlier), the military not only began to accept substandard recruits and draftees once again, but it also initiated programs to help potential retirees seek private sector employment and to train near-discharge servicemen for civilian jobs. DOD denied that it was a social welfare institution, of course, but acknowledged that it had to be concerned with the broader aspects of national security, since all U.S. national goals were significantly interdependent. DOD became involved in several social reforms in the 1960s, in the areas of revised leadership notions, race relations, drug abuse, motivation, and discipline.

New Leadership Responsibilities. One change considered in Army leadership philosophy was long overdue. For years the Army's behavioral scientists had argued that it was important to select leaders for jobs that suited their personal behavior patterns. In terms of career development, requiring multiple routes to officer advancement resulted in better utilization of leaders. This view was quite late in gaining acceptance for the selection and training of junior officers when contrasted to the innovations in enlisted classification that had been introduced and successively refined two decades earlier. In the interest of promoting enlightened leadership for the Army's newly accepted societal settings, the Army War College and the Continental Army Command (CONARC) Leadership Board outlined major themes to be followed. The Army must "facilitate in the leader awareness of his leadership behavior in explicit relation to perceiving himself as a leader, to the group he leads as persons, to his organization in the Army, and to the Army in its societal setting. To foster motivation and participation, the Army must: (1) select leaders for jobs appropriate to their styles; (2) train them to handle situations flexibly in accordance with individual styles; and (3) provide multiple routes to the top" (Helme, 1971, p. 3).

Other aspects of Army leadership were being studied seriously by researchers and the military alike: for example, problems of the officer as a professional, problems stemming from the military system itself, and problems of leadership as viewed by those led in the Army. A credibility gap between the senior commander and junior commanders and between the officer levels and the troops they led was said to be inhibiting professionalism. The system itself inhibited effective leadership by constraining the commander in his "right to fail" (thus leading to the ills of oversupervision) and by rigidly evaluating leaders based on an "up or out" policy. For example, in communicating information to subordinates, senior commanders had to make decisions that were of major significance to their commands but that were contingent on decisions implemented at higher levels. This restriction of downward communication followed by "surprises" for the troops contributed to the credibility gap. Those who led believed that level of motivation of the troops and their decision whether to reenlist might be related to the extent to which they felt they had a say in controlling their own destinies. Leaders also said that troops' motivation might be increased through meaningful and realistic training.

Reducing Racial Tensions. By July 1969, it became apparent to the Army and other armed services that the possibility of open racial conflict existed within the military. Beginning with President Truman's integration order in 1948, the armed forces had been the forerunners in meeting the challenges of racial equality, and initially the services believed they were immune to the open racial conflict that was occurring in civilian communities throughout the United States. Nevertheless, the Department of the Army directed that an educational program promoting racial understanding and harmony within units be developed and taught at all Army service schools and basic training centers. Sociologist Charles C. Moskos, writing in 1971, urged that "the spillover of racial tensions from the civilian sphere into the military must not be used as an excuse for commanders to avoid confronting race problems in the Army" (Moskos, 1971, p. 57). He urged the Army to continue and accelerate its official goals of equality of treatment with regard to promotions, punishment, advanced school assignments, and off-post discriminatory practices.

Commanders and senior officers were advised to get personally involved in a race relations program. Leaders could organize and participate in seminars; improve black visibility; ensure military justice for all; understand racial signs, epithets, and symbols; understand racial paranoia; and improve communications. ARI's research program in 1971 was to identify career motivators for minority personnel; develop troop training programs to improve racial harmony; conduct sociological analyses of military justice; and, at the most utilitarian level, develop a leader's race relations book for the guidance of company grade officers. Suggestions for higher Army headquarters were improved command structure and organization in the implementation of policy and guidelines for lower level commands and units, and greater visibility and responsibility for such an organization.

Moskos optimistically expressed the view that "the Army must not be overly defensive with regard to its racial situation. For with all its troubles, the military remains the most integrated institution in American society. In fact, the military may be the only arena in American society where advancement for blacks is possible without a cultural conversion to middle-class white standards" (Moskos, 1971, p. 7).

Drug Abuse. The Army's program on drug abuse in 1971, in anticipation of and in response to a wide spillover from civilian life, had six functional areas: prevention, identification, detoxification and treatment, rehabilitation, field evaluation, and research and development. The promise of what might be accomplished through research was expressed in modest terms by Brig. Gen. Robert G. Gard, Jr.: "An extensive effort is required, for we know far less about this subject than is necessary to move into any program with confidence. We've got to understand the complexity of this problem, evaluate our programs, and discover new techniques" (Gard, 1971). ARI's drug abuse program was designed to provide data on segments of the problem where the need was critical and where information could provide the basis for action. But in the main, the Army's drug abuse program was primarily an operational one that did not involve application of research methodology.

Discipline and Motivation. In the early 1970s, the Army was also plagued by severe problems in discipline and motivation. Such problems were seen to reflect a general weakening of morale that always seems to accompany the end of a war. If one must err in matters of discipline and motivation, said Moskos (1971, p. 8), let it be in favor of the committed soldier rather than the single-term serviceman; better a sullen and well-trained soldier than a sullen and ill-trained soldier. Behavioral and social scientists considered for research such innovations as the plural Army, consisting of a duality of effective technical ("urbanized") and traditional (combat unit) members. Implications of a plural Army were that traditional leadership skills and technical and managerial skills were equally valid but not readily interchangeable; standards of motivation and discipline would be quite different in the traditional and civilianized sectors of the Army; and the Army would be internally segmented into units dissimilar with respect to traditional or civilianized character. Critics of this kind of Army organization pointed to the probability that a plural Army would create an "elite corps" and a "secondary corps" working and living together constantly, with inevitable dissension and conflict.

John Lovell of the U.S. Naval Academy, speaking in 1971 at the 17th Annual Army Human Factors R&D Conference, said, "It is one thing to recognize that changes are occurring; it is quite another thing to assess accurately the goal values and beliefs that motivate and orient new demands. A more fundamental level of comprehension can be attained only if one is able to grasp the hopes, fears, frustrations, and aspirations that underlie the changing behavior." Lovell sensed that changes could be perceived as so threatening to military honor, self-respect, and sense of purpose that the Army might become more defensive rather than more responsive. He suggested the following questions for the Army and social sciences: Do young Americans reject discipline and authority or the forms and exercise of authority? Are young people today less idealistic, or have the kinds of slogans and "causes" simply changed? Is patriotism less fashionable today than it was a generation ago? Is hostility toward the Army today greater than it had been, say, in the aftermath of World War II and of the Korean War? Lovell believed that the perception of social change as threatening to the military tends to be a self-fulfilling prophecy and may be more apparent than real (Lovell, 1971, p. 11).

Technological Advances on Tactical Problems

Described below are selected ARI research efforts that responded to a few of the specific military requirements of this period.

Continuous Operations. To make tactical and logistical operations more continuous, newly developed sensors, including night vision devices, were developed during the 1960s. This hardware posed a new challenge and role for human factors research. Previous research in this area had been concerned primarily with relating to the engineering requirements for individual night vision and other sensor devices. Research was now needed to supply military users with human performance information to help them make decisions on the establishment of continuous (day and night) operations procedures and the selection of associated equipment for development.

Answers were needed to questions such as the following: Who should use the sensors? Under what conditions should such sensors be used? Which ones should be used? How should they be used? What should be the basis of issue? How can they be most effectively combined? Human performance questions also asked how long a soldier could be used, under what kinds of conditions, and on what kinds of tasks. Researchers hoped to discover the effects of continuous operations on tasks requiring memory, sensory discrimination, manual dexterity, and decision making. From a more general point of view, by utilizing human performance experimentation, scientists could seek principles applicable to many Army systems by studying general behavioral functions or work slices common to a number of systems or operations.

The continuous operations experimentation provided an opportunity for a combined laboratory and field effort, with evaluation and validation of laboratory findings in the field to establish principles and techniques that enhanced human performance. The findings could be applied to the development of selection techniques, training requirements, individual work methods, and team procedures to produce the most effective utilization of personnel within military systems. For example, in continuous operations research involving night vision devices, comparisons could be made between relative performance and selected devices to determine variance and target acquisition failure attributable to device factors and to operator factors. The new sensors being developed and their related systems, including human factors elements, were expected to have enormous impact upon the reconnaissance, surveillance, and target acquisition activities that provided basic input information to field commanders (Hyman & Sternberg, 1969, pp. 136-156).

Command Information Processing. Technological advances had increased the mobility and destructive power of military operations. To permit commanders to make tactical decisions consistent with rapid and serious changes of events, information on military operations had to be processed and used more effectively than ever before. ARI developed a research program designed to provide information on human factors that could be useful in enhancing the output of these developing and future systems. The program was dedicated to providing users, developers, and designers of the current and future systems with information concerning the capabilities, limitations, and reliability of human performance; allocation of functions among soldiers and equipment; various modes and sensory modalities of presenting information for assimilation and decision making; effects of characteristics of the information displayed (such as amount, density, and type); specification of effective individual and group work methods and techniques; and procedures for identifying and assigning appropriate personnel to critical positions.

One example of such research was the study of certitude. It had been found that certitude could be affected by a display variable that has no effect on accuracy of assimilation of information. The implication of this finding for systems of processing command information was that efforts to enhance displays should focus on display characteristics that increased not only accuracy of assimilation but the confidence the operator had in this accuracy, based, of course, on determination of the degree of the relationship of both certitude and accuracy to the effectiveness of decision making.

Concerning the effects of characteristics of the information displayed, research indicated that both the amount of information presented and the amount of change in a single slide (presentation) updating should be kept as small as possible. The highest degree of certainty is generated under such conditions, and it is at this level that accuracy most nearly coincides with certitude (Ringel, Hammer, & Vicino, 1963, pp. 91-101).

Field Testing in Command and Control. At a time when the research literature is full of studies on transfer technology, it is interesting to contemplate a 1970 paper by James D. Baker on bridging the gap between the laboratory and the real world. As he put it, in the typical situation of a decade ago, results of studies were documented and the findings sent to actual and potential users so that the findings could be related, in some philosophical or logical way, toward satisfying the needs of that individual or organization. The degree of success in implementing research findings in this way was moot.

As evidence, Baker used plans initiated by the Computer System Command, and Headquarters, U.S. Army, Europe, for the design verification of an automated tactical operations system (TOS). To design and test such a system, a group was formed and assigned the task of developing a field version of the TOS for Automatic Data Systems within the Army in the Field (ADSAF).

To prepare Army users in Europe for their part in the TOS field test, a vehicle for familiarizing and training the user was needed. The solution to this need was logical and straightforward: Collect the messages and the scenarios from a prior Seventh Army field exercise and rerun them as an in-garrison training exercise using the TOS equipment.

When the training exercise was undertaken, there were the usual bugs and snafus. But even discounting the resulting delays, those involved in the exercise realized that the system was not keeping up with the load. Granted, the Seventh Army TOS was not intended to operate as a true real-time system; however, it had been assumed all along that the TOS would be capable of running in a near real-time capacity. What was causing the problem?

The answer lay in the fact that, in keeping with the current trend in information systems, the TOS designers had gone out of their way to allow the user to communicate with the computer on line and to influence system operations. The answer to why the system was lagging behind was simply this: The collaborative team of system and scenario developers assumed a one-to-one correlation between the messages to be handled and the messages to be fed into the computer. In reality, this situation did not occur. It took more messages to communicate soldier-to-machine than it did to communicate soldier-to-soldier in the original exercise.

One advantage of this approach is that it bridges the gap between the user and the laboratory. The user can directly express and delineate the problems critical in day-to-day operations, and knows that the researcher understands the operation and can meaningfully interpret ideas into a research program. Likewise, the user can have the benefits of laboratory findings directly translated into comprehensive inputs. The user also benefits by working with a trained professional who has a different perspective, who can see things from a vantage point not colored by "we do things this way, because we always did things this way." The human factors researcher is not encumbered by operating tradition and, in addition, has the skills and methods for "quick and dirty" testing of alternatives for immediate fixes to intolerable situations (Baker, 1970, pp. 27-47).

Selection of Special Forces Officers. The Special Forces officer during the 1960s was assigned an unusual set of duties. According to the commanding general of the U.S. Army Special Forces Warfare Center, those duties covered a wide spectrum, ranging from association with heads of state and ambassadorial representatives to instructing a villager how to drill a well. The commanding general's request for ARI to determine those qualities that would enable an officer to perform a special warfare mission to the maximum degree and to devise measuring instruments to aid in selecting Special Forces officers presented conditions for research not usually found in conventional military selection problems. One requirement was to project effective performance in nonmilitary aspects of the assignment—interpersonal, cross-cultural, social, advisory, and teaching relationships. Further, selection was to be made not only for assignment to a 3-year tour of duty in Special Forces (and not to a branch or field that would cover the officer's total career) but was to be made from a highly qualified officer base covering the entire range of company and field grade officers.

In the research, success was to be reflected in three measures: academic average, evaluation of a field training exercise, and peer ratings. An experimental battery was assembled. The Officer Qualifying Examination and the Army Language Aptitude Test (ALAT) were administered to measure cognitive and intellective ability. Interests were measured by the Preference for Army Duties schedule; motivation and personality, by four brief instruments. To measure noncognitive requirements, a Special Forces Selection Battery developed by ARI included a suitability inventory, a critical decisions measure of judgment and risk-taking tendencies, and a locations test, or measure of ability to orient oneself spatially in actual terrain or using photographs. A multiple correlation coefficient for the Officer Qualifying Examination and the Army Language Aptitude Test was .59 against classroom grades, but these two tests had no validity in predicting success in operational assignments following graduation. In general, multiple correlation coefficients of predictors including peer ratings and training scores were encouraging. The preliminary results (based on a small sample group) suggested that certain personality characteristics, assessable at the time of entry into the Special Forces program, might predict effectiveness in operations evaluated some 9 months after graduation (Medland, Green, & Marder, 1965, pp. 147-152).

Prisoner Behavior in Simulated Interrogations. Are there typical differences between a young officer who reveals information to the enemy under questioning and one who does not (as the Code of Conduct requires)? Can such differences be found in a simulated interrogation? ARI conducted a study based on data for 700 lieutenants who, after a year or more of active duty, underwent a harassing 3-day exercise under conditions of total simulation, climaxed by combat-type actions, including a patrol mission during which each lieutenant was captured and interrogated.

In terms of behavior during the interrogation, it was found that those who falsified information (i.e., attempted to mislead the interrogation) tended to depart from the Code of Conduct. The very few who pretended illness or showed belligerence or contrariness also tended slightly to depart from the code. Where comparisons were possible, Regular Army officers tended to adhere better to the code than did Reserve officers, and a higher proportion of first lieutenants than second lieutenants maintained strict security.

There was a slight tendency for officers who were captured without personal papers to observe the code better than those captured with such papers in their possession. The officer adhering to the code was found to prefer a combat-type assignment, to be familiar with patrol missions, to report substantial effort in the patrol assignment, and to be well motivated, even though he had undergone a tedious 3-hour staff activity before dawn on the day of capture. The officer departing from the code was found to be bothered a good deal by being alone for long periods; to suffer from drowsiness and fatigue, especially during the patrol mission; to find that mission stressful; to be bothered by apprehension over possible dangers; and most particularly, to be bothered by the events from capture to interrogation.

On the basis of these findings, a tentative "yes" answer to both research questions appeared justified (Willemin, Sait, & Weinberg, 1965, p. 81).

Matching Manpower Requirements and Resources. In the mid-1960s, the matching of manpower requirements and resources was attempted within a complex functional system that cut across the organizational lines of the operations agencies, researchers, and behavioral scientists. Improvements, including the insertion of appropriate decision models and realistic criterion measures, could be incorporated into an overall "loose" model. The techniques and substantive knowledge required to accomplish this modeling and improve the personnel management system formed a relatively new field of macro human factors. Behavioral scientists believed, however, that the operations research methodology required in this new field should not be overemphasized at the expense of the substantive contributions of psychology and personnel management. It was necessary to precede modeling by a problem formulation phase, with emphasis on the measurement and manipulation of human factors variables in both phases.

The nature of the variables in manpower models required the application of human factors principles for realistic simulation, optimization of criteria, or prediction of results as a consequence of using various policy alternatives in the system. At any rate, it was felt at ARI that more personnel and management psychologists should be assuming the role of macro human factors specialists, who should perform in both operational and research roles. But satisfactory progress in the solution of macro human factors problems would occur only when coordinated efforts were based on activities of both research and operational agencies (Johnson, 1968, pp. 124-125).

Chapter 5

Manned Systems Research, 1960–1971

From the early 1960s to the early 1970s, ARI's research program concentrated on new requirements to make the soldier more effective in the system. Typical research activities included developing techniques to use in command systems for screening incoming data, transforming data for storage and retrieval, assimilating displayed information, and decision making; and developing procedures for rapid acquisition of voice communications in which signals were noise embedded and fleeting. In addition, ARI was involved in constructing the first Armed Services Vocational Aptitude Battery (ASVAB) for use by all services in recruiting and in developing models to evaluate manpower quantity and quality estimates under alternative procurement policies.

Research accomplishments included the following: specification of image interpretation methods for enhancing systems performance by evaluating image quality, real-time information extraction, and computer-aided decisions; introduction of techniques in a developmental tactical operational system that reduced error rate and processing time; development of a model for classifying military tasks based on taxonomies of human performance; implementation in the field of an organizational effectiveness program that improved job performance and satisfaction months after the intervention; prediction of differentiated combat and technical-management leadership behavior through an assessment center approach; introduction of an improved differential Army Classification System that produced major savings;demonstration of the value of adaptive mental testing; development of instruments to predict motivation for an Army career; and development of a handbook for improved race relations for use by commanders and leaders.

The ARI Research Program

For this period, ARI's research program comprised four major thrusts: manned systems, human performance experimentation, personnel selection and classification, and manpower management.*

Manned systems research had as its principal objective the enhancement of human performance in relation to total systems effectiveness. It involved experimentation with various configurations of systems components and considered interactions with trade-offs, not only to improve human performance but also to provide a way to evaluate systems effectiveness as a function of systems factors.

Human performance experimentation research involved studying the behavioral functions common to many systems in order to discover general principles that, when applied operationally, would enhance individual and team performance. Typical outputs were work methods, basis of issue, work-rest cycles, supervisory techniques, and procedures for information input and response output. Ways to improve performance that had been successful in laboratory settings were evaluated later in the field.

Despite a new focus on the soldier within the system, there was no less attention to personnel selection and classification research, which included the evaluation of behavior involving demands on individuals, teams, and systems, and the development of military selection and classification systems for other cultures. The research evaluated implications for manpower planning (e.g., the impact of enlisted personnel with low general aptitudes on training and operations); sought early identification of individual assets for maximum job performance; identified factors in the adjustment and motivation of personnel; and studied operating relationships among fellow team members, particularly leadership relationships within the group, team, or system.

Mathematical models added new dimension to manpower processing, planning, and policy formulation during this period. Computer-aided simulation studies were also part of ARI's manpower management research.

Manned Systems Research

Tactical Information Processing. The Army was developing automated tactical operations systems as part of a larger program—Automatic Data Systems within the Army in the Field (ADSAF)—for receipt, processing, storage, retrieval, and display of different types and vast amounts of military data. Because effective performance of these new systems ultimately depended on human components, the need for human factors information was paramount. Previous research on basic human factors problems had identified five critical information-processing operations: screening incoming data, transforming raw data for input into storage-retrieval devices, input, assimilation of displayed information, and decision making. The results of previous studies on information assimilation and decision making, and on data input and message composition functions, had delineated human performance capabilities and limitations, with implications for increasing the efficiency of the information assimilation/decision process and for improving work methods.

*The leadership of ARI during the early part of this period included Hubert E. Brogden as Chief Scientist and J. E. Uhlaner as Research Manager. Later in this period, Uhlaner became Technical Director. Other key leaders included Philip Bersh, Edmund F. Fuchs, Aaron Hyman, Cecil D. Johnson, and Joseph Zeidner. Additional leaders are listed in Appendix K, along with scientific personnel of this period.


J. E. Uhlaner

Research objectives were to acquaint commanders and their staffs with the critical functions of information assimilation and decision making and to develop techniques for efficient processing and use of information by soldiers in tactical situations.

Interpreter Techniques in a Surveillance Facility. The large increase in the Army's capability to acquire imagery led to a similar increase in the amount of raw reconnaissance data that had to be reduced. Concomitantly, the increasing mobility of armed forces put a premium on the speedy reduction of these data. Within this context, it was the interpreter's job to transform the raw data into intelligence information. The need to handle large volumes of static and dynamic (real-time) imagery of various types (photo, infrared, and radar) in new tactical interpretation facilities demanded a critical evaluation of interpreter tasks. Research emphasizing the cues and signatures for tactical targets was indicated. It was hoped that this research would lead to a definition of the interpreter's job in such functions as screening, interpretation, target location, plotting, and mensuration. Another research objective was to determine the most efficient use of human abilities to maximize the accuracy, completeness, and speed of intelligence information derivable from the interpretation of imagery.

Image-Interpretation Displays. In systems that obtained, processed, and displayed imagery for the extraction of intelligence information, it was vital to consider interface problems relating human performance to display characteristics, which could be varied systematically in the laboratory and their effects evaluated. In previous research efforts, it had been found that stereo viewing did not, in general, improve interpreter performance. It was further found that the time required for screening or interpreting overlapping photography (required for stereo viewing) was considerably greater than for nonoverlapping imagery without compensation in terms of increased accuracy or completeness. Research also indicated that interpretation performance was equally good with positive or negative transparencies. On the other hand, the development and introduction of "error keys" did reduce the number of false alarms appreciably.

The principal research objective was to determine how interpreter performance would be affected by variations in the characteristics of the image (e.g., magnification and image quality) for photos, infrared, and radar imagery and by variations in the nature and content of references and reporting devices used by the interpreter.

Advanced Image-Interpretation Systems. Intrinsic to the development of an effective information-processing system for advanced surveillance were the rapid retrieval of required reference information; the specification of required team methods and communication links among personnel; and the delineation of procedures for controlling system operations and interpreter decision processes. It was necessary to test the total configuration of personnel, equipment, and procedures and compare it with reasonable alternatives under operational conditions. On the basis of such an evaluation, modifications and improvements could be introduced. Research previously had studied how the efforts of several interpreters could best be combined in team operations to meet system demands for increased accuracy, completeness, and timeliness. Work had begun on the establishment of a decision matrix approach to the control of interpretation systems output.

Research objectives included development of techniques to integrate, evaluate, and improve information processing systems for advanced surveillance through laboratory simulation and development of effective techniques for improving team operations, data bank utilization, and the control of the imagery and information flow through the system.

Human Performance Experimentation

Human Performance in Night Operations. An increasing need to improve night operations capabilities had led to the development of sensors that would improve night seeing ability and target acquisition operations. The research efforts of other laboratories had been devoted primarily to engineering requirements. Continuing human performance experimentation was sorely needed to determine and improve the level of human performance effectiveness possible with the current generation of devices and to provide data applicable to use of future generations of devices.

In general, the salient questions dealt with who should use which devices, how and under what conditions, and what should be the basis of issue and mix. Virtually no controlled laboratory or field studies evaluating the actual performance of the newer devices, nor any comparisons of their relative effectiveness had previously been conducted.

To accomplish this research, a field experimentation unit was established at Fort Ord, California, to collect data through a three-phase research effort to support night operations.

Research objectives relating to perceptual performance during night operations included identifying variables and parameters, developing principles and techniques, and evaluating and validating resulting work methods to produce the most effective utilization of personnel.

Dependable Performance in Monitor Jobs. The complex weapons of the modern Army created many new types of monitoring jobs. In one major class of these jobs, operators had been required to detect and identify a variety of weak, fleeting, or unpredictable visual and auditory signals. Examples of such jobs with a strong vigilance component were Mortar-Location Radar Operator (Field Artillery) and Nuclear Power Specialist (Corps of Engineers). Operators had to make fairly simple responses at appropriate times and continue to respond accurately and quickly during long hours and under fatiguing or boring conditions. Successful performance depended as much on the operator's ability to remain alert and vigilant as it did on technical skills. A survey of 1,500 jobs in the combat arms and technical services identified more than 100 monitoring-type duty positions requiring high operator vigilance.

A second major class of monitoring jobs became increasingly important as automated equipment in the newer systems relieved the operator of more routine job aspects. Now the operator was required to discriminate important from very similar but unimportant signals in an active signal environment such as a Communication Receiver in the Signal Corps.

Research objectives included establishing and evaluating techniques and operating procedures to improve the performance of persons working in Army monitoring jobs, as well as the performance of information-monitoring personnel.

Dependable Performance in Controller Jobs. Soldiers in controller jobs were also required to stay alert for relatively long periods—to the presentation of critical information—and to respond quickly and precisely when such information did appear. (Tasks were varied and included providing final navigational guidance to a missile, controlling the air traffic environment, and flying a helicopter.) The displays were usually visual (but could include audio and kinesthetic elements) and could be real world, synthetic, or combinations of the two; most often tasks required assessment and response in real time. Human operator-machine interfaces were decided at a higher level of complexity than those required of a monitor. Development of more effective controller procedures and better ways to identify and assign personnel for controller's jobs was essential.

The initial research focused on problems of performance involving air defense missiles, such as excessive delays in designating and responding to hostile targets, failure to designate hostile targets, and designation of friendly craft as hostile.

Research objectives included developing and testing operating procedures, techniques, and principles to improve job performance in a variety of Army controller jobs and developing measures of each soldier's potential to reach effective performance levels in operator MOS that required precise control response sequences. Of particular importance were control responses to soldier-machine interfaces that presented complex displays having a high density and rapid change of information.

Personnel Selection and Classification

Enlisted Manpower Systems. Congressional legislation had been the basis for the use of the Armed Forces Qualification Test (AFQT) and Army Qualification Battery (AQB) in screening for military trainability. Now, the Department of Defense was requesting research on a common aptitude battery that could be used by all the services. One outcome of this requirement, and of the use of the AQB, was an increased emphasis on expanded testing programs under restricted time limits. Research was indicated on new methods for shortening tests to supplement the conventional methods.

Research objectives included developing new forms of screening measures that would measure more effectively the level of trainability and usability of potential enlistees, on reference measures for use as standards, and on improved methods for extracting predictive information from screening tests.

Differential Classification of Enlisted Manpower. The Army Classification Battery (ACB) was developed to match MOS training courses and jobs to the different aptitudes of enlistees. In general, the changing conditions under which soldiers were trained and utilized on the job were thought to interact with classification tests; accordingly, research was designed to study the magnitude of these interactions. Improved utilization of enlisted personnel was also thought to depend on developing better measures of soldier aptitudes, backgrounds, and interests.

A long-term research effort resulted in the Army Differential MOS Battery, which was tried out on about 25,000 enlisted personnel in more than 100 training courses. The effectiveness of both the experimental and the operational measures in predicting success in initial and subsequent training and job assignments had to be determined.

Research also sought to identify the conditions, such as type of training program and job content, that would interact most favorably with the classification tests, and to maintain and improve the effectiveness of the ACB and related techniques.

Prediction of Officer Performance and Retention. With the advent of U.S. participation in the Vietnam war, research was redirected to permit the collection of human performance data in up-to-date combat or combat-ready settings. The Differential Officer Battery (DOB) of 13 experimental tests had been developed and administered at most of the major branch basic schools to more than 10,000 Regular and Reserve officers. The recorded performance of a sample of 900 officers who had taken the predictors and who had completed a 3-day performance exercise at the Officer Evaluation Center (OEC) was the major data source for differential validity analysis. Meanwhile, officers who were originally given the experimental screening measures and who were still on active duty had been followed up to validate the predictors against actual performance.

Evaluations of actual performance had been obtained in Vietnam, Europe, and elsewhere. In all, the accumulated research data were of unprecedented magnitude.

Research objectives included developing improved techniques and prerequisites for selecting officers who had aptitude and other characteristics associated with enhanced leadership performance in combat, administrative, or technical assignments, and who were favorably oriented toward an Army career.

Performance in Combat and Overseas Services. Past research had indicated that improved ways to identify successful combat soldiers would more likely come through studies of measurable personality factors than of aptitudinal or ability factors. Further, it was considered that differing personal characteristics might be required for effective performance in differing combat conditions and cultural milieus.

The Advanced Research Projects Agency (ARPA) asked ARI to develop a personnel selection and classification system for the Imperial Iranian Army—a system that would be applicable to other selected countries. Each country's qualitative manpower resources were to be studied to help determine the skill requirements needed by its army for military specialist training programs.

Research objectives included developing and standardizing new instruments for selection of combat personnel, with application of findings to the differential classification and assignment of these soldiers; and developing general techniques for instituting military and selection classification systems in selected countries, taking into account dynamic cultural factors.

Selection and Evaluation of Cadet Leaders. Previous research for the U.S. Military Academy, the Reserve Officer Training Corps (ROTC), and the Officer Candidate School (OCS) selection programs had resulted in development, improvement, and operational implementation of tests of mental ability, physical proficiency, and leadership for use in selecting cadets and candidates for later commissioning. The Army ROTC program required continuing surveillance and periodic checks on the validity of its selection and evaluation procedures for the senior division program and for Regular Army commissioning. A similar requirement existed for the OCS program.

Research was conducted to validate and improve procedures used to select applicants for ROTC 2- and 4-year scholarships and to analyze ROTC measures and evaluation forms for Regular Army commissioning. An alternate form of the Officer Candidate Test (OCT) was added to the current selection battery.

Research objectives included developing procedures to improve the academic quality and leadership potential of college and university students selected for Army ROTC programs, including scholarship applicants, initial and advanced ROTC training applicants, and cadets eligible for direct commissions upon graduation.

Manpower Management

Optimum Distribution of Individual Abilities for Unit Effectiveness. Questions of the impact of various levels of mental standards on enlisted performance would resurface with every change in standards. The Army wanted to know what balance of personnel of various mental ability levels was needed for units to be effective.

Objective measures of individual and unit performance were needed to compare units with different distributions of individual ability. Performance measures for individuals took into account typical productivity and disciplinary problems as well as technical ability. The research was carried out in benchmark MOS and units. After prototype studies, the research branched out to a representative number of benchmark units.

Research objectives included developing measures of small unit and individual effectiveness to estimate permissible mixtures of individual mental ability levels. Such measures let the Army set relatively low individual screening standards but still achieve relatively high levels of unit performance.

Officer Performance Evaluation Systems. Research steps based on previous contributions from peer and supervisory rating research, social psychology, and computer technology were planned as follows: (1) Based on a review of research and development of performance evaluation techniques relevant to the military setting, the current system was analyzed on the basis of officer tape data on promotion, selection for schools, and assignments, with the objective of constructing a model defining the requirements of a system to evaluate officer performance; (2) experimental try-out of assessment techniques, such as peer evaluations, structured group (board or committee) evaluation interviews, and rating instruments at given personnel management decision points, were conducted; and (3) possibilities were explored for simulating requirements of critical assignments for use as performance criteria.

Research objectives included developing new and improved officer evaluation techniques for use by personnel management and related agencies, especially at career decision points; in the long range, designing and testing systems to establish a new and comprehensive officer evaluation system; and assisting in the inclusion of new or improved techniques during ongoing revision of existing officer evaluation procedures and instruments.

Simulation Model of Personnel Operations. Early manpower models (such as SIMPO I) had been applied at the manpower policy analyst's level to aid in both the one-time assessment of proposed policy change and the periodic analysis of the projected state of the personnel system. The SIMPO II effort constituted a continuation and extension of the work accomplished in SIMPO I, and included more efficient and effective means of providing input and output for SIMPO I models; development of modules that would create "optimal" policies for further evaluation through simulation; creation of new models as required to solve certain problems for which SIMPO I models were not applicable; and exploration and evaluation of techniques offering promise of extending the usefulness of new and old personnel systems simulation models.

Research objectives included developing new approaches and techniques for use in computerized models of manpower and personnel systems that management could use to evaluate alternative policies; determining the effectiveness and efficiency of those approaches; applying the new approaches and techniques to models developed in SIMPO I to extend their usefulness as operations research (OR) tools; and developing new SIMPO II models capable of solving additional kinds of manpower/personnel management problems.

Selected Research Findings

Image Interpretation

By the end of the 1960s, research in image interpretation conducted by ARI over a 10-year period had produced scientific data on improving the extraction of information from surveillance displays and on efficiently storing, retrieving, and transmitting this information. The objectives of this program were to enhance the performance of the human component in systems then in operation and to provide information to developers to help them provide design specifications for future systems. Most of the separate research efforts had been conducted in response to specific military requirements to optimize the completeness, accuracy, and speed with which intelligence information could be extracted from reconnaissance and surveillance records. A summary of selected research projects and operational applications follows.

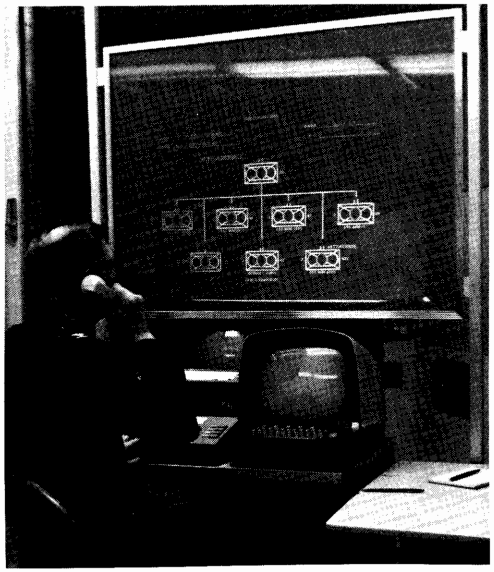
Systems developers had found that image quality limited the amount of intelligence information that could be extracted from a reconnaissance mission. Hence, research had focused on developing quicker, more subjective techniques for evaluating image quality and on determining the effects of mission factors. Using the Image Quality Catalog, facility managers were told they

Early image interpretation system research—The stereo viewing problem

could make subjective estimates of interpretability to predict expected performance (Birnbaum, Sadacca, Andrews, & Narva, 1969). Managers were also advised to acquire the largest scale imagery practicable because degradation of image quality produces a greater loss in interpreter performance for small-scale imagery than for large-scale imagery (Jeffrey, 1973). Systems designers were advised to consider the use of color, which would add a dimension to image quality that would permit interpreters to extract intelligence information in less time than required with black-white film (Jeffrey & Beck, 1972).

The factors of image resolution, presentation rate, and scale had been found to be important in the design of interpretation displays and related doctrine. Therefore, possible trade-offs among those factors were recommended for consideration. For example, facility managers were told that screening accuracy for poor resolution imagery could be increased for presentation rates in the range from 0.8 to 2 seconds per frame by increasing viewing time per frame. Beyond 2 seconds per frame, increasing viewing time would not increase screening accuracy (Lepkowski, 1978).

Real-time information on events beyond the forward edge of battle area (FEBA) could be provided by inflight displays in an aircraft, or the imagery could be telemetered to a ground sensor terminal for interpretation in real time. ARI's research dealt with the interpretation of infrared and TV displays and with the effect of bandwidth compression of digitized imagery on interpreter performance. Its researchers found that such bandwidth compression degrades interpreter performance but could be used under several conditions. Mission



ARI Simulated Tactical Operations Center

planners were further advised to consider the interactive effects of sun angle on performance (Martinek & Zarin, 1979).

The proliferation of intelligence-gathering systems was known to overload the commander with information—some critical and some of little concern, some accurate and some relatively inaccurate. The decision model of this system was probabilistic because the true state of the conditions confronting the decision maker was usually not known with certainty. Research focused on the interpreter's ability to estimate the probabilities and on the decision maker's ability to estimate costs associated with errors. Setting a low acceptable cost level resulted in fewer reports of greater accuracy, whereas setting a high acceptable cost level resulted in more reports with reduced accuracy (Birnbaum, Sadacca, Andrews, & Narva, 1969).

The ability of image interpreters to detect changes in the enemy's intent and capabilities was the subject of additional research on several techniques used to enhance performance. A typical finding was that equipment should be provided to permit variable magnification and rotation in order to minimize the effects of scale and orientation differences (Epstein, 1970). Another finding was that target annotations on the earlier imagery could be a useful technique for change detection (Epstein & Jeffrey, 1973).

One critical task in image interpretation identified for ARI research was photogrammetric measurement, that is, plotting area coverage, determining the size of objects, and providing ground location data. Although some tasks could be automated, other tasks still required an interpreter. Several experiments using different types of imagery and using interpreters with different experience levels were performed to determine the magnitude of errors that had been detected under various conditions. As many as 21 separate findings, conclusions, or recommendations were made as a result of ARI's research (Jeffrey, Martinek, Shvern, & Johnson, 1980, pp. 79-81), such as "Scale graduations—in thousandths of a foot or in tenths of a millimeter on both interpreter scales and magnifier reticles—had no significant effect on measurement variability among interpreters" (Lepkowski & Jeffrey, 1972).

In its partnership with military systems designers and developers in the surveillance area, ARI became concerned with both upgrading and maintaining interpreter proficiency, because certain skills had been found to deteriorate during periods of disuse. As a result of a series of projects, ARI scientists learned the following: Search time could be reduced by training, but only at the expense of fewer detections or more errors; false target detections (inventions) could be reduced by error-avoidance training using an error key (Powers, Brainard, Abram, & Sadacca, 1973); team consensus feedback could be an effective way to develop and maintain interpreter proficiency; and teams that were heterogeneous in proficiency learned more than did homogeneous teams (Cockrell & Sadacca, 1971).

After investigating the types of errors typically made by image interpreters, ARI developed references (keys) for identifying potential targets and for reducing both inventive errors and errors of omission. Such keys were effective even for experienced interpreters (Martinek, Hilligoss, & Harrington, 1972).

These findings and products for improving advanced interpretation systems of the 1960s and 1970s and planning the systems of the 1980s were of continuing interest to users (interpreters, G2 and G3 air officers, commanders, and others), designers, engineers, and the intelligence community as a whole (Jeffrey, Martinek, Shvern, & Johnson, 1980).

Assessing the Human Components in a Tactical Operations System

In the 1960s, the Army began development of an automated tactical operations system (TOS) to help commanders and their staffs collect, process, and summarize information required for command decisions and staff actions. This development contributed to an Army-wide project—the Automatic Data Systems within the Army in the Field (ADSAF).

Although the introduction of automatic data processing (ADP) equipment into tactical operations could be expected to speed up processing and reduce errors, effective performance of the system ultimately depended on its human component. ADP alone could not be expected to extend significantly the capabilities of the system or alleviate the limitations of the human element as an information processor.

Research in a systems setting was undertaken by ARI in Europe to examine human factors problems related to error rate, processing time, and confidence in message format selection, as well as to evaluate a newly devised job aid to use in selecting appropriate formats. The experimental TOS utilized 47 different messages, from among which 14 G3 staff action officers had to determine the appropriate formats to use with each message. Of particular research interest were human factors problems involved in transforming free-English G3 message texts into rigidly defined formats in preparation for user interaction with the TOS. Both ARI-devised aids and a "menu" listing of available formats were used by the subjects, who were placed into two groups for this purpose. Time taken to complete and degree of confidence were recorded. The research confirmed that the transformation process was a potential major problem in TOS development. The time and error rate data in format selection and processing and the expressed certitude of corrections in format selection provided valuable baseline data for comparative study of future performance in such systems and also suggested approaches to training and alternative methods for the transformation process (Baker, Mace, & McKendry, 1969).

Taxonomies of Human Performance

A major problem confronting the behavioral sciences and technologies in the late 1960s was the lack of a structure within which to describe, interpret, and organize information about human performance. The extent to which findings from different studies could be compared, contrasted, and integrated into a body of knowledge was limited. Systematically describing those antecedent conditions of which performance was a function required unifying dimensions.

Of the many conditions that could influence performance, the most poorly described and the least understood were those embodied in the task. Research results obtained with one task could be safely generalized only to other tasks that were so highly similar as to be almost identical. Communicating research findings was similarly hampered. Behavioral scientists and those who had to apply research findings to operational programs were without a language for interrelating performance on different tasks.

A program initiated by DOD's Advanced Research Projects Agency had been adopted by ARI to develop theoretically based language systems or taxonomies that, when merged with appropriate sets of decision logic and appropriate sets of quantitative data, could be used to make improved predictions about human performance. Such taxonomies could be useful when future management information and decision systems were designed for Army use. Several taxonomies had been developed, each with maximum relevance for a different type of application. For example, the ability-requirements approach was an effort to derive preliminary estimates of the construct and predictive validity of human-ability-based task rating scales (Theologus & Fleishman, 1971). The information-theoretic model for task classification treated a task as an information transfer between a source and a receiver; research demonstrated the model's potential for predicting performance on tasks not yet researched and for hardware not yet built (Levine & Teichner, 1971). The task-characteristics approach to performance prediction (Farina, Wheaton, & Fleishman, 1971) viewed performance as a function of three sets of antecedent conditions—the operator, the environment, and the task. Initial efforts using this approach focused on the task component of the model, holding the other components in abeyance.

In this approach, major components of a task were identified and treated as categories within which to devise task characteristics or descriptors. Each characteristic was cast into a rating scale format that presented a definition of the characteristic and provided a 7-point scale with defined anchor and midpoints, along with examples for each point. For example, a high work load—7 on the scale—definition might be "as many output units as possible are to be produced in a fixed period of time," an example of which is "drive as many nails as possible in 5 minutes." At 1 or 2 on the scale, the definition might be "a small number of output units is to be produced in a relatively long period of time"; "drive these 2 nails in the next 5 minutes" (Farina, Wheaton, & Fleishman, 1971, p. 51). Nineteen scales were developed and evaluated in three reliability studies.

The paradigm used to determine whether the task characteristics were correlates of performance upon which predictive relationships might be established was based on performance from studies abstracted from the literature. Subjects rated descriptions of the tasks used in these studies on scales, and the ratings were subjected to multiple regression analysis to establish the extent to which they were related to the performance in question.

A subset of scales having adequate reliability consistently emerged in all three reliability studies, indicating that it did appear possible to describe tasks in terms of a task-characteristic language relatively free of the subjective and indirect descriptors found in many other systems.

Organizational Effectiveness

In the early 1970s, ARI's role in the Army's organizational effectiveness (OE) activity was to develop programs specific to the needs of the sponsoring agency (but that could also be generalized to other commands and ultimately introduced Army-wide) and designed to operate with a minimum of professional direction.

Initial research test beds for the ARI OE program had been established in field station environments of a selected Army agency. Diagnostic instruments, including the Work Environment Questionnaire (WEQ), had been developed and validated over a 3-year period. The WEQ elicited from supervisors and subordinates their attitudes toward and perceptions of job duties, training, performance standards and consequences, organizational supervision, work group, job importance, and feedback. The WEQ used job-specific items that could be adapted readily to fit a variety of duties and organizations.

Seven major organizational problems diagnosed by the WEQ included peer group norms that failed to encourage good performance, insufficient performance feedback, lack of training in supervisory techniques, role ambiguity and conflict, inadequate intergroup communication patterns, lack of clear relationships between performance and rewards, and ambiguous performance evaluation standards. For example, with respect to the latter, a high proportion of operators and analysts on each team did not believe that their supervisors conveyed clear, uniform performance standards to them. In contrast, the majority of the supervisors of these teams were satisfied that *their* superiors did convey clear standards. (The same problems would be identified in successive, separate-year studies.)

With the problem areas diagnosed, a program of active intervention was designed and implemented using OE techniques to reduce the specific problems at the field station. A resurvey of the station (the final OE phase) later indicated that the intervention had successfully decreased certain problems and had increased job satisfaction and performance. But even before the intervention phase had begun, the command had been able to take action on specific problems brought to their attention by the WEQ. For example, on the first WEQ, very few responses indicated that promotions were based on merit, whereas in the following year a distinct increase in positive answers reflected command actions taken in the interval.

The adaptation of the WEQ to a second installation's specific operations signaled the start of a final phase to generalize sets of administrative procedures so that organizations could adapt the WEQ to their needs with little professional assistance (Cohen & Turney, 1976).

Officer Assessment Center Research

Around the early 1960s, ARI had conducted research to identify officers with the aptitudes and characteristics necessary to meet the demands of different types of command responsibility. The experimental Differential Officer Battery (DOB), containing information ranging from military tactics to the physical sciences, sports and the arts, was developed. This test battery also included biographical reports and self-descriptive statements of interests and attitudes. In the process of its development and refinement, the battery was administered to 6,500 active duty officers in 1958 and 1959 and to about 4,000 in 1961 and 1962 (Helme, Willemin, & Grafton, 1971).

Suitable criterion measures were needed to validate this instrument. Ratings by peers and superiors would not be totally satisfactory because the DOB had been designed to assess officer potential differentially for combat, technical, and administrative assignments. An officer's job rating was relevant only to the current assignment, which could represent only one of the three domains. For this reason, situational performance tests were decided upon as the most objective, reliable, and valid means of assessing the differential leadership of officers in the follow-up phase of the research. This type of performance measure, unlike retrospective evaluations and work products, would reproduce critical elements of the job in miniature. In effect, the situational performance tests were developed as job samples. Each officer would be assessed in each of the three domains. Advantages would be uniformity of tasks and standardization of observations.

In March 1962, the Officer Evaluation Center (OEC) was established at Fort McClellan, Alabama, to administer these tests. The first year of the center's operation was spent staffing, training assessors, and finalizing procedures. After a "shakedown" period, actual testing began in June 1963.

All OEC exercises had been worked into a central scenario. The framework was that of a simulated Military Assistance Advisory Group (MAAG) Headquarters. New assessees were told to assume that they were "reporting for duty" at this MAAG Headquarters, located in a friendly host nation. All tests then became a succession of assignments to be performed while temporarily awaiting reassignment to a field unit (Willemin, 1964).

To provide reliable sampling of the technical, administrative, and combat domains, all exercises had to be capable of performance without specialized training and experience, to be recognizable as representative military requirements, and to have projected meaningful outcomes characteristic of good or poor military performance.

Subject matter experts helped to draft exercises, which were field tested and then technically reviewed at the appropriate branch schools. Exercises included measures of the following behaviors: perceiving situational elements, judging future developments, analyzing problem elements, planning future action, organizing resources, deciding the course of immediate action, taking the initiative to act, communicating orders and information, training and directing subordinates, and persisting under stress (Willemin, 1964).

Each exercise was designed to be representative of one of the three domains of interest. Five exercises were developed in each domain:

Combat Exercises

March Order. Examinee plans a tactical road march and reacts to interpretations by senior and subordinate personnel.

Observation Post. Examinee directs fire onto visible targets, perceives terrain and enemy activity, and estimates range as well as communicates this information.

Security Mission. Examinee must anticipate enemy actions, quickly plan offensive and defensive actions, and direct subordinates through face-to-face contact.

Roadblock. Examinee must apply basic tactical principles and communicate important information to others.

Route Reconnaissance Patrol. Examinee must cope with persistent obstructions to mission progress, respond to critical situational factors, and withstand psychological stress under simulated prisoner-of-war conditions.

Combat Exercises—Roadblock problem

Combat Exercises—After the P.O.W. interrogation

Combat Exercises—Roadblock problem

Combat Exercises—Observation post problem

Combat Exercises—Observation post problem

Technical Exercises

Communications Exhibit. Examinee troubleshoots technical equipment and must use subordinates as effectively as possible.

Automotive Inspection. Examinee detects equipment deficiencies and recommends or performs corrective actions.

Road Damage and Radiation Survey. Examinee must organize teams, train subordinates, collect and communicate information, and make plans under conditions of time pressure, obstacles, harassment, and fatigue.

Airfield Layout. Examinee must use technical information to select an airfield site and compute the necessary length of a runway.

Weapons Assessment. Examinee reports on the characteristics of an enemy weapon from the point of view of technical intelligence.

Administrative Exercises

Improper Supply Records. Examinee analyzes supply records, writes a summary memorandum, and (tactfully) communicates decrepancies.

Office Management. Examinee must organize administrative tasks and correct improper office procedures.

Production Analysis. Examinee must analyze officer work flow with a view toward diagnosing and correcting nonproductive procedures.

Site Selection. Examinee must use logistical judgment to interpret information and consider factors in site selection.

Highway Traffic Plan. Examinee must plan logistical support for a large-scale tactical operation and respond to rapid political and military changes.

Each officer took the exercises as an individual. The entire set required 3 days to administer. The combat setting was made as realistic as possible, with 17 officers and 41 enlisted personnel playing the roles of U.S., allied, and enlisted personnel. The first day's exercises were carried out under time pressure but "peacetime" conditions. On the second day, the examinee was awakened at 0230 after about 4 hours' sleep and told that the host nation was at war. The remainder of the exercises were carried out under "emergency" conditions with the intent of inducing fatigue and stress in the examinee (Helme, Willemin, & Grafton, 1971).

The most fundamental findings of the DOB/OEC concerned correlations between the major factors across the two kinds of measures of evaluations—DOB psychological and personal characteristics factors, and leadership behavior factors of performance in the OEC. Because the DOB had been administered at time of entry on active duty or soon after and the OEC exercise had been conducted after the officers had been on active duty for 1 to 2 years, the DOB measures were examined for their effectiveness in predicting leadership performance following branch basic school training and a year or more of first-tour active-duty experience.

How well did the DOB predict leadership behavior on the situation-related performance factors evaluated in the OEC? For this analysis, measures of performance in the OEC situations were grouped functionally according to kind of leadership required—combat command, staff activity, or technical specialization. Combat leadership potential measured at entry on active duty predicted leadership in OEC combat situations and intelligence staff functions ($r = .36$). Measures of scientific potential and measures of general knowledge predicted

all general staff functions and technical specialist performance as well ($r = .26$ to .39). Political orientation measures predicted personnel staff performance only, and mechanical technology measures predicted technical specialist functions only.

Broad combat leadership performance, as measured by the OEC situation, was best predicted by the score on the combat leadership factor of the DOB, which also predicted the OEC mission persistence factor quite well ($r = .22$). DOB scientific potential and general knowledge factors predicted technical/managerial leadership, tactical skills, and technical skills quite well, and mechanical technology predicted technical skills at a substantial level ($r = .40$).

Differential Prediction of Leadership. These results demonstrated that the two most important domains of leadership behavior—combat and technical/managerial—can be predicted differentially. In other words, it appeared possible that such instruments could be used to indicate the relative strength of an officer's potential for leadership in different domains, such as combat command and technical/managerial, as well as the absolute level of each potential.

Two major areas of application suggested themselves: Officers whose behavior was differentially effective in the two domains could be more effectively employed by assigning them to their better domain; and the career potential of cadets or junior officers could be assessed during training, using psychological techniques that provided information for early decision points, such as entry to advanced ROTC, Regular Army commissioning, branch choice, and early school selection and duty assignments. Early identification of the most promising career officer leaders and their career directions was an innovative possibility (Helme, Willemin, & Grafton, 1974, pp. 1-10).

How effectively could the OEC variables discriminate between participants who chose to leave the Army after their initial obligation and those who remained for a full career term? After about 20 years, a follow-up was done, based upon an examination of records of the 900 first and second lieutenants who underwent the 3 days of skill assessment, and of the 2,000 measures taken from the 15 exercises administered. The capability of 25 summary variables to discriminate between the group of officers who had left the Army after their initial 2-year commitment and the group remaining for a full career term was tested. One group for comparison consisted of 101 career officers. Data were available on 352 discharged officers. Of these, 237 homogeneously fit the pattern of having the minimum 2-year active duty commitment and having completed the remainder of their obligation in some type of a reserve unit. Excluded were 115 officers killed in Vietnam, West Point graduates who left after their minimum 4-year commitment, medical dischargees, and a variety of unique cases. A stepwise discriminant analysis was performed using the "2-year" and "20-year" career groups described. A significant discriminant function was found; the canonical correlation was .318. In this active-versus-discharged analysis, 65.38 percent had been correctly classified.

Mays and Dyer, who conducted the follow-up in 1981, concluded, "It appears somewhat remarkable that OEC measures given so early after entry into the Army were able to measure something of what distinguishes a future career officer from a non-careerist. Given a few more years, we will be able to determine how well these variables can discriminate among the successful and the 'supersuccessful,' i.e., those officers who become colonels and generals rather than retiring as lieutenant colonels. Perhaps the best is yet to come" (Mays & Dyer, 1981, p. 798).

An Improved Differential Army Classification System

The Army's aptitude area system of classification had been introduced in 1949. In 1958, following a major program to develop combat predictors, the aptitude areas were reconstituted. With some modifications, the reconstituted composites were used through 1970 to match the capabilities of individuals to the demands of the MOS, so that as far as possible the aptitudes of soldiers entering the Army were used to best advantage.

By 1970, military equipment had become more complex; Army training programs had to adapt to requirements for greater technical competence in enlisted personnel. Accordingly, experimental and operational Army Classification Battery (ACB) tests were evaluated in an extensive research study involving 25,000 soldiers in more than 100 MOS training courses. The MOS covered all job areas open to persons entering the Army. Tests were evaluated in terms of how well they predicted success in MOS training courses. The new battery consisted of 13 tests yielding 16 scores and combined into 9 composites.

When the new aptitude area system had been thoroughly analyzed, it was found to be superior to the previous system in a number of ways. Average validity of new composites was higher than that of the previous composite. Thus, training assignments could be made more effectively. Expected gains from the new ACB were a decrease in training failures of 20 percent; a decrease of 20 percent in the number of marginal performers; and an increase of 15 percent in the number of superior performers. The Army would benefit because the soldiers accepted would perform at higher levels, and training resources would be utilized more effectively because failure rates would be reduced. Individuals would benefit because fewer persons unlikely to succeed would have to experience the frustration of failure in the Army.

Monetarily, these benefits translated into a net gain to the Army of some $80 million in increased performance. Savings in testing time were also anticipated—1 or 3 hours, depending upon the tests being given— and in scoring answer sheets and recording score results (Maier & Fuchs, 1972). In 1972, implementation of the new ACB and aptitude area system was proposed and accomplished.

Adaptive mental testing using a computer terminal

Adaptive Mental Testing

In the 1960s, ARI began a series of investigations in adaptive mental testing to reduce technological gaps. McBride reviewed the state of the art in the context of ARI's projected program and contributions to military problems (McBride, 1979). It had long been known that administering the same test items to all persons—as is done in conventional group tests—provides less than optimal discriminability, and that the ability to differentiate accurately among persons of varying trait status could be enhanced by tailoring the test items to the examinee. Conventional group ability tests, it was recognized, do not measure individual differences with equal precision at all levels of ability, because accuracy and precision of measurement depend upon the appropriateness of the difficulty of the test item to the ability of the individual being measured. In adaptive ability testing, all levels of ability can be measured with high precision, theoretically, by choosing test items sequentially during the test, adapting the test to the examinee's ability based on responses to earlier test items. This can be done by a human examiner, using paper-and-pencil tests with special instructions or by using a mechanical testing device, most commonly an interactive computer terminal.

To construct a conventional test, the test designer chooses some subset of items from a larger pool of available items known to measure the relevant variable. Since the items in the pool typically vary in their psychometric properties—particularly in their difficulty—the test designer must decide the configuration of properties that best suits the test purpose. In an adaptive test, the test administrator can choose items sequentially during the test, approximating the high-point precision of a peaked test, and can extend that high level of precision over the wide range of a uniform test. As a result, a well-constructed adaptive test can be more broadly applicable than a conventional test of comparable item quality and length, and in fact should be because the adaptive test's precision characteristics make it useful for classification about one or many cutting points, as well as for measurement over a wide range.

Psychometric and practical problems originally hindered the development and implementation of adaptive testing. Some psychometric problems were inappropriateness of classical test theory and lack of design guidelines, scoring methods, and ways to assess the measurement properties; practical problems included the need to develop new media for administering adaptive tests and methods for assembling the large pools of test items demanded.

For most adaptive test strategies, the traditional score of number correct or proportion correct will not suffice for charting individual differences on the attribute being measured. Since the goal of adaptive testing is to achieve equiprecision of measurement, test difficulty must be approximately constant across a wide range of the attribute. But in practice, adaptive tests can be expected to fall somewhat short of the goal of equiprecision, so that some supplementary information from traditional scoring methods may be needed.

Most research on adaptive testing has focused on computers as control devices and on computer terminals as the medium for test administration, since computers provide ease of storing and displaying test items, recording and scoring responses, and branching sequentially from item to item.

Today, the services are working cooperatively to develop and evaluate the hardware, software, and test items for a future automated, adaptive version of the Armed Services Vocational Aptitude Battery.

Military Career Motivation

By the middle of the 1960s, considerable research had been directed toward the development of instruments to predict whether an individual would remain in the Army beyond the first term of service. Such instruments would have been useful for a number of purposes, including selection for NCO and officer training programs and for other critical programs requiring long periods of training. A measure of career motivation would help make assignments where the choice was among individuals equally qualified on the basis of aptitudes and other requirements.

Instruments designed to predict motivation for an Army career had typically employed biographical, interest, and personality items, with modest validity. But one aspect of personality make-up that was thought to deserve a more direct and systematic study in assessing military career motivation was the individual's value system, since value satisfaction had been found to be an important determiner of choice behavior. Gordon and Medland (1964) obtained measures of six dimensions on the Gordon Survey of Interpersonal Values (SIV)—Support, Conformity, Recognition, Independence, Benevolence, and Leadership—from enlisted and officer trainee samples in the 5th and 10th weeks of Army service, respectively. Officers who desired to remain tended to score higher on Conformity and Benevolence, and lower on Independence. Enlisted personnel scored higher on Benevolence but lower on Independence and Support. In general, individuals who were Army career oriented appeared to place more importance on conforming to rules and regulations and on helping others and less importance on having freedom of personal action. Officers scored significantly and substantially higher than enlisted personnel on the Leadership value, indicating that they placed a much higher premium on being in a position of command or authority. On the other hand, officers' lower scale reading on Independence probably reflected a greater willingness to relinquish personal freedom of action, a condition also required in a military career. The results were viewed encouragingly, suggesting that the measurement of values might be a useful contributor to the prediction of the military career decision.

Job Satisfaction and Social Outlook

Many of the traditional linkages between the military establishment and American society were disrupted by the ending of the draft and the advent of the volunteer force. As Segal (1979) pointed out, the feeling in many military quarters was that if the Army was to be sustained without a draft, job satisfaction would be one of the dimensions accounting for the Army's success (or failure) in the accession and retention of high-quality personnel who had other employment options available to them in the civilian labor market.

Had junior-level enlisted personnel changed their perceptions of the nature of their service to the Army with the end of conscription? Was their level of satisfaction in the volunteer force different from that of its draft-era counterpart? These two research questions increasingly were being asked of sociologists and social psychologists in the early 1970s.

One project analyzing this period of transition called for a comparison of the work-related attitudes of soldiers in the all-volunteer force with the attitudes of soldiers in the conscription-based Army of World War II. In 1973, a representative sample of volunteer junior enlisted men (EM) was compared with 1943 samples of EM; elite EM (airborne, infantry, and ranger); and EM who had gone AWOL, been returned to military control, and surveyed while in military correctional facilities. In general, the 1973 soldiers were shown to be more negative toward their jobs than were any 1943 soldiers except the AWOLs, who seemed to be the most similar to the 1973 EM. The multitude of factors involved precluded any simple conclusion that satisfaction was lower in an all-volunteer force than in a conscription-based force. But at a minimum, there is a motivational difference between peacetime and wartime armies.

Even the World War II data showed a decline in emotional commitment and affect between 1943 and 1945.

> While enlisted men in the conscription-based U.S. Army may well have regarded their service as a duty and responsibility of citizenship, much as they might have regarded paying taxes, we have yet to see evidence that these soldiers ever saw their service as a higher calling, to be evaluated in terms of different criteria than are jobs in the civilian labor force—while we would prefer to see a higher level of job satisfaction in the volunteer force, it may be that being a soldier in a peacetime Army simply isn't that satisfying a job (Kramer & Segal, 1980, pp. 9-10).

Segal, who directed studies to determine the degree to which military personnel were coming to view their service as jobs, believed that the general concern with job satisfaction and work-related attitudes in the Army was rooted in theories about the transition of the Army from a unique institution to a civilian-type workplace, with a concomitant change in the nature of military service from a quasi-sacred calling to a more or less ordinary job. In fact, he found that military personnel in the volunteer force defined what constituted a good job much like their civilian counterparts (Segal, 1979). Thus, military service had become a job as well as a calling to many. This finding was also reflected in the attitudes that high school seniors had toward military service.

Race Relations and Equal Opportunity in the Army

In the late 1960s, ARI initiated a program of research on race relations in response to an Army requirement. A comprehensive survey was made of actions taken and programs established to improve race relations in the Army. One outcome of the survey was a resource book providing the following types of information to help ensure more effective approaches to improving race relations: Army policy and efforts to combat racial problems; available educational and training programs; equal opportunities in off-post housing; reviews and findings at race relations and human relations seminars and conferences; policy and organizational changes; compliance, cultural recognition, and information programs; a review of complaints of racial discrimination in recruitment, selection, promotion, and retention and in the administration of military justice; a summary of major actions contained in the Department of the Army's Race Relations/Equal Opportunity Affirmative Action Plan and Force Structure Plan; and a summary of race-related research projects being undertaken under the auspices of ARI.

In 1972, the Army issued its Affirmative Action Plan to provide equal opportunity and treatment for uniformed members, regardless of race, color, religion, national origin, or sex. Goals of the plan included the achievement of minority representation in the officer corps equal to the minority representation in the nation (about 15 percent), and equalization of minority representation in certain officer career fields that strongly affected minority soldiers, for example, justice, the chaplaincy, information, military police, and medicine. As of mid-1972, blacks composed 17.1 percent of the Army's enlisted ranks, but only 3.9 percent of its officers. In September 1972, blacks composed 7.0 percent of OCS enrollment, 13.7 percent of ROTC members, but only 3.4 percent of U.S. Military Academy cadets.

ARI's race relations research program was designed to support and supplement the Army's affirmative action programs and shared with them the fundamental objective of ensuring equal opportunity as a fact of life in the Army. Research activities included collecting baseline data pertaining to race relations problems and the Army's efforts to ensure equal opportunity; developing and evaluating methods and techniques for alleviating and resolving race relations problems; and developing and maintaining the skills and expertise required to keep the Army abreast of scientific and professional knowledge in the areas of race and equal opportunity. ARI program objectives covered a wide range of concerns:

> Developing a training program designed to improve the unit commander's motivation, knowledge, and skills in implementing equal opportunity programs and managing race relations problems.
>
> Conducting an attitude survey of American soldiers in overseas environments to determine the impact of third-country nationals on race relations among American servicemen. Emphasis would be placed on the effects of those environments on race relations among Americans. An interest was expressed in supplementing the Eighth Army Racial Awareness Program and in covering race-related problems unique to that command.
>
> Replicating on Spanish-surnamed soldiers the research done on the black soldier, focusing on attitudes toward the Army, perceptions of other races, and perceptions of the Army's Race Relations/Equal Opportunity Program.
>
> Writing a handbook to provide guidelines to commanders and leaders for improving race relations—a compilation of information about race relations in the Army. The handbook would discuss the nature of the race problem, supply guides for diagnosing race problems in a unit, and describe actions that could be taken by the commander or leader to improve race relations. An evaluation of the handbook would be included in a comprehensive field study of the Army race relations program.

To study minority group members and their motivation to serve in the Army, that is, to determine the individually oriented factors (cultural, demographic, and psychological) and Army-oriented factors (institutional, organizational, and social) that positively and negatively influenced minority personnel, interviews and attitude questionnaires were specifically designed. Information concerning personal values, attitudes, and feelings on a wide range of topics related to the Army was expected to lead to baseline data for use in developing experimental programs to improve retention rates of high-quality minority personnel, with emphasis on junior officers.

Other planned research included determining the feasibility of using a culture-assimilation programmed-learning experience as a race relations educational training device, conducting cross-attitude surveys of white and black soldiers, and developing models to help commanders assess the racial climate of their units and predict potential racial outbreaks (Nordlie & Thomas, 1973).

Early Prediction of Disciplinary Offenders

In the 1960s the Army wanted to know whether potential disciplinary offenders could be identified on entry to military service. Previous research and military experience had shown that persons of lower mental ability tended to have higher rates of disciplinary problems, and therefore a lowering of mental standards could be expected to lead to an increase in that rate. Since mental standards are lowered each time the Army faces mobilization, the relationship between mental ability level and disciplinary rate is a problem of recurring interest. With the advent of "new standards" personnel in such programs as Project 100,000, there was renewed interest in reducing this problem and in finding possible ways of identifying such individuals. Hence, in 1966, a study was undertaken to determine the effectiveness of written testing instruments, administered prior to Army entry in identifying persons likely to become offenders. Persons so identified might either be rejected or assigned to some form of special training.

Three measures were developed—a personal opinion measure, a personality questionnaire, and an overall acceptability measure representing the best written predictor of Army disciplinary record that had resulted from previous research. At reception stations, 1,999 personnel were tested with the battery, disciplinary records of their first 16 weeks were obtained, and the personnel were categorized as offenders (6 percent) or nonoffenders (94 percent).

None of the measures was sufficiently effective for operational use in the early identification of potential offenders. The most effective predictor, the overall acceptability measure, if used, would have screened out an undue number of nonoffenders in the process of identifying (and eliminating) a small number of likely early offenders. In retrospect, the research was a good example of the futility, typically experienced in the World War II era when time was a crucial factor, of placing hope in "commercially available" face-valid instruments

for specific military personnel objectives. The personal opinion measure had been standardized on adolescents but had not been used in military research. It contained a Psychopathic Delinquency scale interpreted as reflecting "tough, amoral, rebellious qualities, coupled with impulsivity, a conspicuous distrust of authority, and a relative freedom from family and other interpersonal ties." A Neurotic Delinquency scale was intended to measure "impulsive and aggressive tendencies . . . accompanied by tension, guilt, remorse, depression, and discouragement." A Subcultural Delinquency scale appeared to mirror attitudes, values, and behaviors commonly thought to occur among members of "culturally and economically disadvantaged delinquent gangs in whom personality maladjustment per se was not clearly evident." The overall acceptability measure, however, was not only tailor-made on the basis of earlier research, but its near success in this research was believed also to be attributable to its concentration on background information rather than personal opinions (Bolin, Larson, & Kristiansen, 1969).

Drug Education and Prevention Programs

From the early 1960s, the illicit use of psychoactive drugs had increased significantly among certain segments of American society, especially among high school students and college-age youth. The Army, which had cause for concern regarding the potential impact of drug use on troop morale and combat readiness, initiated a comprehensive program to prevent and control alcohol and drug abuse. The functional areas of the Army program as previously noted (Gard, 1971) were prevention, identification, detoxification, rehabilitation, evaluation, and research. The prevention of drug abuse through education and training was a major feature of this program, but little was known about the impact of these programs. Accordingly, research was conducted to assess the effectiveness of the Army's drug education and training programs.

The effectiveness of drug education on patterns of drug use was assessed using a cross-sectional survey of 1,716 enlisted personnel at 16 Army posts and a pretest-posttest evaluation of a drug education program at 1 post. Group interviews were conducted with 191 enlisted personnel. A questionnaire was administered to determine drug use over the previous 60 days, participation in drug education, and background characteristics of the individual. Exposure to a drug education program was measured by the item, "What did you learn from the alcohol and drug education program at this post?"; respondents were placed in "not exposed" or "exposed" groups on the basis of their responses.

The Army's drug education programs were found to be consistently ineffective in preventing or diminishing drug use, and this failure occurred regardless of the educational process or technique used. The hope of preventing drug use through a single educational program was apparently an unrealistic one. Background and situational factors were considerably more likely to account for changes in drug use than drug education influences. Both findings were corroborated by concurrent civilian studies (Cook & Morton, 1975).

Taking Stock

As the war in Vietnam came to a close in the early 1970s, the Army faced a host of problems such as dissent, racial conflict, drug abuse, and antimilitarism that threatened established institutions. The all-volunteer force was instituted at a time when the Army enjoyed little popular support. As a result, the Army had to enlist recruits from a lower socioeconomic segment and from lower ability levels than at any time since before World War II. Military systems, however, were becoming more sophisticated, and the Army was launching a major program of weapons modernization. Force structure, tactics, and doctrine were also undergoing rapid change.

Better utilization of personnel thus became a real goal, not just a cliché. Army leaders stressed the need for improved personnel and training systems, and called for systems development processes that would consider human capabilities more seriously than ever before.

One response to the all-volunteer force was the newly developed Enlisted Personnel Management System (EPMS), which incorporated products of personnel and training research. EPMS provided a career ladder for each soldier, with specific training and on-the-job experience specified at each rung. Evaluation drove the entire system, including classification, assignment, training, and promotion of personnel.

Under EPMS, the Skill Qualification Test (SQT) was the principal evaluative tool. SQT consisted of a written test, hands-on performance tests, and job certification by the commander. All three components were based on information gathered from job and task analyses, which identified critical tasks already performed on the job, conditions under which tasks were performed, and standards of performance. Course instruction, as well as training conducted in operational units, was based on the identical lists of tasks and standards used in developing SQTs. The lists were also used in soldiers' manuals, which the Army provided for each MOS at each skill level. Each manual had three major sections: a list of critical tasks the soldier was expected to perform; a list of reference materials the soldier could consult for essential information about each task; and a description of an actual performance test that could be used to assess ability to perform the critical tasks—essential ingredients for a "behaviorally stated instructional objective."

Training Research

During World War II, the Army had begun a training research effort to improve the performance of aircrews. When the war ended, this research was terminated in the Army but continued as part of the Air Force's Aviation Psychology Program. Training research had had its primary impact on the Army Air Corps in World War II. In 1951, the Army initiated its own training research through the Human Resources Research Organization (HumRRO) in its capacity as a university-linked Federal Research Contract Center. In the late 1960s, steps were taken to transfer gradually the training research function to ARI along with the responsibility for translating research results into packages for operational use.

While this transition was taking place, the Army's training systems were undergoing considerable change. By 1970, the Army's institutional training had become significantly different from what it had been two decades earlier. The most pronounced change was the Army's adoption and implementation of a systems engineering approach to curriculum development. Unit training, however, had not changed very much since World War II and was still based on following directives for mandatory training, regardless of specific training needs.

In 1971, training was decentralized and became the responsibility of the commanders of battalions and even smaller units. Commanders were given mission-type instructions instead of specific training directives, were told the level of readiness expected of their units, but had the freedom to train their personnel in their own way.

A Combat Arms Training Board (CATB) was established in 1971 to provide training assistance to units, to expedite development and distribution of training literature and materials, and to link units in better fashion with service schools for the solution of training problems. CATB was a developmental, rather than a research, agency. Its official function was to "collect, publish, and disseminate to combat arms units in the form of informal training literature, or otherwise communicate descriptions of, those approaches to training which have worked well for some unit or units and should be made available to others—commendable training techniques, training devices, or training management," and to "monitor, and sponsor, when appropriate, research, studies, and tests designed to promote improved training in combat arms units." Over the next several years, the CATB was engaged in training extension courses (TEC), instructional systems design, the Army Training and Evaluation Program (ARTEP), training device development (an almost total revamping of the Army's training literature), and specification of research requirements to support training initiatives.

Training and Doctrine Command. By the mid-1970s, the entire training establishment was reorganized into the Training and Doctrine Command (TRADOC). TRADOC was responsible for developing, managing, and supervising the training of officers and enlisted personnel throughout the Army. The initial TRADOC focus was on institutional training. Gradually, a decentralized individual training program evolved in which TRADOC developed "exportable" training: tools and techniques a unit commander could use anywhere in the world.

Thus, TRADOC interpreted its mandate for individual training as extending beyond the arena of schools and centers into the operational units of the

Army and providing support for individual training wherever it took place. In doing so, TRADOC introduced training technology into the entire Army system.

The Army Training Management Institute (TMI) was established in 1975 to improve the content, approach, and methodology of training conducted in the Army's service schools. TMI also served as a "translator" in that it packaged "instructional technology" for use by the service schools without the need for much outside help.

One major TMI task was to develop a complete individual training plan to support the EPMS through a "life-cycle MOS training plan." Another task was to increase Army use of self-paced courses, but to do so within the framework of systems-developed training (i.e., performance-based, criterion-referenced training).

The Army Training Support Center (TSC) was established in July 1976 as an additional means of improving training through use of research results. TSC replaced the old Training Aids Management Agency. The mission of TSC extended beyond a simple concern with training aids to consolidation and institutionalization of training technology in an exportable training management structure.

Activities integrated into TSC included the training extension course program from CATB, the TRADOC Training Devices Requirements Office, the Army correspondence course program, the Army training literature program, the engagement simulation program, the Individual Training Evaluation Group (to supervise development and implementation of Skill Qualification Tests), and the Training Aids Service Officer program (to place liaison officers at each major TRADOC post to encourage use of training aids in various institutional programs).

The underlying basis for many of the new programs was the job-and-task-analysis process, through which critical tasks for each duty position at each skill level were identified and cataloged. In training development, a six-step procedure was prescribed: (1) conduct job-task analyses to produce validated task lists; (2) determine whether instruction should be given in an institution or in the unit; (3) prepare tests of individual and unit performance; (4) develop validated, exportable, performance-oriented training materials; (5) conduct the training; and (6) evaluate and analyze training outcomes.

Technological Change. By the time the Army returned to an all-volunteer force (the first time since the end of World War II), several important technological changes had already taken place in training: institutional (school) training time was reduced; unit training had increased; performance-oriented, competency-based training had increased; individualized computer-based instruction had begun; and job-related personnel evaluation systems based on tested skills and knowledges had been established.

The Army, always positively inclined toward hardware-oriented research, increasingly supported training research. A key reason for this emerging receptivity was the establishment of a systematized process for forging a complete research cycle, from statement of need through research utilization. Scientists and training developers were then ready for the enormous contributions that microelectronics and information engineering and applications promised.

Human Factors

During the 1960s, human factors research had changed drastically. Its original concern had been with equipment, displays, and controls, with an emphasis on engineering. The emphasis shifted to the soldier-system interface wherein the operator or maintainer constituted a vital component in each system and was expressly considered in weapons design. Human factors began to examine the features of systems that would maximize human strengths and compensate for functions not performed well by individuals. The concept of human factors in the Army was extended to include the comprehensive integration of all manpower characteristics—personnel skills, training implications, behavioral reactions, human performance, anthropometric data, and biomedical factors—into all systems.

Human Engineering Laboratory. During this period the Human Engineering Laboratory (HEL) participated in a number of systems engineering and analysis studies, including in-process reviews of developing systems. At the same time, research was being done in audition, memory, eye movements, and visual perception. HEL also began a series of field exercises to determine the performance of weapons systems in artillery, armor, and aviation. The objective of these exercises was to isolate the major error sources in the operational setting for correction or for research. The work performed by HEL in this period included development of the following:

Instrumentation and techniques that would permit the gathering of accurate system performance data in small arms, armor, and artillery fires, especially with respect to near-miss indication and position location.

Valid quantitative total systems performance data, using present generation systems in armor, artillery, infantry, and aviation.

Optimum small arms and pistol concept configurations that could be considered by the Army for further development purposes.

Valid, objective design and evaluational criteria for body armor and helmets.

Good design criteria for armored personnel head protection devices.

Design criteria for the detection, acquisition, and target tracking of forward area air-defense gun systems.

Evaluation methods for determining a soldier's performance under continuous operations requirements.

Aggregating Manpower, Personnel, and Training Requirements. By the end of the 1960s, ARI's interest in the development of new command-and-control, intelligence, and surveillance systems began to mature in earnest. Research was initiated to determine manpower, personnel, and training requirements for new systems. Particularly important were methods for the more precise aggregation of manpower, personnel, and training requirements across systems. Limited manpower availability had to be treated as a resource constraint in the design process to minimize its impact, particularly in identifying soldier-system functions to enable trade-offs among training, equipment design, and personnel requirements.

In the following decade, this interest coalesced around a major effort in manned integrated systems technology (MIST). MIST's central objective was to estimate manpower, personnel, and training (MPT) requirements early in the design of new systems to ensure that the supply of soldiers would match the demands of individual systems or systems in the aggregate.

Related research objectives that emerged out of ARI's work in the 1960s were to generate a technology that would estimate training tasks and programs at the earliest stages of the development of weapons systems and to provide their cost and performance implications to hardware engineers early enough to influence design; to improve command group and individual staff member training simulations capabilities using low-cost, high-powered developing microprocessing technology; to enhance effectiveness and efficiency of tactical systems through the application of high technology for advanced terrain representation and for computerized voice communications; to develop a comprehensive set of human factors guidelines and evaluation criteria for the design of user-operator transactions in battlefield automated systems; and to optimize performance of existing automated systems and provide design criteria for future systems. The last two steps would be accomplished by conducting human factors, safety, and training analyses of battlefield automated systems in the field to develop recommendations for improving operator selection procedures, training, doctrine of employment, and equipment design.

As ARI entered the mid-1970s, it was ready to formulate a research agenda for future systems that would focus on developing and applying technologies for matching soldier abilities to hardware design; determining manpower, personnel, and training requirements early in systems design and aggregating those requirements across systems; freeing the soldier for decision-making tasks; providing cost-effective system training for operators and maintenance personnel; and assessing quantitatively total systems effectiveness in realistic field conditions.

Thirty Years of Psychometric Accomplishments

By the end of the 1960s, military psychologists had completed a three-decade involvement in selection and classification research. Robert Thorndike's keynote address to the Eleventh Military Testing Conference provided an excellent review of psychometric accomplishments by the services for those 30 years. Since Thorndike had been a leading psychometric authority and participant in military, academic, and industrial environments for those 30 years, his remarks are presented here in abundant detail (Thorndike, 1969, pp. 3-14).

Thorndike believed that the history of the contributions of military testing to psychometric theory and practice could be viewed as a play in three acts—testing during World War I, testing during World War II, and testing during the extended period of military preparedness from 1946 to 1969. World War I had been a relatively brief episode compared with the other two periods, so that developments of a theoretical nature were relatively meager. When World War II came, both the military establishment and the testing profession had been prepared to work together at a new level of cooperation and competence. During World War II and the decade that followed, most of the basic theoretical and procedural issues in the classification problem had been worked through. Thorndike saw the assignment problem as basically one specific case of the general mathematical problem of linear programming. With respect to any pool of recruits, if the quotas to be met could be specified, along with an estimate of each soldier's value in each job, present-day computers could readily assign the set of personnel so as to meet the quotas and maximize the sum of the recruits' estimated values in their assignments.

Requirements for a test battery—differential validity of each test over the array of jobs, and low correlation of the validity vector from one test to another—call for a kind of test quite different from those traditionally used in aptitude measurement—civilian or military. A composite, complex test with widespread validity for many or most jobs, similar to the traditional test of general intellectual ability, seemed likely to have little to offer for classification purposes.

Value to the Organization. An aspect of the classification problem that was understood on the theoretical level, but that had not been dealt with successfully at the practical level, was that of setting up procedures for translating training school grades, supervisory ratings of proficiency, and other criterion measures of job effectiveness into a convincing measure of "value to the overall effectiveness of the organization." How should the value of a superior cook be balanced against that of a mediocre electronics technician? How should the gain from getting a half-standard deviation improvement in a company clerk be measured against a standard deviation loss in effectiveness of a medical corpsman? Although there had been attempts to formulate the "dollar equivalent" of a particular level of proficiency in a particular job, any useful metric for expressing value had still been largely undeveloped. Some way was needed to move from the probabilities of achieving different outcomes that could be handled in a rational way to a statement of the benefit of these probabilities to an organization or an individual. Progress was needed here for a completely rational approach to the classification problem ever to develop.

Differential Assignment. Thorndike was convinced that the classification problem probably appeared in a purer form in the military setting than anywhere else in society. In civilian settings, it was more typical for an applicant to be a candidate for a specific job than for the employer to have wide latitude in assigning the person to any type of vacancy. Related to the notion of classification was the notion of placement, implying differential assignment on the basis of individual differences on a test or battery. However, placement differed from classification in that it typically referred to the assignment to different training programs representing alternate routes to a common goal.

A somewhat different type of interaction between testing and training was based on the premise that for different adaptations of a training program, different tests would be the best predictors. Thus, where heavy dependence was placed on textual materials, the best predictors might be tests of verbal ability, whereas if presentations were largely pictorial, diagrammatic, and concrete, the best predictors might be tests of visualizing. Such an interaction would call for assignment to variants of the training program on the basis of differential performance on the two types of tests, much as in the model of classification into different jobs.

Personnel Data Banks. One projected contribution from military testing to psychometric theory, according to Thorndike, is an accumulation of evidence on the extent to which educational placement in terms of level or type of ability is fruitful; and, where it is, a definition of what types of adaptation of instruction to what types of variation in input would be useful and rewarding.

Thorndike also credited military testing with pioneering the personnel data bank long before the notion of data banks had begun to enter the thoughts of most civilian psychologists. He saw the bank of test data as especially valuable for psychometric research, both within the military organization and for civilian follow-up. At the end of World War II, the Army Air Force had a file of 20 test scores, representing a 2-day testing program, for each of approximately a half-million soldiers who had been applicants for aircrew training. In 1955, this file included the scores of 17,000 of these soldiers who had been tested with a common battery within one 6-month period, as well as their answer sheets displaying specific items in a biographical data bank. The results of a follow-up, published in 1959 with the title *10,000 Careers*, gave a picture of subsequent work histories in relation to the wartime test records that was then, and still is, unique. Data banks became commonplace. Project Talent, a civilian undertaking in which a comprehensive test battery was administered to a half-million high school students for follow-up over a 20-year period, was a lineal descendant of military testing programs and *10,000 Careers*. Over time it was hoped the project would produce many valuable findings for psychology and education. Whatever its accomplishments, Project Talent would owe a debt to the testing and records programs of military psychology.

Other Contributions. An exciting recent development in proficiency testing is the use of objective test procedures for testing skill in medical diagnoses. The basic model, in the context of military electronics troubleshooting, had promise for all types of situations in which diagnosis, information getting, and decision making represented important recurring sequences of activity.

The problem of obtaining ratings of employee proficiency had been a chronic one in industrial psychology and personnel research since its beginnings and was equally a problem for military psychology. Novel developments have filtered into the civilian workplace largely on the basis of research in the military setting; for example, the forced pattern of personnel rating developed in the Army toward the end of World War II. The development of forced-choice procedures made a big stir in the world of civilian personnel evaluation and personnel research during the following two decades.

Job analysis procedures have been influenced by the work done in and for the military. Specifying job requirements through the collection of incidents is one approach that has been generalized to many civilian settings. Formulating training requirements in terms of detailed task analysis, which seems related to interest in detailed programming of training sequences for civilian school and job training, is another approach associated with military research.

In summary, Thorndike felt that on the basis of their vast experience, research, and data from testing programs, the services had not only made many important contributions to the general progress of psychometric and psychological knowledge, but had also demonstrated leadership in this discipline that would very likely continue.

Looking Ahead

ARI research in this decade consolidated many advances that would prove invaluable in the all-volunteer force: determining the impact of enlisted screening standards on unit performance; developing the Armed Services Vocational Aptitude Battery used by the services in a joint recruiting program in high schools; developing a new Army Classification Battery, which included measures of general mental ability, specialized academic knowledge, specialized nonacademic knowledge, and vocational interests (its usefulness was studied in more than 100 training courses); formulating measures of differential potential for effective performance in field command and technical leadership for application in officer selection, classification, and guidance; measuring factors related to career orientation and motivation for use in continuing career management and guidance; determining reliability, usefulness, and feasibility of rating techniques and personnel records analysis for given personnel decisions; and developing new approaches and techniques for use in computerized models of manpower and personnel systems management to evaluate alternative policies.

In the all-volunteer force of the 1970s, ARI's program of research to staff the force would cover a broad spectrum of issues. Personnel requirements for the force would cover a broad spectrum of issues. Personnel requirements for the Army of the future had to be projected. Personnel resources for staffing the Army of the future had to be projected. Personnel resources for meeting those requirements had to be identified and ensured, either through retention of highly qualified soldiers already in the Army or through recruitments. Anticipated resources had to be effectively allocated to anticipated requirements. Individual soldiers then had to be recruited, selected, classified, and assigned to training tracks in such a way as to optimize the fit between Army job requirements and individual capabilities. Programs for retaining effective soldiers were needed to protect the enormous investment in training and experience that an effective soldier represents.

Part 4

A Behavioral Science Perspective for the Army

Chapter 6

The Emergence of the All-Volunteer Force

As military pay lagged, the all-volunteer force in the 1970s depended increasingly on recruits who were socially and economically disadvantaged and who had lower mental abilities. By the early 1980s, however, U.S. forces were considered combat ready. Training was more extensive and realistic than it had ever been. The challenge of operating and maintaining advanced weapons systems to their fullest capabilities became a major concern of research in training and personnel systems. Such research placed greater emphasis on maturing technologies to motivate and train soldiers. In the Army, the decade of the 1970s was one of dramatic change in modernizing the force and in formulating new concepts and systems for the Air Land Battle 2000. Army leaders looked to ARI for research results in the following areas: developing new techniques for collective training in the field; performing "front-end analysis" and personnel affordability studies in systems acquisition; designing realistic ways of training while fighting; forging cohesive and committed units; and developing integrated leadership systems at all levels.

The Technological Environment of the Services

Since 1973, the military has relied on the all-volunteer force. The makeup of that force, its qualities, and its ability to meet manpower quotas have been under continuous analysis from the beginning. Generally, these analyses have dealt with: the social composition of the force versus manpower goals, including the costs of meeting ceilings with the desired quality of soldiers. By the end of the 1970s, when military pay began to lag behind civilian pay, the force was not achieving its manpower goals, and was falling about 5 to 7 percent short. In addition, the services were increasingly dependent on socio-economically disadvantaged persons. It became evident that the social composition of the forces had changed, with a growing reliance on minorities and a disturbing decline in mental aptitudes and educational levels. But by the early

1980s, substantial improvements were made in military pay. Meanwhile, high unemployment among youths made military service an attractive employment opportunity; this factor resulted in increases in both the quantity and quality of recruits. The heavy loss of officers and NCOs also had stopped.

Militarily, the United States, though it finds itself outnumbered by potential adversaries in the 1980s, has attempted to counter quantitative superiority with qualitative advances in military weapons systems. Hardware quality may be high, but sophisticated systems must be operated and maintained with available personnel, whose performance ultimately determines whether maximum system effectiveness is achieved in combat. How is this requirement being met?

First, many capable personnel are needed to operate and maintain these systems. But ironically, the outlook for filling that need is not good throughout the 1980s. Consider these facts: the number of males 18 to 24 years old (the country's primary recruiting pool) is expected to drop 22 percent between 1980 and the mid-1990s; the country has experienced significant declines over the past 25 years in average science and math scores on national tests such as the American College Test and the Scholastic Aptitude Test; and the Department of Defense's "Profile of American Youth" estimates that the median reading grade level of persons 18 to 23 years of age is now 9.6 and is not likely to improve significantly over the next decade (Office of the Assistant Secretary of Defense, 1982).

Countering an Inadequate Recruitment Pool

The implications of all three declines have already been felt or have been made the basis for discouraging projections. For example, inadequate scientific and technical training is cited as the cause of a 90 percent failure rate on proficiency tests administered by the Army and Navy. The Air Force estimates that by 1990 most skill codes will require at least a 10 percent increase in minimum aptitude to meet the requirements of highly technical jobs. Countering an inadequate recruitment pool will evidently require more effective selection and training of the available population of recruits if the United States is to achieve a combat-ready fighting force.

The challenge of operating and maintaining new weapons systems to the fullest then becomes the responsibility of the research and technology programs in training and personnel systems. The Defense Science Board Summer Studies of 1981 and 1982 recommended that increased emphasis and funding be placed on training, training technology, and soldier-machine integration; compliance will involve the use of microprocessors coupled with advances in artificial intelligence (AI), displays, and the testing, measurement, and prediction of human performance.

Over the past several years, greater emphasis has been placed on maturing technologies, such as those based on personal computers, educational games, and visual information compression and digitalization. Using such technologies as the basis for field demonstrations, the military forces will be able to improve skill performance, reduce training time by about 30 percent, establish a crosswalk, or correspondence, between recruit capability and on-the-job performance, reduce the need for instructors by 10 to 30 percent, and provide self-motivating training opportunities.

The Army's Technological Environment

The decade of the 1970s was one of dramatic change for the Army and one that coupled research objectives in behavioral science with Army needs more closely than during any previous period. The Army underwent a major force modernization, including development of more than 600 items of new equipment, 40 of which could be considered major systems, with soldiers integral to all of them. But while Army systems were proliferating, troublesome demographic signs were emerging. The potential recruitment pool was declining significantly even as the Army was developing concepts for the Air Land Battle 2000 calling for higher soldier and leadership qualifications than ever before!

In the early 1980s, while the Army continued to modernize and prepare for the future battlefield, it still faced problems of recruiting, classifying, and training new soldiers and leaders for the active force. Making correct personnel decisions was more critical than ever; resources were constrained and diminishing, and job requirements were of greater variety and technological complexity. To train the force was a continuing Army need, but rapidly increasing costs and the complexity of training required were major obstacles. To overcome them, the Army recognized that an entirely new approach was needed, one that capitalized on the advances in microcomputers so that training could be distributed and brought to the soldiers in their units at reasonable cost. A greater need for simulation and special training devices was evident.

The Army has traditionally recognized that wars can be fought effectively only when individuals are organized into teams and units. Individuals may fight wars, but only when soldiers are assimilated into a structurally supported unit does an effective force evolve. The paramount task of unit commanders is to develop and maintain unit readiness; thus, training is the unit's most important peacetime activity. The leaders of a unit, both officers and NCOs, must also develop individual soldier maturation and morale and meld soldiers into a cohesive and effective fighting force. For this fighting force to be combat ready, the units must be up to strength; equipment, operationally ready; and each soldier, skilled. Soldiers, equipment, and doctrine must be synchronized to be used effectively.

Training Systems

Starting in the early 1970s and continuing to the present, the Army leadership began a series of dialogues with ARI that helped its scientists to develop a systematically long-range direct research program. ARI was invited to consider in its work about a dozen concepts to meet the problems of the day and of the future. A number of issues were raised by Lt. Gen. Paul F. Gorman, first when he was associated with the Dynamic Training Board and later when he was the top training official for U.S. Army Training and Doctrine Command from October 1973 to July 1977. General Gorman noted that most Army training was conducted in classrooms and directed at the soldier as an individual, whereas the Army performed in the field as a collective unit. Accordingly, he emphasized the development of collective skills: Soldiers proficient in individual skills must be provided with training experience that effectively integrates those skills into team performance. He encouraged ARI to develop training strategies for utilization by teams in the field.

General Gorman also emphasized technological innovations that would realistically simulate combat training with feedback to the trainee. One approach was the development of weapons systems that could be employed as self-contained training systems, which ARI later called "embedded training." He emphasized proficiency through use of "hands on" training—a badly needed supplement to the cognitive achievement that had hitherto predominated in training. He also recognized that more formal training evaluation was essential to determining the effectiveness of techniques. Objective means of performance evaluation could determine promotions of soldiers as well as dictate content in training development. Many of the research programs started in ARI in the early 1970s grew out of discussions with General Gorman and his associates. Finally, General Gorman saw that appropriate research funding was secured for this rapidly expanding training program.

Developing Weapons Systems

At the time TRADOC was developing its renaissance of training developments and technology through General Gorman's efforts, his superior, General William E. Depuy, the TRADOC commander from July 1973 to June 1977, was looking at systems development from the viewpoint of the commander in the field. General Depuy recognized that the current system of rewards for systems managers (the individuals responsible for the acquisition process) might actually penalize operational commanders in the field in future years. The systems developers operated under tight money and time constraints and tended to assign lower priority to issues that could arise in the operational environment concerning the reliability of the soldier and his ability to operate and maintain equipment in the field.

General Depuy introduced the "front-end analysis" problem—how to ensure that manpower, personnel, and training considerations were effectively considered and that appropriate trade-off analyses were accomplished. The argument went as follows: There is a disconnect between the skill performance requirements for operation and maintenance of new weapons systems and

the aptitude of the available or projected manpower to meet those requirements. To facilitate a solution, General Depuy elicited help from ARI's ongoing manned systems research program to develop methods for assessing systems impact on manpower, to identify where training might increase performance, and to specify simulation training devices early in the acquisition process. He also directed the establishment of a network of systems development managers within TRADOC to analyze and evaluate the degree to which systems would meet the soldiers' and the commanders' needs in the field.

General Depuy argued that for the Army "to win the first battle of the next war" it was necessary to obtain a very high level of performance from each weapons system to compensate for potential numerical deficiencies in force size. To ensure that soldiers and leaders were adequately trained, he conceived and helped to establish the National Training Center (NTC), where units up to battalion size could be exercised under a realistic two-sided play with feedback. He reaffirmed that the effectiveness of the unit was a function not only of the weapons and tactics used but of the proficiency of the unit as a whole and that, under strong tactical leadership, collective training was needed to obtain the most out of a system. The NTC, as General Depuy visualized it, could be used as a surrogate measure of combat performance for training diagnosis and feedback and for developing new tactics. He foresaw that the NTC would provide information to a data base from which training programs and technology could be developed and evaluated. Such a data base would be a prime source of information on management and technology for the entire training community. (The NTC would eventually employ the Multiple Integrated Laser Engagement System (MILES) system, the technological embodiment of ARI's REALTRAIN system.)

Organizational Effectiveness

General Bernard Rogers was deeply committed to development of human resources. First as the Deputy Chief of Staff for Personnel (DCSPER) and then as Chief of Staff, from November 1972 to November 1974, one of the principal techniques he promoted was organizational effectiveness (OE). The aims of OE are to increase human performance effectiveness in an organization and to improve teamwork and job satisfaction. To achieve these aims, diagnostic instruments are developed to identify problem areas; then management intervenes with organizational development techniques to correct the problems; and finally the intervention results are evaluated in terms of productivity and job satisfaction. General Rogers urged a major research effort within ARI to develop a set of carefully validated diagnostic instruments and OE techniques that could be used Army-wide with a minimum of professional involvement.

To implement OE fully within the Army, General Rogers established an OE center to train OE officers for later assignment to operational commands and units to help commanders analyze and solve problems of human resources. ARI was asked to develop improved techniques for OE officer training and to assess the value of the program.

Closely linked to this program was General Rogers' concern with the development of policies and procedures that would contribute to unit effectiveness through soldier cohesion and commitment principles. He wanted improved communication among all echelons of the Army, not only the dissemination of information from the highest headquarters down, but from lower to upper echelons. He supported research for a variety of social programs, to solve problems related to discipline, race, drug abuse, and family support. To provide current and comprehensive information on the state of human resources readiness, he asked for the development of trend reports employing survey mechanisms and statistical comparisons against baseline data. With his encouragement, ARI updated its leadership and management research domain in general, placing special emphasis on organizational effectiveness and productivity.

Air Land Battle 2000

General Edward C. Meyer, the Chief of Staff from June 1979 to June 1983, from the beginning of his tenure had instituted programs wherein ARI involvement was both natural and of great importance. If preparing the force was "the greatest challenge the Army is facing today," then achieving traditional recruitment, selection, and classification goals was only a basic framework. He had, in fact, set his sights on formal manning systems incorporating unit replacement and rotation and home basing—techniques successfully used in the British regimental system.

General Meyer regarded the unit commander as a "teacher on the log," the focal point for the training and readiness of the soldiers and teams in the field. Of paramount importance to General Meyer was distributed training, that is, training technology exported to the units.

General Meyer asked the research and development community to establish long-range goals linked to the goals and objectives of the Army, and in so doing he wished not only to ensure that the future Army have the best technology but that laboratories be provided with a stable, structured research environment that would not be disturbed by short-term or changing requirements for resources. Perhaps of greatest significance for the long-range research agenda of ARI was the development of the Air Land Battle 2000 concept, which has been of central importance in shaping research efforts within ARI.

The systems of the Army of the year 2000 are on the drawing board or in development now. While battle concepts of the future influence some of a system's blueprints, other concepts in the development of new systems in turn influence the way war is fought—the soldier's role in it, in particular. The new systems move faster, have a wider range of movement, have greater depth

of coverage in both sensors and armament, have greater fire power, deliver more accurate munitions on target, and contain more electronics, but they have fewer people on board because automation has increased systems capability.

Future conflicts will see rapid deployment of the standing ready force. The execution of engagement during combat will become more and more automated once the decision has been made to engage. The role of command and control will be one primarily of choosing the conditions of engagement. The commander will be relatively remote from the action, and the weapons themselves will fight the actual tactical conflict. A minimum of direct personal confrontation on the future battlefield is expected. A greater integration of combat arms will be necessary to fight a unified battle. At the same time, it will be desirable to permit autonomy of individual weapons to fight on the basis of local conditions; "hunter-killer" units consisting of small, self-sufficient teams will be common.

As expected, the changing faces of warfare, tactical doctrine, and weapons will have many implications for research. The soldier-system interface will require mixed-initiative dialogue, natural language, and a very friendly interaction with computers. The operator will need a great number of aids to facilitate operations, information processing, and decision making. In short, information engineering is critical to Air Land Battle 2000, together with a new perception of tactical leadership and a shared perception of how the battlefield works.

Human System

Lt. Gen. Maxwell R.Thurman, the DCSPER from August 1981 to June 1983, viewed the role of the DCSPER as a proactive one, operating in areas formerly outside the domain of personnel, such as examining personnel affordability issues to aid the systems acquisition process and providing realistic estimates of manpower supply and characteristics. He visualized readiness as a peak product of manning functions (structure, acquire, separate, train, distribute, develop, sustain, and deploy) within the Army's functional areas (structure, equip, man, train, provide facilities, mobilize, sustain, and deploy).

General Thurman called for the development and use of the Joint Optical Information Network (JOIN) system, which is designed to be placed in each of the 1,800 recruiting stations to assist in recruiter time management, to facilitate optimal recruit and MOS match-ups, and to make training reservations. General Thurman also asked ARI to develop, for improved recruiter productivity, techniques based on more effective assignment, motivation, and organization support. He enthusiastically supported research on improved selection and classification systems, and sought ARI participation in researching a new leadership system and in defining and evaluating human goals and initiatives. He encouraged the establishment of the Manpower and Personnel Policy Research Group within ARI, and actively worked to strengthen both ARI's responsiveness and status within the Army. Through his efforts, the collaboration between the General Staff and ARI became much closer.

To further this collaboration, General Thurman spent a good deal of time with ARI scientists describing "people" needs of the Army and eliciting research addressing these needs. His intent was not, however, to meet the challenge of the moment but rather to obtain substantial answers that would meet future needs. This concern could rightly have stopped there. But General Thurman recognized that scientists needed to be given time not only to develop creative new approaches to problems, but time to collect empirical data for validating ideas. His sensitivity in allowing scientists to determine for themselves the direction of research recognized that motivation could come only from genuine interest and scientific ability. Thus he was willing to support truly novel ideas, even ideas that others might accord low probability of payoff. He was a strong advocate of basic research and supported the notion of the "right to fail."

General Thurman was the first leader to appreciate and act on the notion that science could not be compartmentalized into tight packages to avoid jurisdictional quarrels: He repeatedly sought to bring researchers of various disciplines and organizational affiliations together to address personnel issues.

Deeply committed to the human element in all facets of Army developments, General Thurman would ask ARI scientists whether they had had their say in systems under development or in early conceptual phases, whether a policy correctly reflected human needs and family concerns, and whether "standard operating procedures" would tend to demotivate soldiers. To him, ARI scientists were a welcome and integral unit of the military organization. If they had a solution or a better answer and could prove it, he would make it happen within the Army. He visited ARI scientists in their laboratories more frequently than any other general officer in history. Because of this, he developed first-hand knowledge of the strengths and interests of a good number of scientists and they in turn knew that they could try out their ideas on him. ARI scientists came fully to accept and trust his leadership and support.

Research Utilization

Maj. Gen. William L. Webb, Jr., served as the Assistant DCSPER from November 1978 to August 1982. In May 1974, as a result of a reorganization of the Headquarters of the Department of the Army, ARI's General Staff affiliation was changed from the Office of the Chief of Research and Development to the Office of the DCSPER. When General Webb became the Assistant DCSPER, he assumed direct organizational supervision of ARI for the General Staff. It was the first time since its tie to the Office of the Deputy Chief of Staff for Personnel (ODCSPER) that ARI had found itself reporting to a level higher than any of the individual directorates within the ODCSPER. This organizational relocation enhanced ARI's visibility and stimulated interest in ARI as the major Army-wide soldier-oriented laboratory. General Webb was principally responsible for the development of procedures by which the ARI program could be adequately reviewed and supported at the highest Army levels. One such procedure was a "board of directors" comprised of general officer and secretariat representatives who would periodically review the programs and progress of research, recommend programmatic modifications, and suggest appropriate levels of budget support. General Webb presided over the board.

General Webb strove toward more effective communication to keep Army's very top leadership abreast of research accomplishments and applications. He helped ARI deal with the Army's different constituencies. Over the years, he developed a detailed understanding of ARI's research programs and operations; in fact, he was an eloquent spokesperson on its behalf, whatever the issue—program justification, personnel, budget, or mission. Through his encouragement, ARI found new ways of relating to the user community and of portraying findings in cost-effective terms. ARI has had a significant number of impressive military sponsors of research throughout its history, but none has labored for so long, in such a dedicated fashion, and with so much knowledge and concern as General Webb. He provided ARI with the affiliation of his office and his personal involvement and representation at the highest levels of the Army—advantages that ARI had lacked for so long. (See Appendix R for a comprehensive listing of key Army leaders affiliated with ARI over the years.)

The Services' Training and Personnel Technology Program

The Department of Defense directs its Training and Personnel Systems Technology Program toward four major technical categories representing areas of specific interest to the user community: manpower and personnel, education and training, human factors, and simulation and training devices. The services have significant research programs in each of these four areas. The budget for the total research and development program for FY 1982 was about $250 million, of which more than half was spent in the development of simulators and training devices. (For a complete listing of program elements, see Appendix L.)

Manpower and Personnel

The objectives of manpower and personnel programs are to research and develop methods for improving the ability to forecast manpower needs and to recruit and retain personnel needed by the Department of Defense; the basic concern of manpower and personnel research is overall force management. Efficient personnel management ultimately means having the right number of competent people in the right place at the right time. It is achieved by improving traditional methods and techniques used to recruit, screen, select, assign, and evaluate personnel and by taking steps to reduce the attrition and increase the retention of high-quality individuals. In a broader view, career management helps to optimize career progression patterns and to control the dynamic flow of the thousands of individuals in the services from stage to stage in the "pipeline" process. Computer-based models are used increasingly to support the personnel management process, from keeping track of all participants in the system to special applications such as adaptive testing (which permits the individualization of the testing processes involved in screening, selection, and classification). The services are also finding that good incentive management can raise productivity while upgrading morale. Morale is also maintained by unit cohesion efforts and by enhancing the individual's commitment to the service and the unit.

Programs in manpower and personnel reflect a need for higher quality, better trained, and motivated soldiers at a time when a declining manpower pool increases competition for those available. Research efforts being conducted are described in Appendix M.

Education and Training

The objectives of the education and training program are to research educational capabilities and aids that help train military personnel to perform job assignments throughout their careers. Education and training is a major function within the services, whether its purpose is to fulfill the comprehensive educational needs of all personnel or the compensatory educational needs of certain low-aptitude personnel. Cost effectiveness of training is a primary concern and is achieved with the help of computers, individualization of training, or both. Skill acquisition and retention research is also conducted in the interest of cost effectiveness and teaching efficiency. Education and training further strives to balance classroom and on-the-job or field learning. The value of the education and training category is probably best exemplified by developments in computer-assisted instruction (CAI) and in computer-managed instruction (CMI). CAI is used as the direct means of conveying lessons; CMI is used by both student and instructor to assess progress and work out the best sequence of instruction. Determining and exploiting the nature and limits of the individual's information-processing capabilities to meet increasingly complex skill needs is also an urgent objective. Research efforts being conducted are described in Appendix N.

Human Factors

The objective of human factors research is to enhance operator performance effectiveness and safety through improved user-oriented analysis, design, and evaluation of weapons and support systems. A principal objective

here is to ensure the operability and maintainability of major new weapons systems. Research is conducted to perfect the match between human and machine elements of these systems. The assumption must first be accepted that it is possible to design machines compatible with the capabilities and limitations of the persons available to operate and maintain them. Systems designers must understand that not until their recommendations incorporate a full consideration of human factors for prototype operational equipment can the design be deemed adequate.

A second major objective is to promote survivability in hostile environments through development of life-support systems that maximize protection and aids for special performance. Two examples are warmer boots for cold weather operations and better ways to illuminate work areas that are not readily detectable by hostile sensors. Research efforts being conducted are described in Appendix O.

Simulation and Training Devices

The objective of research in simulation and training devices is to develop tools that will improve our ability to train military personnel to operate special equipment. Safe, realistic training in peacetime for combat and emergency situations continues to challenge DOD training research organizations. Research on simulation strives for combat readiness—a high level of combat proficiency achieved in a peacetime environment. The emphasis is on simulating the weapons system in its operational environment for more effective individual and team readiness training. Technological advances in computers, electronics, and optics all contribute to such training.

Research objectives continue to be focused on providing initial and life-cycle cost reduction on maintenance and operational trainers by reduced dependence on expensive equipment. Rapidly advancing technology also permits flexibility of training: It can be conducted when and where desired, in relative safety, and with immediate knowledge of results.

The services have established cooperative and coordinated programs on visual, maintenance, and munitions simulation. For example, each service has developed, using both computer and model board image-generation techniques, complementary technological approaches for simulating very wide field-of-view scenes for aircraft weapons systems simulators and for conduct-of-fire trainers.

Service programs have concentrated on developing concepts and techniques for incorporating a range of U.S.and potential adversary weapons systems into engagement simulation exercises and training devices. Research efforts being conducted are described in Appendix P.

Chapter 7

Information Engineering, 1972–1982

This decade of ARI research is focused on "information engineering" and the criticality of computer-based aids in enhancing information processing and decision making in operations for the Air Land Battle 2000. The soldier-system interface in distributed warfare will require mixed-initiative dialogue, natural language, and very friendly interaction with computers. Information engineering will also be required for improved management of the Army's limited share of the national manpower pool. Employment of longitudinal manpower data bases will result in better policy formulation and utilization of personnel. Information engineering is essential for modernizing the Army's collective training systems. Although microelectronics permit the development of inexpensive, portable training systems, the systems that work well must be based on sound instructional engineering and its supporting information network.

Since 1979, ARI's research has been structured into five programmatic domains: Structure and Equip the Force; Man the Force; Train the Force; Develop the Force; and Maintain Force Readiness. Typical research undertaken in these domains was designed to develop the following: automated techniques to free soldiers from repetitive tasks and allow them to concentrate on tasks requiring decision-making capabilities; refined and expanded measures for assessing an individual's abilities and for making a better person-to-job match; techniques based on emerging technologies for use in simulation and in training devices; techniques for melding "green" soldiers into effectively performing units; and models for assessing individual and unit battalion readiness. A new manpower and personnel policy research program was initiated in 1981. The basic research program designed to develop the behavioral science base was expanded during this period to include a larger number of university efforts both in the U.S. and overseas.

The research program has operationally affected soldier-machine design; battlefield automated information systems; performance-based personnel selection, classification, and utilization; warrant officer retention; engagement simu-

lation; skill qualification testing; basic rifle marksmanship; and organizational process in combat readiness.

In the previous chapter we described the all-volunteer force, the Army's increasing dependence during the 1970s on recruits of lower mental ability, and the changing face of warfare reflecting concepts and systems of Air Land Battle 2000. This chapter describes ARI's response to the Army modernization program and to dramatic shifts contemplated in future warfare.

The ARI Research Program

Since 1979, ARI's research program has been structured into five programmatic domains in support of the Army's efforts to:

Structure and Equip the Force. Determine the capabilities Army personnel must have to use new systems to full advantage.

Man the Force. Determine the kinds of personnel the Army needs, how it should obtain them, and how to retain them.

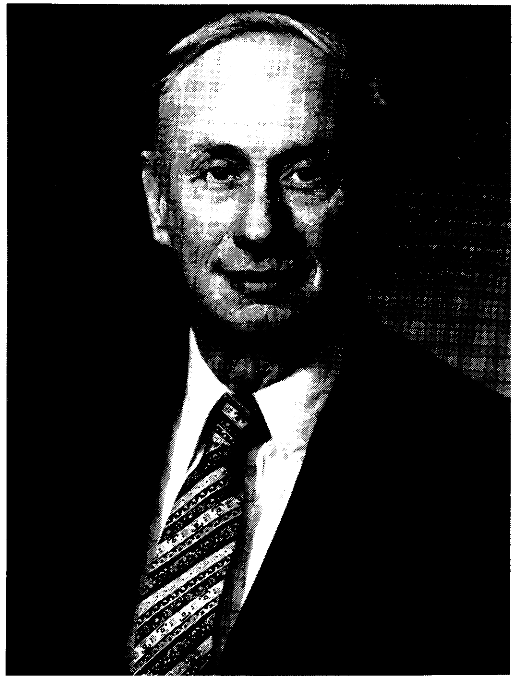
Train the Force. Determine the tasks personnel must perform and ways to maximize the quality of performance.

Develop the Force. Ensure that the whole of the Army is equal to, or greater than, the sum of its component parts.

Maintain Force Readiness. Ensure, when all of the above are put together, that the resulting organization works optimally on the battlefield, and if it does not, determine what changes must be made.

ARI's research program is carried out through topical thrusts within each programmatic domain.* A thrust defines a specific area of investigation and includes several work units of scientific research. The first two levels—domain and thrust—tend to be stable over many years. Work units change from year to year in response to near-term and long-term objectives, implications of prior year research findings, and completion of specific efforts. Brief descriptions of ARI's recent thrusts are presented below. They follow the summary given in ARI's annual report for 1982 (Cosby & Zeidner, 1982).

*The leadership of ARI during this period included J. E. Uhlaner, Technical Director and Chief Psychologist of the U.S. Army until February 1978. He was succeeded by Joseph Zeidner, who in turn was succeeded in November 1982 by Edgar M. Johnson, who had been director of the Systems Research Laboratory. E. Ralph Dusek was director of the Training Laboratory until September 1980. Harry O'Neil became permanent director in May 1982. Joyce Shields became director of the newly organized Manpower and Personnel Laboratory in May 1982. Other key leaders, along with scientific personnel of the period, are listed in Appendix Q.



Joseph Zeidner

Structure and Equip the Force

A major research challenge of the 1980s resides in the soldier-machine interface. Emphasis must be placed on the design of equipment, as well as on the persons who must operate and maintain it. Automation can free the soldier of monotonous, repetitive, energy-sapping tasks and allow concentration on tasks requiring cognitive, decision-making capabilities.

Research is also required to develop improved methods for determining the manpower, personnel, and training requirements for new systems. Particularly important are methods for the more precise aggregation of manpower, personnel, and training demands across systems.

More detailed information on the performance capabilities and limitations of soldiers is required so that more "user friendly" equipment can be designed. Laboratory and field test beds, in-house simulators, mockups, and ground and flight test vehicles can produce parametric data on operator performance under various simulated operational conditions and for different possible system configurations.

Determination of training requirements for new systems is also a major concern. Operator training requirements must be determined early so that necessary training can be designed parallel with system development to achieve full operational potential. Maintenance training should emphasize rarely performed tasks that are critical when they are required. "Embedded training" is potentially the most cost-effective approach to new system training and can best be achieved in the design of a new system when training requirements are identified early.

New System Design. Army managers must consider human resources availability—the concept of "personnel affordability"—as one parameter of weapons system design. Such concepts as future cost and availability of appropriately skilled and trained soldiers are needed before managers can evaluate requirements to alter either personnel policy or hardware design. Differentiation of tasks best performed by soldiers versus machines will enable trade-offs among training, equipment design, and personnel requirements. Research in this thrust is directed at determining manpower requirements for specific emerging weapons systems.

For example, during the acquisition of Army materiel systems as defined by the Life-Cycle System Management Model, there was a continuing requirement for information on the personnel necessary to operate and maintain the system, on the training requirements for the system, and on the associated costs. It was particularly important that these human resource demands be assessed early in the acquisition process.

ARI has also explored the value and utility of the Hardware versus Manpower (HARDMAN) methodology developed by the Navy to determine the feasibility of applying it to Army systems. The test bed for the project was the Division Support Weapon System, which was in an early phase of the developmental cycle. Results indicated that this methodology appeared to be a useful approach in assessing the impact of human resources earlier in the acquisition process than ever before.

Systems Manning. To plan for future recruiting and training, it is necessary to identify both the quantitative and qualitative personnel demands of the Army's new systems and also to aggregate the total demand across all systems. The next step is the long-term forecasting of the numbers and skills required Army-wide. This information can help determine recruiting and personnel management policies and facilitate the development and evaluation of system manning alternatives.

One major effort in this area seeks to design a comprehensive set of human factors guidelines and evaluation criteria for user-operator transactions in battlefield automated systems. Research identifies the functional and operational components of systems under development and the human-computer interaction anticipated. Based on this work, provisional human factors guidelines are being developed. This research will lead to battlefield automated systems with design features and operating procedures compatible with the Army's expected user-operators. Research will also provide system proponents, developers, and managers with objective criteria and techniques for assessing the degree to which proposed design features and operating procedures meet the human factors requirements defined in the guidelines.

New System Training. System design includes the specification of operator performance and maintenance requirements. Training requirements should also be included at this time. Specifying required skills and knowledge permits the development of training strategies and the determination of simulation design requirements. When training requirements are addressed as a part of system design, training programs and simulation will be available to ensure immediate effectiveness when the system is fielded. With systems that include one or more computers, there is also the opportunity to embed a training capability. The role of research is to provide techniques for the early identification of system training requirements and to specify appropriate approaches.

Developing Automated Systems. Automated systems to handle and manage large amounts of battlefield information and aid in increasingly complex combat decisions continue to be developed under the Army's Command and Control Master Plan. Command, control, communication, and intelligence (C^3I) systems provide the technological context for tactical analyses and battle management. Optimal operational decision making depends both on accurate information and analysis. A particular concern of ARI research under this thrust is the user-display interface both in command and control systems and in weapons systems. Also of concern are procedures for improving the handling and utilization of such information in automated C^3I systems and artillery systems. This thrust addresses the role of the human operator in C^3I systems and in the computer-based weapons systems of the future automated battlefield environment.

Assessment of New Systems. A determination of the potential effectiveness of new systems can be achieved only through the use of appropriate analytical tools during systems design. One objective of such analysis is to measure the extent to which the person contributes to system effectiveness. The difficulty lies in the selection of appropriate criteria for predicting the human impact on effectiveness prior to system engineering.

Among the most successful efforts in new systems assessment has been the development of a preliminary handbook on the Human Resources Test and Evaluation System—a systematic approach to the comprehensive evaluation and diagnosis of human resources and performance in the operational testing and evaluation of evolving systems.

Developing a human aptitude/ability assessment technique is also vital. This work builds on previous research identifying basic aptitudes or abilities and their relationship to performance on a wide range of tasks. The immediate goal of this effort is to refine the current methodology of aptitude assessment and to adapt its use to the early stages of systems design. Research should eventually result in a reliable and efficient skill assessment technique to help designers and developers assess the aptitudes required to perform operation, maintenance, and support tasks. Data obtained by applying the technique to each system will help the Army to aggregate the total demand across all systems.

Man the Force

Each year the Army recruits, selects, classifies, trains, and assigns thousands of new soldiers to the active force. It supports, develops, deploys, and manages these new soldiers as well as the hundreds of thousands of first-term and career soldiers of the active Army and the Reserve. To provide necessary leaders for this force, a system of recruiting, selecting, training, assigning, and developing leadership at all levels is in operation. Overall, the Army must make effective and efficient personnel decisions in a period of constrained and diminishing personnel resources and in the face of increasing diversity and sophistication of jobs. ARI has developed a program that will produce new techniques, tools, and procedures to aid decision makers in the Army's personnel system.

Personnel Requirements and Resources. The Army is undertaking its greatest modernization program since World War II. The addition of hundreds of items of new equipment and systems will impose requirements for personnel in various numbers and of various skill mixes. Further, because of the historical availability of conscription, the Army has not been required until recently to focus much attention on the supply side of the manpower issue. With decreasing manpower and rising life-cycle costs and skill demands, determining the numbers of available personnel, including the civilian sector, for the full range of mental and physical abilities has become an important operating objective. Because designers must consider available manpower in devising weapons systems, the Army must determine and project its total manpower requirements. It will have at its disposal sophisticated task analysis techniques, computer simulations, survey techniques, mathematical gaming, and modeling to analyze resources and requirements and to estimate optimal matches.

Recruiting. With an all-volunteer force, the Army faces continuing and increasing pressure to define and meet recruiting quotas. Army recruiters compete with universities, private industry, and the other services at a time when demographic changes have reduced the usual population pool from which recruits are drawn. The challenge for the Army is to expand the pool of potential candidates; improve recruiter performance through better selection, evaluation, and motivation; and make analytical trade-offs among such controllable variables as selection standards, initial assignments, and enlistment incentives.

One research project for improving recruiter productivity would seek to determine the factors that explain the varying levels of productivity among active Army recruiters. Analysis of the recruiter's personal traits and background as well as related geographic, socioeconomic, motivational, and organizational factors is one approach. Development of a quantitative model interrelating characteristics of recruiters and their environment with those of their respective recruits, including the recruits' subsequent performance in the Army, is another. The goal is increased recruiter productivity, based on more effective assignment, motivation, and organizational support.

Selection and Assignment. To capitalize on the Army's limited share of the national manpower pool, improved selection and assignment procedures are needed. The Army is developing systems that use the latest automated techniques to counsel, classify, and commit desired positions to potential recruits. Also, refined techniques of assessing an individual's abilities in a consistent and reliable manner for an appropriate person-to-job match are essential; ways of using cross-service selection measures and system-specialized assignment techniques must be perfected to effect an efficient assignment process. Such a process is currently being developed.

Tests and other measurements can predict the applicants most likely to succeed in flight training; similar tools are needed for assigning student pilots to specific mission training tracks. One product of this research—the Revised Flight Aptitude Selection Test (FAST)—has been fielded and is in current use. Other research seeks to ensure that the new procedures do not discriminate unfairly against any particular applicant group and that the FAST is fair to minority and female applicants.

Techniques for selecting officer trainees, to be administered to prospective officer candidates during the screening process, include performance-based assessment, a structured interview, and a paper-and-pencil test. Training modules are being developed to remedy deficiencies identified in the screening process. New Officer Selection Battery forms (with supporting manuals), norms, and technical reports of reliability, validity, and fairness are among the expected products of this effort.

Retention and Reenlistment. Retention of highly qualified personnel ranks high among Army priorities, because of the limited manpower pool, extensive investment in training, and increasing levels of skill required to operate and maintain Army equipment. Research is needed to evaluate the efficiency and cost effectiveness of the existing retention programs and to find new ways to retain soldiers with essential skills and experience. Because job commitment is a positive retention factor, efforts to evaluate how training affects commitment are needed. Commitment is also related to certain personal attributes, including experience level. These relationships must be defined and analyzed so that they can be managed to influence retention properly.

In an effort to reduce first-tour attrition, particularly during Initial Entry Training (IET) and the rest of the first 180 days of enlistment, two orientation films were developed for screening at all nine installations conducting IET.

The retention and reenlistment problem in armor units has also received recent research attention. Studies on tank crew turbulence have provided information delineating several underlying causes of attrition among noncommissioned officers. This research points to the tank commander as the key to maintaining high levels of unit performance and decreasing the ramifications of attrition and turbulence in operational armor units. Data on personnel in high-performance armor units are evaluated to determine the techniques and procedures that improve tank commander retention.

Train the Force

ARI's training research program is intended to support the Army's through the application of emerging technologies to provide more cost-effective training in school and in units. The new instructional technologies will emphasize the use of simulation and training devices.

ARI's research program has been tailored to provide the training community with the scientific foundation needed to develop new methods. The goals are to require fewer personnel training resources, to spend less money, to achieve higher levels of performance, and to permit more accurate assessment of the state of training readiness. The program will seek answers to questions such as the following: What instructional and learning strategies are appropriate for soldiers of varying abilities? How should training programs for individual training be structured to achieve the most efficient training? To what degree can simulations and training devices substitute for costly operational equipments? What design parameters for computer-based instructional systems most significantly influence learning?

Developing Basic Skills. Although low-aptitude personnel may have the potential to serve effectively in a MOS, they often do not possess the life-coping skills and basic knowledge necessary for Army life. Special training strategies may prepare such personnel to benefit from standard military training, possibly through individual instruction provided by advanced technology. After mastering basic learning skills as well as the duties of their MOS, they can then become effective members of the force.

Developing Individual Skills. Research conducted under this thrust focuses on critical areas, such as rotary-wing pilot training, maintenance training, and individual tactical training for the maneuver arms to develop complete individual training programs. Research considers such variables as the amount of training required to achieve full proficiency; frequency of training to maintain desired performance levels; the optimal training medium as a function of type of learning required (i.e., the learning of a simple procedural skill vis-à-vis a complex decision-making skill); the optimal mix of simulators, training devices, and other training media in a comprehensive training program; and performance measures for assessing training performance, as well as the adequacy of the training provided.

Currently, two factors compound the training challenge: the need to create training for the new and more complex weapons systems entering the inventory and the need to provide efficient training for personnel with widely varying aptitudes. The task of expanding and refreshing existing individual skills within units is an even greater challenge, especially for the combat arms. Brief examples of research follow:

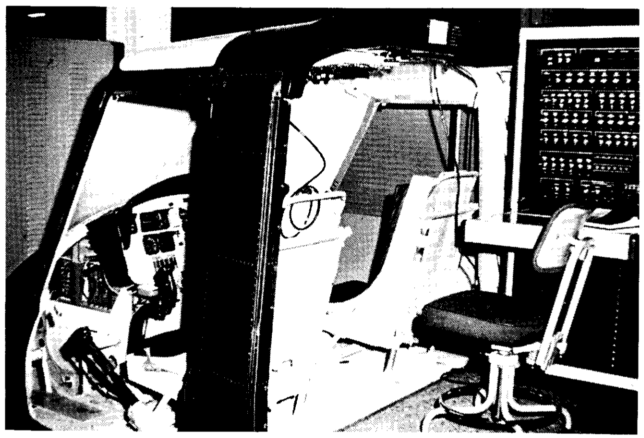
Research to achieve the optimal mix of training devices for improved tank gunnery performance to compensate for reduced main gun ammunition. Results will be used to recommend cost-effective device combinations supporting tank gunnery training in such settings as institution, unit, reserve, and mobilization.

Development of innovative training methods for assessing and improving the retention of armor skills, as with development of a unit training program for sustained performance on the M1 tank. The program consists of procedural guides for each crew member, exercises on critical skills, study guides for the tank commander and gunners on special knowledge items, and gunnery drills for crew practice in the tank as a substitute for being on the range using live ammunition or moving on terrain.

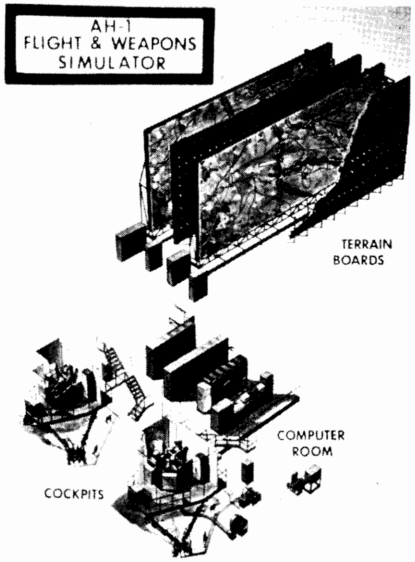
Development and validation of training materials for use by helicopter units in field settings, including a light-attenuating filter that enables aircrews to train for night flight operations during daylight conditions. Also underway is development of a standardized lexicon for more effective communication during nap-of-the-earth flight.

Developing Technology-Based Instructional Systems. Computer and electronic technology offers great potential for helping the Army provide efficient and cost-effective training in units as well as in institutional settings. The critical research problem is determining how technological advances such as videodisc and voice recognition and synthesis can be applied most effectively.

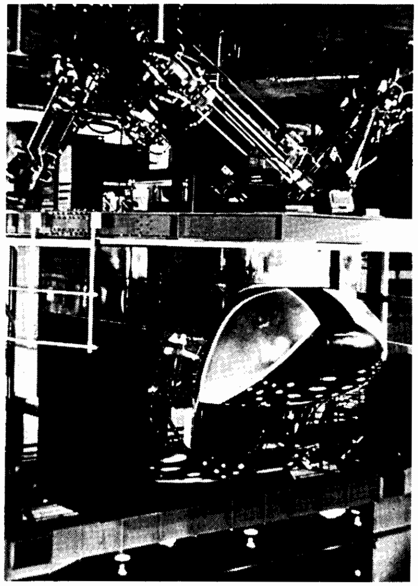
Considerable success has already been realized in developing techniques for the application of interactive videodisc technology to both training and performance testing. The Adaptive Computerized Training System (ACTS) was developed to train electronic troubleshooting procedures, has been evaluated in a laboratory setting, and is now being evaluated in an Army school.



2C35 Procedures Trainer



AH-1 Flight and Weapons Simulator



Rotary Wing Motion-Based Simulator

Goggles for simulating darkness of night operations

Developing Simulations and Training Devices. Extending training to the field places new requirements on providing full, simulated combat environments. To be cost effective, the training must provide significant training benefits at costs substantially less than training conducted on actual equipment. A continuing program of research is providing an empirical base for the development of simulations and training devices.

For example, the PATRIOT (Phased Array Tracking to Intercept of Target) is an air defense system designed to cope with the field army air defense threat of the 1980s and 1990s. ARI research scientists designed and supervised the development of a complete set of self-paced instructional training materials utilizing a tactical operations simulator consisting of a 16-bit microprocessor, graphics processor, line printer, electrostatic printer, card reader, magnetic tape drive, 320 kilobytes of memory, display consoles, and computer-managed instructional techniques. The materials were subsequently validated and used to train preoperational test II subjects for the PATRIOT air defense weapon system (Howard & Reynolds, 1981).

Research to evaluate aviator proficiency and training system effectiveness assesses the demand for flight simulators, such as the Rotary-Wing Motion-Based Simulator and the AH-1 Flight and Weapons Simulator, and specifies the characteristics required of them. These efforts also establish guidelines for programs of instruction that will result in maximum aviator training effectiveness at minimum costs using such devices as night goggles for night operations simulation and the 2C35 Procedures Trainer.

Aviation research will also determine requirements for the simulation of combat missions for new Army helicopter systems, as well as the extent to which simulations can be used in lieu of such flight vehicles as the TH-5 and UH-1 helicopters for initial flight training.

PATRIOT (Phased Array Tracking to Intercept of Target) is a field Army air defense system for the 1980s and 1990s.

Develop the Force

Although individuals fight wars, it is only when individuals are organized into teams, crews, and units that wars can be fought. These collectives have a common mission to which each individual brings his or her own special capabilities. Inexperienced soldiers, usually with journeyman skills in their MOS, arrive in units fresh from the training base. These individuals must be molded into effective teams and crews until they can function as an integral part of the parent unit. A soldier being assimilated into the unit can have significant problems of adjustment when the highly structured and supportive environment of initial entry training is replaced by the more complex unit environment.

Developing Units. Research is required to develop technology-based methods for more efficient, less personnel-intensive training in units. The commander needs to know the state of training readiness, the effectiveness of the training, and the procedures to carry out training responsibilities.

The capabilities of unit leaders at all levels are particularly critical to mission accomplishment; research must focus on the development of leader and tactical skills. From NCO through senior general officers, soldiers must be proficient in the "battle management" tasks demanded of them, have up-to-date knowledge about the capabilities of the weapons systems at their disposal, and be able to make necessary, reasoned tactical decisions quickly. Leaders must be able to develop individual soldiers—in maturation and morale as well as in combat skills. Finally, leaders at all levels must be able to weld their soldiers into cohesive, effective fighting units.

Developing Collective Skills. This thrust is a logical extension of the training necessary to produce effective unit performance. Soldiers proficient in individual skills must be provided with training experiences that effectively integrate these skills into team and unit tactical performances. Alternative strategies for conducting this training will be designed, developed, and evaluated. Special emphasis will be placed on the application of technological innovation to this training in simulated, tactically realistic, and interactive environments. For example, because of the overwhelming competitive requirements for time, a commander needs a computerized system to help manage and execute the battalion training program. Hence, one research objective is to design and develop a computer system that networks above the battalion, through the chain of command. The purpose is to improve the battalion's ability to manage all administrative tasks, but especially its training program. The computer system will include an extensive data base and later provide interactive assistance for scheduling training through the use of goal programming, knowledge engineering, and artificial intelligence. The product or payoff, it is hoped, will be systematic sources for improved chain-of-command accountability.

The development of technological solutions to meet the requirements of unit technical training is another example. The High Technology Test Bed

(HTTB) is creating an Advanced Technology Light Division (ATLD) to develop prototypical combat units capable of exploiting the significant technological advantage of both existing and near- to mid-term hardware or doctrinal developments. Hence, research objectives are to develop and evaluate integrated training programs required for specific ATLD battalions and to develop a cost-effective Computer-Operated and -Managed Battlefield Tactical Training System (COMBATTS). The goal is a refined and extended computer-based training system that will improve small-unit training and increase opportunities for the conduct of tactical training made affordable through the use of inexpensive simulation.

Assessing Individual and Unit Proficiency. Measurement of proficiency requires accurate assessment of both individual and collective performance. For simple procedural tasks, proficiency measurement is relatively straight-forward; for more complex cognitive tasks and for collective performance, the challenge of accurate measurement is much greater. Still, refined techniques are required for the measurement of individual proficiency, even as improved procedures for determining unit capability are required for home-station use and for the National Training Center (NTC).

The NTC will conduct battalion task force training under the most realistic conditions possible, supported by extensive instrumentation for measurement, analysis, display, and feedback. One objective of ARI's effort is to develop the methodology, knowledge, and tools for this type of training and supporting analyses. Also, since unit performance at the NTC is in a real sense the terminal output of the entire Army system, the second objective of research is to examine the influence of Army-system-related factors on performance at the NTC.

Assessing Training Systems Effectiveness. The Army has a critical need to know how ready each individual, team, and unit is to carry out the assigned job or session. It is also important to provide feedback to Army training developers so that they can modify curricula and procedures to increase the efficiency and effectiveness of training. Any evaluation of training requires an ability to assess both individual and collective performance accurately.

Managing Training. The value of training is reduced and resources are wasted if it is not well managed. Unit training managers must frequently cope with limited resources, unorganized materials and devices, and little guidance or instruction on how to conduct effective performance-oriented training. Thus, research is seeking to improve the management of training, especially at the unit level.

An example of ARI's efforts to improve the management of training innovations is the evaluation of the methods used to introduce the Multiple Integrated Laser Engagement System (MILES) into units worldwide. ARI first developed a model of the Army's training technology transfer process, which was then used to guide the development of the MILES evaluation plan. The model describes methods, procedures, and guidelines on how to plan effectively for the development and implementation of training programs, including how to monitor progress and sustain training development until it is integrated into routine Army training.

Leader Development. Army leader development occurs at three levels: the junior- and mid-level NCO, the company grade officer, and the field grade commander. Leaders have little time for formal instruction, a fact that must be taken into account when leader development strategies and implementing materials are considered. Attention should focus first on senior leaders to produce a climate favorable to the development of leadership skills at junior levels and to reinforce these skills when they emerge.

NCO leader development research seeks to identify and develop methods for helping soldiers acquire NCO "soft" skills; to identify, develop, and evaluate appropriate delivery systems for soft skill training; and to develop a functional job competence model for the NCO as a guide to development of an integrated NCO professional training program.

Organizational Cohesion. The Army is developing improved methods for assimilating soldiers and high technology into units through new manning systems and organizational designs. As the Army moves to unit replacement and unit rotation from individual replacement, soldier cohesion and commitment in these types of units are being studied. Useful data should result for specifying policies and procedures to assure that the new manning systems will work to full advantage.

Another research effort focuses on improving the assimilation of replacements in units as a principal means of increasing cohesion and commitment in combat arms units. Data gathered in Forces Command (FORSCOM) units will measure the development of cohesion and commitment in relation to leadership practices in operational units. It is expected that this research will lead to stronger commitments and more positive attitudes among soldiers arriving at their first unit of assignment. As a result, the Army could expect far less attrition of desirable soldiers.

In U.S. Army, Europe (USAREUR), research is investigating the processes by which soldiers become integrated into the operational environment and Army community in Europe. Soldiers assigned to Europe are faced with many unique problems that can adversely affect their integration into the unit and the Army community. There is a need to relate these problems to specific integration processes so that methods for improving such processes can be developed. In this way, stresses and other problems that affect performance can be alleviated or eliminated. Research is attempting to identify USAREUR-unique factors reducing training time and skill acquisition, determine how to deal with these factors, and relate these factors to attrition, retention, family and legal problems, absenteeism, interpersonal relations, and job competence.

To assess factors in small-unit productivity, procedures have been developed for applying sociotechnical systems techniques to increase productivity and enhance the quality of work life in Army organizations. A sample of quasi-industrial Army facilities will be selected for application of this technology. The objective of the application is to enhance productivity, reduce wastage, and increase the quality of work life. The research is identifying work groups within these facilities having productivity problems and assessing factors that affect productivity. Changes in work flow, practices to manage incentives, control measures, and other appropriate management dimensions will be identified and implemented as appropriate. Each work group will be followed longitudinally to assess the effectiveness of the implementation. A model will be developed to identify organizational factors that predict successful applications of sociotechnical systems technology within the Army.

Maintain Force Readiness

For a fighting force to be combat ready, units must be up to strength, their equipment operational, and every person skilled in carrying out his or her responsibilities. Personnel, equipment, and doctrine must be combined and used effectively.

Units in the field must maintain specified levels of readiness. However, every unit faces numerous roadblocks in its attempt to maintain the required level of readiness. Personnel turbulence and the many competing demands for each individual's time are major roadblocks. Certain organizational structures may provide a better functional unit because they minimize the negative impact of these external influences. It is also critical to understand clearly the criteria for assessing unit readiness and to specify more precisely than is now possible the standards to be met. Research is intended to address the Army's major personnel-related problems; one part of the program is concerned with issues of personnel readiness in field units, a second with issues of training readiness, and a third with procedures to be followed by Army personnel in the effective employment of modern weapons systems on the field of battle.

Managing Personnel Readiness. A model of battalion readiness that will tie together all variables known to affect it is needed to assist the commander, or other interested parties, in examining battalion status and in assessing alternative policies and procedures for improving it. Such a model would include the state of individual and unit training, mandatory training requirements, distractors, personnel and equipment fill, geographical dispersion, maintenance, soldier support activities and facilities, and other considerations that affect unit readiness.

Maintaining Proficiency. Once individuals and units have achieved desired levels of proficiency, these levels must be maintained. The program under this thrust addresses research leading to the development and evaluation of comprehensive programs to support individual and collective training in the field, especially in combat arms. This program also is concerned with the development of technology-based training and job performance aids to solve common training problems and with the design of an information system that will provide feedback on the state of readiness for senior decision makers and unit commanders.

Employing Weapons Systems. The dynamics of the battlefield require that many weapons systems be effectively employed singly and collectively, in concert with other weapons systems. The understanding of how various weapons systems should be combined in tactical operations to obtain maximum benefits from each type is critical. The principal focus of this research is to develop an understanding of and methodology on how to maximize the effectiveness of each of a number of different weapons systems, alone and in combination.

One research effort seeks to develop a set of operator, commander, and maintainer models for use in simulating families of air defense systems in tactical configurations. Sets of multipurpose human models for perception, learning, decision making, and motor functions are being generated. Models will be given specific test implementation for crew and operator configurations; software logic will be generated for linking human process models to different hardware systems, and a field test will be made to evaluate the usefulness of the product for integrated system tests in the United States and NATO.

Another research effort is planned to determine the effects of sleeplessness and fatigue on howitzer crews operating in high-intensity battle environments and to develop a method to evaluate the effects of crew size, composition, and cross-training on extended performance.

A computer model that contains task and time data permits tasks to be assigned to different size crews and to plan the effects on the time of firing, set-up, and march ordering of a howitzer. Performance decrements under simulated battle workload and rest and sleep conditions are determined so that long-range performance decrements can be estimated.

Manpower and Personnel Policy Research

A new program of research was established in 1981 to provide an economic research complement to the Man the Force research domain. Manpower and personnel policies must be modified to attract and retain personnel. The mix of personnel must be examined over a number of years; therefore, recruiting, training, assigning, and discharging of soldiers should be evaluated as an integrated personnel system with the techniques associated with economic and systems analysis. Alternative policies and practices will be evaluated to determine the best mix of personnel to meet job requirements adequately at the lowest cost. The structure of compensation and incentives is very important in securing the desired mix. Promotion policies, bonuses, awards, and special recognition that might motivate people to higher performance levels are other areas of potential investigation.

Demographic Research

Provision will be made for a comprehensive description of demographic, economic, and social trends and their potential impact on Army personnel policy, along with establishment of a computerized base for immediate access to the desired information. Through use of a national inventory, the prevalence of militarily related skills in the civilian population will be identified to help personnel policy makers in the following ways: broaden the base from which military personnel are drawn, structure training programs to be maximally efficient, improve design of weapons systems to capitalize on preexisting skills, make better estimates of available manpower in designing mobilization plans, and develop better incentives for attracting targeted populations. In addition, requirements will be projected to determine the effects of defense expenditures on requirements of skilled personnel over the next several years.

Economic Enlistment and Reenlistment Modeling

A macroeconomic model will be developed to examine the determinants of enlistments, to predict future enlistment levels, and to estimate the importance of economic and sociodemographic factors. Factors that affect an individual's decision to enlist in the Army at the local or regional level will be determined. Such research will have important implications for recruitment strategies by enabling policy makers to allocate recruiting resources more efficiently. A recruiter "early warning" system will be developed to identify and test the significance of leading indicators, such as economic ones, of potential recruiting difficulties by region. On the basis of this system, a model will be developed for a more efficient allocation of recruiting resources.

To assist in reenlistments, the impact of the Selective Reenlistment Bonus (SRB) on reenlistment rates will be measured, along with impact of earnings, civilian employment opportunities, and other factors bearing on an individual's propensity to reenlist. The effectiveness of the SRB program can then be evaluated and changes leading to an optimum SRB level made accordingly.

Manpower Cost Modeling

A life-cycle manpower cost model will be developed for the Army. It will allocate recruiting, training, and retirement costs over the operational years and produce cost estimates.

Under consideration are calculations of the costs of on-the-job training of enlisted personnel in selected MOS (including two selected for a pilot lateral placement program and four other MOS of a critical and technical nature), estimates of the cost of first-term attrition (with special attention given to recruiting and training costs and how these costs are amortized over time), and estimates disaggregated by MOS, rank, and various soldiers characteristics. Policy makers will then have tools to assess the attrition problem and the cost effectiveness of programs designed to reduce it.

Factors influencing Army attrition will be measured to determine whether separation rates of enlisted personnel are comparable to job mobility behavior for similar workers in the civilian sector. Determining these turnover and separation rates has important policy implications because personnel losses through attrition are costly and adversely affect unit readiness.

Basic Research

ARI's basic research program is conducted to fill gaps in scientific methodology and in data bases that may support future applied research areas. The program is implemented primarily through contracts with the academic community based upon internal peer review of unsolicited proposals. In 1982 the program sponsored 61 such contracts with U.S. organizations, almost all of which were individually executed efforts within universities and private organizations. A few additional efforts are supported in Europe and Israel.

To help provide direction and expert advice for basic research in the human factors domain, ARI—with the Office of Naval Research and the Air Force Office of Scientific Research—participated in establishing a triservice committee on human factors within the National Academy of Sciences. This group now meets regularly to review the state of basic research in this area.

Objectives of the basic research program are to develop the behavioral science base on which to build new technologies that improve future effectiveness of soldiers and systems; capitalize on new research developments that have the potential to resolve future Army problems; involve innovative scientists in research relevant to the solution of future Army problems; and lead the next generation of applied research efforts.

By virtue of its purpose of filling gaps in scientific methodology and data bases, the basic research program is "future focused," that is, its implications are referenced to ongoing practices of the Army (for example, determining how to train soldiers in multiple skills). And yet this basic research is conducted independently of current laboratory programs and takes shape at least in part as a function of the proposals, which are received unsolicited or in response to the most general of guidelines. Such guidelines consist mainly of outlining possibilities for basic research within the five applied research domains of ARI described earlier.

The program is broad in scope and permissive in entertaining proposals on topics that may at first glance appear to be completely irrelevant. But contract awards are ultimately made on judgments of relevance, scientific merit, and uniqueness with respect to sponsored efforts within Army, DOD, and other government agencies (the latter based on well-structured intergovernment coordination activities).

Basic Research in the United States

Some ongoing basic research contracts of note include the following: Robert Sternberg, Yale University, "Components of Verbal Intelligence"; Siegried Streufert, Pennsylvania State University, "Training for Cognitive Complexity"; Sigmund Tobias, City University of New York, "Macroprocessors and Adaptive Instruction"; Donald Dansereau, Texas Christian University, "Cooperative Learning"; Andrew Sage, University of Virginia, "Information Processing Using Structured Frameworks"; and Alexander Levis, Massachusetts Institute of Technology, "Information Organization with Acyclical Information on Structures."

One of the more successful approaches to the training of military leaders was based on Fred Fiedler's "Contingency Model of Leadership Effectiveness," which takes into account the performance and success of a group or organization as affected by the leader's style and by the situation in which he or she must operate. Dr. Fiedler developed a system of programmed instruction based on his model for use with Army personnel; it was tested in a variety of ROTC summer camp settings. As evaluated by trained officers and NCO advisors, students trained under the method were found to perform significantly better on all leadership measures employed. The training program is cost efficient because supervision of trainees is unnecessary in the self-administering format (Fiedler, Mahar, & Carroll, 1978).

William Rouse, of the Georgia Institute of Technology, has tested a basic assumption that problem-solving skills are common to all diagnostic tasks. His research results showed that general decision strategies should be followed whether one is diagnosing a broken radio, a malfunctioning aircraft engine, or any other piece of equipment. Use of a computer-based, context-free, nonequipment-specific diagnosis task in training led to improved performance by students when they were tested on their ability to do repairs on specific equipment (Rouse, 1980).

Basic Research in Europe and Israel

Within the last several years, ARI's Scientific Coordination Office in London, England, (colocated with the Office of Naval Research and the Air Force's Office of Scientific Research) has sponsored several basic research contracts each year. This research has been conducted in areas where data acquisition, for various reasons, is difficult in the United States or where research can be conducted by scientists who have international stature or unique professional or research capabilities. The following efforts, spanning the past several years, are representative.

Jack S. Rachman, at the University of London, is providing an analysis of psychological attributes of personnel who perform both capably and courageously in extremely dangerous and stressful assignments.

Gwyn Harries-Jenkins, at Hull University, England, conducted an analysis of factors in various Western European Armed Forces that led to personnel dissatisfaction and demands for group representation. The analysis provided "lessons learned" in how to handle and how not to handle such situations and provided options for forestalling similar situations within the U.S. Army all-volunteer force (Harries-Jenkins, 1977).

Schlomo Breznitz, at the University of Haifa, Israel, is providing information and guidelines on how to offset the psychologically deadening effects of false alarms, which are fairly prevalent in early warning systems (Breznitz, 1980).

Raymond Fuller, at Trinity College, Dublin, is providing quantified data on the effects of prolonged work schedules on relevant motor skills and alertness.

Elliott Jacques, at Brunel University, England, has found an almost linear relationship between level of command, that is, company, battalion, corps, etc., and implicit job requirements for more global, abstract thinking. He is producing provocative implications for career development of senior military personnel.

Gordon Pask, of Systems Research Development Ltd., England, has performed a systematic exploration of theory and practice in individual and group decision making, leading to the development of simulation tools usable in study and potentially useful for training individuals and groups in decision making (Pask, 1980).

Claude Levy-Leboyer, at the University of René Descartes, Paris, has performed a detailed analysis of the qualitative and quantitative impact of managerial and organizational factors on the efficiency of research personnel (Levy-Leboyer & Voisin-Vedrenne, 1978).

Peretz Lavie, of the Israel Institute of Technology, is conducting research on the effects of natural human biorhythms on prolonged performance and has identified a new 6-hour biorhythm. His finding, if sustained, will explain previously confounding data on human performance capabilities and their changes over time.

Donald Mitchie, at the University of Edinburgh, is applying techniques of artificial intelligence to develop a system that can process and synthesize large-scale, multiple-input sources of information. Applications of artificial intelligence to development of Army C^3I systems are possible.

In-House Laboratory Independent Research

The Technical Director's ILIR program has contributed significantly to ARI's programmatic growth, not only through specific project findings but also through developing a climate for scientific research. ILIR has sparked the enthusiasm of the ARI staff by granting individual scientists the opportunity to pursue their specialized areas of endeavor to the mutual benefit of their own professional growth and the Institute's programmatic vigor. Perhaps more so than in the basic research program, operational concepts envisioned by the Army for the future (e.g., the need to maintain adequate force strength and readiness and

to maintain the critical soldier-machine balance) have helped generate strategy for the ILIR program. The projects selected have usually been those that appeared to scientific peers to offer the greatest potential of a high return on investment.

Carolyn A. Carroll examined factors responsible for engaging human beings in extended interaction with electronic games for their potential relationship to ARI's program in training and instructional research, which is relying more and more on simulation and automated training devices. Preliminary results indicated that factors thought responsible for holding a player's interest over long periods—fantasy, challenge, curiosity—while necessary, may not function directly to make a game motivational. Other factors, such as the role of feedback and rewards and the social context in which the games are played, seem to have greater effect on the motivation to play.

Paul G. Rossmeissl conducted research to lay the foundation for a technique to estimate the human aptitude requirements of weapons systems being developed. Rossmeissl first produced a taxonomy of aptitudes relevant to several military systems; the taxonomy was then implemented on a microcomputer to increase assessment reliability and efficiency. This procedure broke new ground in the development of techniques for assessing the aptitude requirements of Army systems. Interim appraisal of findings led to a decision to continue and expand what is considered a promising approach.

James D. Baker examined age and its relationship to cognitive processing of information and short-term memory. His effort specifically examined particular military tasks and skills that he thought might be adversely affected by aging and led to the development of appropriate training and/or testing procedures to assure the highest level of performance in critical Army jobs. He used a microprocessor designed for use in the Apple II system. Preliminary findings suggest that chronological age alone is a poor predictor of individual performance, especially age-related deficits in psychological abilities critical to military performance, and that individual differences as well as specific performance environment must be considered when attempting to assess the effects of age-related changes in the older individual. The innovative aspect of the research, however, is new ground broken in attempting to determine actual limiting effects of aging on skills relevant to the Army.

Research Program Highlights

The "top dozen" ARI research efforts over the next several years, in terms of research emphasis and resources, are summarized below.

Assessing Human Resource Requirements during System Development

The purpose of this effort is to develop an integrated system to control the generation, integration, and management of manpower, personnel, and training (MPT) requirements data within the context of the Life-Cycle System Management Model. While such data will be usable throughout the acquisition process, early consideration of MPT requirements will be emphasized. This research will help users determine personnel performance and training issues and constraints during concept formulation; forecast manpower and personnel requirements, both quantity and quality; develop training requirements and estimate training costs in parallel with weapons systems development; identify those MPT issues (drivers) requiring consideration during test and evaluation; and meet MPT information requirements of the Army and Defense Systems Acquisition Review Councils (ASARC/DSARC) processes.

C³I System Design and Training Considerations

Design recommendations are needed for automated C³I systems to maximize combat staff operations. This research will examine the information processing and decision-making requirements for such systems, identify those that produce the most effective individual and collective performance, and determine the C³I tasks that can be automated. Long-term focus of this research will be on distributed systems for the battlefield of the future and on data that will permit designers to evaluate alternative organizational options and doctrinal concepts in terms of the personnel necessary to staff future battlefield systems. A better understanding of the training requirements for C³I systems is also expected; such understanding will in turn lead to improved training programs directed at enhancing and maintaining tactical decision-making skills.

Soldier–System Interfaces in Automated Systems

The objectives are to develop, test, and implement techniques, procedures, alternate displays, formats, and languages for the soldier-system interface in battlefield automated systems. The research will address display symbology, cueing mechanisms, interactive graphics, interactive land combat model usage, information format and content strategies, input and output techniques (including voice), and types of users (e.g., dedicated operators, casual users, and untrained users). Soldier-system interface research will also include the interactive information and communication needs of a distributed decision team in command and control networks. The research in any one area will be directed to a specific "host" system to solve issues within that system; however, results will be applicable to similar issues in other systems.

Performance-Based Personnel Selection, Classification, and Utilization

This research is directed at methods for obtaining a complete picture of an individual's ability to serve effectively as a soldier through development of postenlistment predictors and the measurement of non-job-specific aspects of soldier performance. Improved measures of school and training success will be developed and their relationship to eventual performance on the job determined. Measures of individual performance in specific and common soldiering skills will provide an indication of a unit's overall achievement of individual training requirements. The most immediate application of this research will be in validation of the new ASVAB. Soldier-job matching will be significantly improved in longer range applications.

Officer Leadership Development

The objective is to develop a total systems approach to enhance the development of leadership skills at all officer levels during training and assignments. Appropriate training programs that build on previous training and experience will provide the basis, and the final objective is to develop a model for an integrated program of training and developmental assignments. Cost-effective application of advanced information technologies, such as computers and satellite transmissions, will be emphasized in the development and sustainment of both technical and soft skills for officers in remote assignment areas.

Personnel Policy Research

The Army Science Board in 1980 stated that "there is a pressing need for the development and utilization of human-issues-relevant models to aid in direct policy making, analyses, and decision making." ARI's recently established personnel policy research program is directed at the utilization of technically authoritative, scientifically defensible information to support management decisions in the military manpower policy arena. Some examples of issues include the impact of compensation changes on retention, effect of ASVAB score limit changes on recruiting and performance, overseas tour length changes, determination of reserve requirements, total force manpower mix, productivity enhancement initiatives, up-or-out promotion policy changes, new GI bill strategies, and retirement system changes.

Human Performance Modeling

Human performance models for crew-served weapons systems will permit designers and combat and training developers to examine empirically the potential impact of changes in the personnel subsystem for estimating the effects of crew size, organizational composition, and aptitudes on system performance, as well as the impact of changes in soldier-machine relationships and operating conditions on overall system performance. Designers will be able to estimate personnel demands for new systems; training developers, to determine system training requirements; and combat developers, to determine the effects of changes in operational conditions on system effectiveness.

Microelectronics for Training

The capability of microelectronics for storage, distribution, processing, and display of information will provide almost unlimited opportunities for accomplishing Army missions in simulation, maintenance, and general training administration. ARI's past efforts include the design of prototype systems for basic skills instruction (Hand-Held Vocabulary Tutor) and maintenance job aiding (the Personal Electronic Aid for Maintenance or PEAM). Its research program will be expanded to solve some of the Army's critical training problems with "personal" portable training aids, learning/training/performance aids, and unit/school environments. The research objective is to enhance the portability, usability, functionality, and implementability of microelectronics technology in Army training.

Training Performance Management Information System

The Training Performance Management Information System will provide reports to senior managers on the status of training in the Army. Information will be fed into the system by units at all levels in Major Commands (MACOMS), TRADOC, Department of Army agencies, and other sources, and will include the status of training, devices and systems, and ammunition management. Raw data will be converted into information meaningful to senior users in identifying critical training strengths and weaknesses and in making decisions. The senior manager will have access to user-friendly decision-support packages. Future versions will use artificial intelligence techniques to deal with garbage-in/garbage-out problems. Input agencies can access the system for accurate, up-to-date information to assist in managing local command training.

Low-Cost Simulations and Training Devices

Simulators and training devices developed with the school environment in mind are often not appropriate in a field setting because of their complexity and the magnitude of resources required to support them. Research is directed at the design of effective training simulators at the lowest cost to determine how and to what degree simulators and training devices may be substituted for operational equipment.

National Training Center Unit Training and R&D Center

The National Training Center Unit Training and R&D Center supports the National Training Center in training maneuver arms battalions as they will fight, that is, with full combined arms operations against opposing forces (OPFOR) under conditions that give a high fidelity portrayal of the "dirty" battlefield. Training includes credible engagement simulations, which assist in providing high-resolution unit-performance measurement. ARI has planned a multiyear, two-phase research program that will address both near- and mid-

term needs. The products of this research will have broad applicability to Army training and doctrine, including use by Deputy Chief of Staff for Operations (DCSOPS) for assessing force readiness; by Forces Command (FORSCOM) for assessing training readiness; and by TRADOC for improving training and evaluation programs, for evaluating and improving tactical doctrine, and for developing combat development alternatives.

Maintenance Performance and Training

The Maintenance Performance Research System integrates various R&D subcomponents into an Army-specific system, which requires technological and methodological improvements to provide more cost-effective maintenance training. Current methods are considered too ineffective and inefficient. New approaches will take full advantage of available technological breakthroughs and innovations. Component technologies will include the Navy's Enhanced Electronics Maintenance Trainer (EEMT), the Army's Adaptive Computerized Training System (ACTS) and Maintenance Performance System (MPS), and the Air Force's Advanced Instructional System (AIS) Software Conversion.

Selected Research Findings

Soldier–Machine Interface

Roughly 200 materiel systems will be added to the Army's inventory in the next decade, a period likely to be characterized by resource constraints, particularly those stemming from the rising cost and declining availability of personnel. In spite of temporary personnel surpluses because of general economic conditions, the Army can expect great difficulty in recruiting enough qualified individuals to operate and maintain those increasingly sophisticated systems.

ARI is developing an approach to determine the adequacy of current procedures for developing manpower information during the materiel acquisition process. The challenge is to integrate manpower, personnel, and training requirements into the decision process for weapons system design and acquisition. This challenge can be met by using and modifying existing procedures and by adding new procedures where warranted. Methodologies to support these procedural changes must also be developed.

The weapons system design and acquisition process has five phases: concept, design, full-scale development, production, and deployment. By the end of the concept phase, 70 percent of the life-cycle-cost decisions will have been made. Manpower, personnel, and training considerations must be addressed during the concept phase and must be completed before the end of the design phase.

Planners should be able to determine very early in the design phase the abilities a person needs to benefit from job training related to the system under development. This determination must be assessed in the context of the projected manpower supply. Furthermore, the aptitude/skill delineation can serve as an overlay to determine alternative MOS that could be used to meet this need.

For example, one requirement in the procedural dimension is the documentation of qualitative and quantitative information on personnel requirements. Accumulated during the acquisition process, this information helps planners identify the number of operators needed for the end items and the necessary MOS. In some cases, this means identifying the knowledge, skills, and abilities an individual needs to qualify for a recommended specialty. Typically, this information is randomly assembled late in the acquisition process, but with the development of appropriate methodology, the process could be made more precise.

MOS requirements should be determined before development rather than after. The thrust of the research effort includes detailing requirements and subsequently providing tools, techniques, and job aids for system developers. Handbooks were recently published that provide guidance to managers of programs and training systems on the required manpower, personnel, and training inputs necessary for effective operation of the life-cycle system management model (LCSMM) and that couple these requirements to the program, plans, and budgeting system (PPBS) model.

Presently, ARI is developing preliminary detailed guidance documents and aids so that training considerations can be made early in the acquisition process. As stated in the *Defense Management Journal*, "The Army has come to realize that the era of equipping the man is giving way to the era of manning the equipment" (Baker, 1980).

Managing Information Flow in Battlefield Automated Information Systems

For several years the Army has been developing battlefield information systems. Within the intelligence community, attention has recently focused on the Battlefield Exploitation and Target Acquisition test bed and the All Source Analysis System. Concurrently, ARI has conducted extensive research in human factors and addressed the role of the human operators and users of automated systems. To optimize the overall effectiveness of such systems, the flow of information must be managed carefully: The right information must get to the right person at the right time without overloading recipients unnecessarily.

The technical capabilities of new computer-based tactical command and control systems may increase the density of information (e.g., information on current enemy situations during critical periods of enemy attack and withdrawal) to the point where it overwhelms the users. Condensing and organizing incoming information into manageable form will require summarization routines. ARI has been investigating what makes up a good intelligence summary prior to developing a consistent and reliable means of condensing information as it passes from one staff element or echelon to another.

Guidelines for good summaries were developed through an application to the intelligence task of "schema" theory from cognitive psychology. Highly skilled Army officers served as a resource. The theory holds that the comprehension of any information is affected by past knowledge, which is organized as a mental outline of an individual's general information on a topic. This schema, or underlying logical structure, provides the outline for organizing and interpreting new material.

First, "good" summaries of a series of messages conveying Enemy Situation Data (ESD) were identified and then analyzed to suggest the following guidelines. Summaries should be prepared in conversational style, should give a well-founded interpretation of the information, not just "hard facts," and should emphasize information concerning enemy movement.

Before implementing the guidelines, it was necessary to determine if they could actually help Army personnel produce better summaries. Experimentation by ARI showed that messages summarized according to these guidelines were distinctively superior to those written without. Also, a good summary was better than an extended text for promoting the reader's comprehension and retention of the main points. The guidelines now have been fully tested and have been successfully demonstrated to help staff officers produce better summaries (Parrish, Gates, & Munger, 1981).

Abbreviations and Battlefield Automated Systems

This work is one of the many efforts carried out at ARI to facilitate user-system interactions and to produce design guidelines and criteria for operator transactions with battlefield automated systems.

When automated command and control systems are introduced onto the battlefield, they perform many of the tactical functions formerly performed manually. While the advantages of automated systems are clear, problems can occur at the human-computer "interface." Potential incompatibility exists not only at the physical level (poorly designed keyboards, hard-to-read display screens), but also at the level of mental processes (human reasoning, memory, and perception). Research-developed guidelines for the use of abbreviations will improve the interface between systems and their users.

Most computer systems use abbreviations, which increase the amount of information that can be simultaneously displayed on a screen and decrease the amount of computer memory required. But their use can create problems for computers and their users. The computer remembers the correct abbreviations for a number of words. Most computers are extremely rigid; if a single letter is missing or out of place, the computer rejects the entire statement and waits for it to be entered again. If the abbreviations in a battlefield automated system are so hard to remember that its users make frequent errors, then the system's ability to do its job is degraded and may even be compromised (Ehrenreich & Moses, 1981).

Abbreviations can cause severe problems: there are many to remember, the level of training of the user is deficient, or the stress under which the user is working is inhibiting. Also, it has been empirically determined that unnatural terms are difficult to remember (CATK for COUNTERATTACK), that abbreviations are not standard across systems, and that abbreviations are inconsistent because of the arbitrary manner in which they are generated (e.g., DEF for DEFEND, but ATK for ATTACK). When all Army systems use the same abbreviations, Army computer operators will be able to transfer their experience and knowledge from one system to another, and they will benefit from positive transfer of learning.

ARI is determining the best systematic method for creating abbreviations that are easy to use and also is producing a simpler algorithm for creating and decoding abbreviations.

Uncertainty and Reliability in the Processing of Intelligence Information

Judgments of the probable accuracy of intelligence data and products are integral to the intelligence process. Even though intelligence is seldom perfect, evaluations containing inadequate data and doubtful conclusions can often be extremely useful. The user of an intelligence evaluation will naturally be influenced by the degree of certainty that has been attached to it. Thus, the intelligence officer must determine the degree of certainty of a given statement and then communicate this information. Communicating uncertainty in terms of source reliability and accuracy of information is a problem for both the intelligence section and the users, but it is essential to the effective production and use of intelligence.

Edgar Johnson asked 14 enlisted personnel and 14 extension college students to encode on a 0-to-100 scale each of 15 probability phrases in each of three sentence contexts. The 15 phrases systematically covered a wide range of probabilistic meanings; the three sentence contexts involved a weather forecast, a prediction of personal success, and an intelligence report. Johnson found no significant differences in the encoding of probability phrases into numerical equivalents among the three sentence contexts between the enlisted personnel and the college students, or as a function of age, sex, or educational level. Subjects were relatively consistent in their own encoding of given phrases but differed, often radically, from other subjects. Thus, differences in the encoding of qualitative expressions did not appear to depend on any of the general

factors evaluated in this study other than the ambiguities in qualitative phrases themselves as influenced by individual differences of unknown sources.

The use of qualitative expressions to communicate the accuracy or relative likelihood of occurrence of intelligence data and products often seems to result in a high degree of misunderstanding. Johnson concluded that persons involved in the production and use of intelligence should be extremely wary of attempting to infer numerical values from qualitative expressions of uncertainty (Johnson, 1973).

In another effort to learn ways to improve processing of intelligence information (that is, to increase the amount and variety of data channeled into the intelligence system), a study of human processing and use of unreliable, or "ill behaved," data was undertaken (Johnson, 1974). Although such data were often discarded, some researchers believed that unreliable information could contribute to the production of intelligence if improved methods and techniques of processing information could be developed. Johnson examined the ability of people to consider the reliability of a data source and the strategies people use to process unreliable data when intuitive probabilistic inferences are required.

Johnson presented reports from data sources of given reliability and diagnosticity to 22 subjects in a series of two-hypothesis decision problems. For each problem, the subjects selected the most likely of the two hypotheses and the subjective odds favoring that hypothesis. Subjective odds varied as a function of the data diagnosticity and source reliability. However, the subjects generally failed to extract as much certainty as possible from the data; subjective odds were generally conservative with respect to odds computed by a normative Bayesian model. But in most cases, as reliability decreased, subjective odds increased relative to Bayesian odds until the subjective odds were generally greater than Bayesian odds at the lowest level of reliability. Subjects' protocols and data analyses indicated that subjects were using nonoptimal inference strategies in which reliability was incorporated as a multiplicative weighting factor. Johnson concluded that if the diagnostic impact of the data "if it were true" were correctly evaluated, this strategy would lead to increasingly inaccurate subjective odds as reliability decreased and the data diagnosticity increased.

Although this research suggested several techniques for improving intuitive inferences based on unreliable data, further research is needed to test the utility of these techniques and to develop better methods to improve intuitive inference.

Maintenance Performance System

The chief goal of ARI's research effort here has been to improve the conduct and quality of on-the-job training of repairmen in the performance of technical tasks in direct support battalions. Having Army vehicles and other equipment in a state of readiness is crucial to maintaining the expected efficiency of increasingly complex and expensive weapon systems. But a continuing series of audits and inspections prior to 1979 had indicated that equipment maintenance was not as effective as it should be. For one thing, managers had no systematic way of pinpointing individual or unit training needs.

ARI's research response to this problem was twofold: to develop a maintenance performance system to provide unit management with current information about the experience, training, and skills of maintenance personnel; also to develop a diagnostic and prescriptive aid for managers to match training methods and materials to skill and performance needs. The resulting Maintenance Performance System (MPS) provides timely reports to management to keep track of progress and to flag deficiencies in maintenance operations so that training priorities can be set. Provisions are included for a unified record of the technical training and experience of each repairman in the unit. The MPS also yields current and historical records of mean days to repair, mean hours expended for specific tasks, mean days in each job status, and unit man-hour availability and use.

Four documents aid the user battalion in implementation and use of MPS: Reference Manual (the most general document); Training Guide (tools and techniques for identifying and correcting deficiencies in technical skills); Operator's Manual (methods and procedures for operation and maintenance of MPS); and Information Guide (principally for maintenance managers in diagnosing problems in operations and training) (Katz & Drillings, 1981).

Development and Validation of Army Selection and Classification Measures

ARI has initiated a 7-year, multimillion dollar research program to relate better accession criteria to soldier performance. The research will involve an iterative procedure of relating preaccession characteristics, performance in training, and soldier performance in units with objectives of validating the Armed Services Vocational Aptitude Battery against soldier performance; developing new selection and classification procedures and measures to optimize the soldier-requirements match; and developing computer-based decision aids for managers of the Army's personnel processes.

Since the current classification system has not been validated against soldier performance, early development of MOS-specific and Army-wide measures of soldier performance are needed. Performance data will be collected for tracking soldiers from the recruiting command through training and through first, second, and all succeeding tours. These data will be used to develop a longitudinal data base so that ARI can develop the models for selecting and allocating soldiers more effectively and permit assessment of the trade-offs in varying standards and costs to the Army. The research will undertake exploration of new ways to measure and collect data on the civilian labor pool; develop and evaluate new measures of soldier aptitudes, such as psychomotor abilities; develop new methods to analyze training performance; and develop and refine adequate, efficient performance measures and predictors of NCO success.

Characteristics of the future system for selecting, classifying, and using enlisted soldiers will differ greatly from today's system. The Army will have an automated accessioning system, along with the data required to make critical personnel decisions throughout a soldier's career based on individual performance and the needs and priorities of the Army.

The value of this research project is as follows: It is estimated that the future personnel system will result in a 20 percent improvement over the present one. Expected cost avoidance savings are anticipated in reduced attrition, retraining, and benefits paid to post-180-day attritees, for savings of an estimated $127 million per year. The value of improvements in combat readiness and soldier performance has not been estimated in dollar terms, but should have a major impact on achieving a competency-based Army.

The personnel system of the future is envisioned as including more and better measures of an individual's characteristics and aptitudes; a greater understanding of the links between preaccession measures and soldier and unit performance; and an efficient means of expressing Army needs and policies in terms of personnel goals, costs, constraints, and trade-offs. It will be a dynamic, self-adjusting system to support Army management decision making. The tools, systems, and data produced will have a major impact on the Army, the Department of Defense, and society in general in providing a better understanding of the relationship between individual characteristics and performance capabilities.

Warrant Officer Retention

Research assistance has been requested from ARI to reverse an alarming increase in attrition among aviation warrant officers (AWOs). In 1979, about 55 percent of aviation warrant officers were leaving active duty at the end of their initial tours. The increased separation rate was thought to signal the onset of a trend that would significantly increase training costs and reduce the combat effectiveness of Army aviation units.The $125,000 training investment per aviator meant total replacement costs of about $350 million a year. Moreover, limitations in the number of aviators programmed to be trained each year precluded any significant increase in AWOs to fill the projected shortage.

ARI conducted an in-depth investigation to determine the factors that influence an AWO's decision to separate. Information was collected by questionnaire and interview from more than 1,200 aviators (approximately 900 warrant officers and 300 commissioned officers) around the world. Three major influences emerging from the investigation were pay and benefits, leadership and supervision, and assignment and career management.

Variables examined in relation to attrition were age, marital status, installation, source of entry, career status and track, civilian education, desire for a commission, and the civilian job market. Findings suggested that AWOs who plan to leave the Army are typically younger than those who plan to remain in the Army. Also the retention rate was almost double for AWOs responsible for two or more dependents, and a larger percentage of single and divorced AWOs attrite compared with married AWOs. But once the AWOs had been assigned a career track (safety, operations and training, or maintenance) or had become voluntary indefinite,* their retention rate significantly increased.

ARI research indicated that changes were necessary in personnel policies covering such areas as compensation, leadership management, and supervision. Official actions have improved retention of AWOs and benefited the entire warrant officer corps. As reported in the *U.S. Army Aviation Digest* (Morgan & Joynson, 1981, p. 36):

> The importance of the ARI study cannot be overestimated. Many programs designed to alleviate problems never get off the ground because a "problem" cannot be specified or substantiated. This is the real world in which decisions are made. The aviation warrant officer retention study provided the needed substantiation and specifics. At last, "what everybody knew" became a specific outline that expressed the concerns, irritants and dissatisfiers that affected officer retention. It provided a starting point for action.

Engagement Simulation

One of the most revolutionary changes in combat training ever introduced was fielded in the first half of 1981. The Multiple Integrated Laser Engagement System (MILES) simulates weapon effects with personnel-safe lasers and gives the Army capability for highly realistic peacetime combat practice.

Although "training realism" is desirable, tactical exercises in the past have shown little resemblance to combat conditions. One reason is that the lethality of modern weapons is often ignored in training exercises. Soldiers and vehicles move about training areas as if immune to enemy weapons. Casualty assessment systems are based on probability tables or the subjective opinion of controllers. For a casualty assessment to work, particularly at small-unit level, a key consideration is that it be believable and that it accurately reflect soldier performance. It must be related to the ability of soldiers and crews to use their weapons (REALTRAIN, 1975, p. 2).

Operating on the premise that the key to effective performance-oriented tactical training was objective and credible casualty and damage assessment, ARI began developing new tactical training techniques in 1972. The modern

*Status of those AWOs who upon completing their obligated tours in hardship areas accepted the Army's invitation to extend at least 1 year more with the privilege of choosing their next assignments.

techniques of Tactical Engagement Simulation (TES) began with a relatively simple, low-cost method for training small light infantry units (SCOPES, or Squad Combat Operational Exercise Simulation). As a result of one ARI field experiment with infantry, TES-trained units showed an eightfold improvement in mission accomplished compared with a twofold improvement for conventionally trained units.

As increasing emphasis was placed on combined arms training, the infantry squad method was expanded to include simulation of armor and antiarmor weapons fire under the name REALTRAIN. As a result of later experimentation, TES-trained units in infantry and armor won more than three-fourths of all engagements, with overwhelming superiority in casualty ratio.

Development soon began on a method of engagement simulation requiring fewer training support personnel through automatic casualty assessment, which permits highly realistic tactical training for units up to Battalion Task Force size. The resulting method—MILES—is being used to train Army combat units (Atkinson, 1980).

MILES produces an accurate ongoing account of the mock combat, clearly identifying the winners and losers. More important, the causes of success and failure can be determined. The highly effective feedback techniques developed by the research team increase the likelihood that training experience will carry over to the real battlefield. This technique provides the central capability for the Army's National Training Center, where full battalions are given the opportunity, for a 2-week period, to train as they will fight.

After-action review

Tank on attack—REALTRAIN

REALTRAIN validation crew in USAREUR

One caution must be noted, however. The final performance values obtained during field tests of TES cannot be projected into statistical predictions of larger and more complex engagements, simulated or actual. Nevertheless, the outstanding improvements in soldier proficiency as shown in TES tests will greatly increase the combat effectiveness of U.S. forces.

Skill Qualification Tests

Under the systems approach, units train their own troops for MOS duty positions. The major tools for individual training are soldiers' manuals, commanders' manuals, job books, training extension course lessons, and skill qualification tests (SQT). The SQT program has significantly improved individual training and personnel management in the Army. The tests differ from conventional tests, however, in that the latter are designed to compare individuals with one another and are norm based. SQTs measure a person's actual performance against specific performance objectives and are task based.

The training development process begins with job and task analysis to identify specific performance objectives. The objectives clearly state how well the task must be done to meet requirements. Soldiers are then tested, trained, and retested until they can meet requirements.

ARI has participated in the development of the SQT program since 1975 as part of a plan to modernize and decentralize Army training. According to ARI findings, task-based training must progress beyond its present state of including only selected samples of tasks in soldiers' manuals. It must now develop small progressive sequences of task-based training modules to deliver the kind of competitive excellence on the battlefield that was originally envisioned. Research on the measurement characteristics and interpretation of SQT scores is expected to promote continued development of task-based training evaluation methods (Bolin, 1981).

Skill Retention

The Army has identified skill deterioration as a critical problem in training. Little is known about the rate of skill deterioration for specific Army jobs. Army commanders and trainers do not know the most efficient procedures for acquiring and maintaining proficiency; how often tasks have to be performed, evaluated, or trained to ensure performance to standard; or how a commander should intervene if a task is performed infrequently and not evaluated regularly.

The adage "once trained, always trained" is a recognized myth. The results of skill qualification test results confirm that Army job skills deteriorate. But tasks vary in how difficult they are to learn and how quickly they are forgotten. The rate of proficiency loss has implications for training, training literature, on-the-job aids, and hardware design. Because it is impractical to measure retention for each Army task, however, ARI undertook research to identify variables or task factors that would predict rates of proficiency loss for Army tasks.

First, an extensive survey of the military literature was conducted on variables known to affect or suspected of affecting retention of learned motor behaviors over lengthy no-practice intervals. Task variables thought to underlie the long-term retention of motor skills included duration of the no-practice period (or retention interval); nature of the response required to accomplish a particular motor task; degree to which the learner could organize or impose order on the elements that defined the task; structure of the training environment; and initial or "natural" ability of the learner to perform a task without prior practice. Procedural variables thought to affect long-term retention of motor skills included degree of proficiency attained by the learner during initial training; amount and kind of refresher training; transfer of skills on one task to performance on another task; presence of interfering activities; distribution of practice during training; use of part-task versus whole-task training methods; and introduction of extra trials prior to final testing.

The survey lent empirical support, at least tentatively, to a number of generalizations: discrete motor responses are more likely to be forgotten than continuous motor responses; functional similarity is a necessary and sufficient condition for learning procedural tasks; augmented feedback can enhance performance by enhancing motivation, learning, or both; individuals of higher initial ability tend to achieve higher levels of proficiency and retain skill at a higher level than individuals of lower initial ability; the single most important determinant of motor retention is level of original learning; learning and retention are benefited by test-taking opportunities.

A major conclusion of the survey was that because long-term retention appears to depend so heavily upon a trainee's original learning level, this would seem, at least initially, to be the most direct and effective means of attacking the issue of skill maintenance in the Army (Schendel, Shields, & Katz, 1978).

In 1977, Shields, Joyce, and VanWert had set the following research objectives to help commanders and trainers: evaluate retention of Chaparral missile crewmen skills between training in school and utilization on the job, determine the effect of refresher training, and provide substantive data on how people on the job forget over time. The team selected the following tasks for research: preenergizing, energizing, and deenergizing the launch station; carrying out before-operations performance measure checks on the M730 carrier; installing and operating a field telephone; and performing emplacement and operator checks and adjustments on the target alert data display set. The researchers developed and validated hands-on performance tests for each task and divided 99 soldiers into three experimental groups. In all groups, soldiers were tested immediately following completion of Advanced Individual Training (AIT), were tested and trained to standard upon arrival in one of seven

USAREUR Chaparral battalions, and were retested 4 months after arrival and training in USAREUR.

In general, the elapsed time between AIT and testing in the unit did not degrade the soldier's performance. However, after soldiers were trained to perform the tasks to standard (100 percent criterion) using the appropriate technical manual, small decreases in performance over the 4-month period occurred. The data suggest that once soldiers learned to perform the task to standard using the technical manual, they continued to perform to standard or close to standard over the 4-month interval of the research. Average scores on the tasks never dropped below 80 percent of the performance measures passed.

The researchers concluded that although performance did not decline between AIT and arrival in unit, performance decreased gradually after arrival. The procedures used in the research effort forced the soldiers to use the appropriate technical manual (job aid) to perform the test task, thereby helping them maintain a high level of performance. The required frequency of training to maintain proficiency probably would have been much greater without the use of the job aid. Failure to show significant decreases in performance between AIT and first unit testing may be attributable to the feedback provided at AIT on errors made during performance of the test tasks. Actually, performance testing may be a promising way to maintain task proficiency.

The finding that use of job aids facilitates skill retention and reduces the need for refresher training was expected to apply to other situations, as findings were basically the same for all Chaparral tasks (Shields, Joyce, & VanWert, 1979, pp. 1-8).

In another experiment, Field Artillery Training Center evaluators tested soldiers' performance on 20 basic common tasks. The sample included soldiers who were completing entry-level training and soldiers who had completed this entry training during the previous 12 months. Training Center evaluators rated task performance "go" or "no go" for each task step and for the task as a whole.

Tasks varied in the rate at which the percent "go" declined since training. Three factors accounted for most of the differences in retention: number of task steps, order of original training, and the presence or absence of subtasks. Soldiers could perform most steps. Those that were forgotten tended to be the steps not suggested by the previous sequences or by the equipment. For example, in weapon tasks, soldiers either tended not to perform or performed incorrectly the safety procedures.

It was suggested to commanders that they could use the results of the research to determine the relationship between soldier proficiency and time since training. Commanders could schedule training to maintain desired levels of proficiency in critical skills. Further research is needed to determine the consistency with which factors identified in this research could predict retention of other Army tasks. The eventual goal is to develop guidelines for determining tasks that require frequent training and tasks that can be maintained at high proficiency for long periods without practice (Shields, Goldberg, & Dressel, 1979).

Basic Rifle Marksmanship

Following several years of declining scores on marksmanship tests, the average American soldier of 1979 could hit only 55 percent of the personnel targets fired at from ranges of 50 to 300 meters, and only 27 percent of those at 300 meters. The Army effort to examine and improve its marksmanship training program within acceptable costs of time and ammunition has most recently included a thorough analysis by research psychologists on the ARI staff. They participated in basic rifle marksmanship (BRM) training themselves; interviewed Army, Marine, and British experts; tested the M16A1 rifle; designed new targets; and tested more than 12,000 soldiers.

The old BRM program did not give the soldier enough detailed and timely knowledge of shooting performance to benefit skill development. ARI researchers also found that under the old program the committee group and drill sergeant instructors generally lacked knowledge of the basic fundamentals of marksmanship. Instructors had come through a similar thin, noninstructional, nonfeedback marksmanship program themselves, and they were not able to give the new soldiers individual attention when it was needed most.

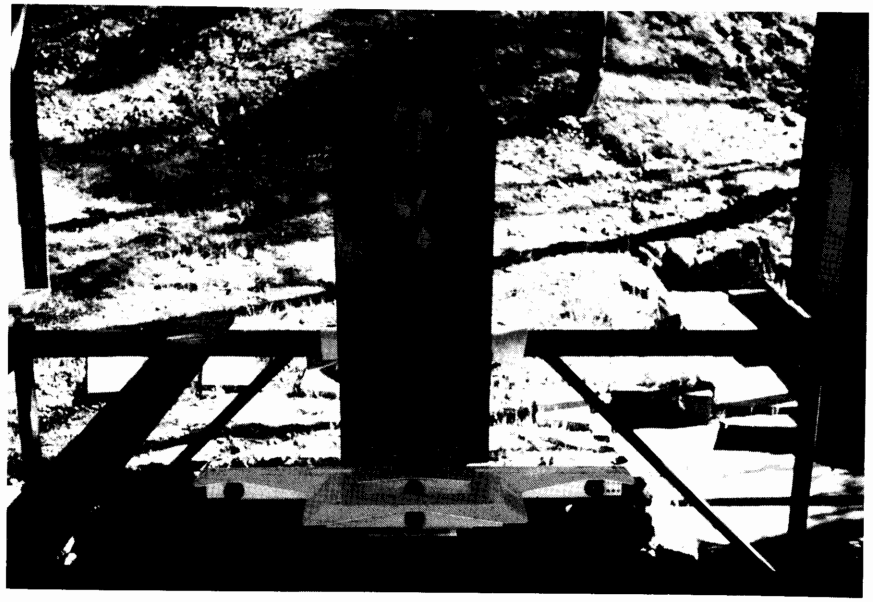
Researchers also found that there were few chances for trainees to practice or to review the material and that too few performance measures were taken to check a soldier's progress or detect problems. Some substantive content was neglected, such as wind and gravity, distance targets, and rifle zeroing, and there was no opportunity to make up missed instruction. ARI developed the new Program of Instruction (POI) by testing 1,151 male and female soldiers. The major features of prototype POIs evaluated included use of the ARI zeroing target, scaled silhouette target transitional exercises, and feedback by walking down range to examine targets. ARI also focused on the four fundamentals of firing, on the various means for diagnosing shooters with problems, on a logical progression for acquiring skills, and on every possible way to provide shooting performance feedback (Smith & Osborne, 1981).

All Army Training Centers now use the new POI, refined and tested on more than 8,000 soldiers who were in their initial entry training with the 1st Infantry Training Brigade at Fort Benning, Georgia. Improved marksmanship throughout the Army is evidenced by a rise in average hits among new recruits at all eight training centers. While an average of 23 hits on 40 targets was standard before the program, the average is now 28, and some centers are reporting closer to 30.

After completing the basic rifle marksmanship training research, the ARI team devoted resources to implementing BRM, as well as improved advanced rifle marksmanship (ARM) and unit training programs. Expected shortly thereafter was a training guide to be released Army-wide to assist unit marksmanship personnel. Several research issues continued to receive emphasis. LOMAH (location of misses and hits) is new technology that permits precise live-fire feedback on both hits and misses. Research on moving target engagement and automatic fire will utilize this equipment breakthrough. There was also promising research to test low-cost, microprocessor-based, part-task trainers such as MACS (multipurpose arcade combat simulator).

Automated Instruction Management System

If a student must wait for equipment, assignments, tests, instructor aid, and even other students, the benefits of progressing through a course at an individual pace are lost. Computer-managed instructional (CMI) systems pro-



LOMAH—Location of Misses and Hits (Fort Benning)

vide the necessary data processing associated with self-paced instruction so that timely information can be made available to instructors and students. In 1975, Army leadership directed that self-paced training be implemented throughout its schools. A feasibility study to determine the most appropriate of three CMI systems selected the Navy's Versatile Training System (VTS) as the best to satisfy training support requirements such as management information (including scheduling assistance, computer-assisted instruction (CAI), aids to authoring/developers, and modest CAI); optimal hardware configurations; maintenance; continued personnel support; and evolution potential. The Automated Instructional Management System (AIMS) is Army's version, designed to provide automated data collection, processing, and retrieval for personnel files, diagnostic testing, training schedules, graduation prediction, and course information.

Melissa Berkowitz and Harold O'Neil developed a plan to evaluate the training and cost effectiveness of the AIMS. They started with an examination of the functional description of the proposed AIMS to identify the hardware and software packages intended for development. Next they formulated evaluation questions to guide the examination of the AIMS hardware/software, training management, courseware, training effectiveness, cost, and organizational factors involved in implementation. They also prepared milestone and staffing requirements and draft data collection instruments.

A reduced version of the evaluation plan was prepared for the AIMS test site at the Field Artillery School, Fort Sill, Oklahoma. This formative evaluation was to provide data for the implementation of system revisions prior to AIMS installation at the remaining training sites. Pre- and post-AIMS analyses were planned to provide information for the design of the next generation of computer-based instructional systems (Berkowitz & O'Neil, 1980).

Combat Vehicle Identification

Success on battlefields of the future will depend in part on the ability of U.S. and allied forces to discriminate quickly and accurately between friendly and hostile vehicles at extended ranges of engagement. New weapons systems have increased engagement ranges to 3,500 meters and beyond, and at these extended ranges many combat vehicles begin to look alike. Moreover, the battlefield of the future in Europe will be an extremely fluid one.

Previous training emphasized cues such as fuel tanks, searchlights, number of road wheels, and other features that may not be clearly visible except at close ranges. Studies of combat arms soldiers in the continental United States (CONUS) showed that they could correctly recognize as friend or enemy only about 50 percent of the vehicles that confronted them.

The Army's new program in Combat Vehicle Identification (CVI) trains soldiers to identify combat vehicles quickly and accurately at realistic combat ranges. A product of ARI's Target Acquisition and Analysis Training System, the CVI program has been adopted as the first standardized, scientifically developed training in long-range recognition and identification.

The CVI program addresses a number of former shortcomings. It provides maximum learning in minimal training time, requires minimal support, trains soldiers to recognize only those cues important for recognition at realistic combat ranges, provides an ongoing measure of training skills, is modular in design and usable in short training periods, permits the simulation of all realistic engagement ranges with all optics (e.g., 3,000 meters for TOW gunners with 13-power optics), and provides for the simultaneous training of platoon-size groups. Most NCOs can participate in the program with little preparation.

The basic program consists of color slides of 30 different NATO and Warsaw Pact vehicles, arranged in groups for modular presentation. Each module projects slides of five vehicles in five different positions on a realistic terrain board for varying periods. Trainees write the friend/foe recognition and vehicle identifying name. Any optics/distance requirement can be simulated by varying distance from the viewing screen. The instructor can select any scaled range from 250 meters to 4,000 meters for common optical powers of U.S. weapons systems, from the unaided eye to 13-power magnification.

The program has not only been adopted by the Army as the basic recognition and identification training program for all soldiers of all MOS, but it is also being used by selected units of the Marine Corps and Air Force. Analyses of performance data indicate that the CVI program results in greater increases in skill than any other program tested.

Several advanced CVI programs have also been developed to provide for recognition and identification of masked vehicles; vehicles partially obscured by vegetation, fog, and smoke; and vehicles viewed through thermal (IR) and night vision devices. A program designed for the artillery school provides a CVI program for the operators of the new Remotely Piloted Vehicle (RPV) System.

A pocket-size packet of CVI picture cards has been developed to supplement classroom training and permit the simulation of various ranges and optics. Other research is concerned with incorporating the entire CVI program into a self-paced instructional format using interactive videodisc technology. Both the picture card packet and the videodisc simulations will provide supplemental material that may be used by individuals on an optional basis.

This is the first time that a unified, comprehensive, and effective CVI program has been made available to all of our armed forces and allies (Smith & Gividen, 1981).

Organizational Process and Combat Readiness

During the late 1970s, research was conducted to examine relationships between performance of critical organizational processes—sensing, communicating information, feedback, decision making, communicating implementation, coping actions, and stability—and combat readiness of command groups as measured by outcomes in battle simulations. The research was conducted also to determine the feasibility of training Organizational Effectiveness Staff

Officers (OESOs) to observe, assess, and provide feedback on the process performance of Table of Organization and Equipment (TOE) unit battle staffs so that improved performance would result.

The ability of an organization to respond flexibly to changes in its operational environment and to maintain effectiveness under pressure from its environment depends on its organizational competence, which comprises reality testing, adaptability, and integration. Organizational competence had been found previously to be strongly correlated with organizational effectiveness as measured by battalion performance (Olmstead, Christensen, & Lackey, 1973).

Data were collected on 12 battalions of the 8th Infantry Division in Europe during 1978 as part of participation in a larger training exercise involving four modules of PEGASUS battle simulations. Following each module, OESOs reported and discussed their observations with battalion commanders who, at their discretion, used the feedback information to adjust procedures, roles, processes, and behavior within their command groups.

A significant correlation of .67 was obtained between overall process performance of command groups and overall combat outcomes across the four modules of the battle simulation. Comparisons between the six battalions with the highest overall process performance scores and the six with the lowest showed superior performance by the "more effective" units on all five of the separate components of combat outcomes.

Because OESOs were able to identify various organizational processes and assess their quality with little difficulty after training, it was determined that it would be feasible to train such officers to assess process performance and give feedback on the results of their assessments to commanders and staffs. Interviews with OESOs and battalion commanders produced a number of "lessons learned" concerning selection, training, and use of OESOs with combat units. The one major requirement for effectiveness seemed to be the ability of the OESO to establish credibility with command groups and battle staffs; this condition is most easily met if the OESO is a combat arms training officer (Olmstead, Elder, & Forsyth, 1978, p. 29). The ease with which the OESOs assimilated the concepts, recommended procedures, and applied them within the context of an operational TOE left little doubt that properly qualified OESOs could be trained to assess process performance and feedback results of such assessments in a meaningful manner(Olmstead, Elder, & Forsyth, 1978, p. 21).

Significant differences were found in process performance among all modules, with progressive improvements following each feedback occurrence. Battalion commanders felt that OESOs contributed significantly to improving the performance of the command groups. Although some battalion commanders had initial reservations about the potential value of process feedback, most commanders rapidly perceived its utility and used the information provided by the OESOs to make on-the-spot adjustments in staff procedures, role relationships, and even leadership styles during the course of the exercises (Olmstead, Elder, & Forsyth, 1978, p. 25).

It was concluded that the quality of command group performance of the original processes included in the research is strongly correlated with unit combat effectiveness, that feedback of process observations by OESOs appears to increase the effectiveness of command groups, that OESOs who are qualified in the combat arms can be easily trained to assess and provide constructive feedback concerning the process performance of command groups and battle staff, and that it is feasible to train command groups and battle staffs to improve their process performance through use of OESOs as consultants and trainers (Olmstead, Elder, & Forsyth, 1978, pp. iv–v).

The research just described provided fundamental information needed to accomplish the second phase, which is concerned with development of a delivery system for training command groups and battle staffs in process performance, and with evaluation of the capability of such training for enhancing combat readiness.

Chapter 8

Research for the Air Land Battle 2000 Era

Emerging technologies and changing military requirements carry strong implications for behavioral science research. Automation to support soldiers in their use of cognitive and perceptual skills will increase in importance in the soldier-system interface. The merging of artificial intelligence (AI) and cognitive psychology is a promising new research area. Because of increased labor costs and declining availability of skills, it is urgent that human factors be considered in the design of developing systems.

ARI's 7-year program to relate preaccession ability measures to actual soldier performance on the job can also serve as a test bed for adaptive testing, goal-programming techniques, validity generalization, and new laboratory-based cognitive processing measures of individual differences. Labor force trends—age structure, working women, compensation and benefits, and skill mix—are important human resource demographics for the Army to consider in attracting and retaining soldiers.

Research can capitalize on new training technology by using a data base on performance measurement, technological innovations to motivate recruits, intelligent terminals with voice recognition and synthesis capabilities, embedded training in new weapons systems, transportable software, and modern microprocessors to enhance flexibility and realism for training combat leaders.

Toward a Distributed Force

By the end of 1982, the U.S. armed forces were considered by experts to be combat ready—an achievement that had not been realized for many years. The volunteer force, once a major worry, was never in better shape. The massive loss of officers and NCOs had stopped; reenlistments were higher than they had been during the previous decade, largely because competitive pay and the depressed economy made military service attractive. The quality of personnel also improved: The number in the lowest acceptable mental category on the ASVAB had plummeted to half its 1980 level, and 86 percent of new recruits were high school graduates, a level higher than that of the general population. Troop training was more extensive and realistic than at any time since the Vietnam conflict. At the Army's new National Training Center, fighting units could test their mettle against Soviet-style forces and tactics in a frighteningly realistic simulation of desert warfare.

The picture, unfortunately, is not entirely rosy for years to come. Readiness costs the military a large part of its total budget, half of which goes to pay people. Manpower requirements will remain high over the next decade, but the supply of eligible recruits will diminish by 22 percent. Increasingly sophisticated systems will require more technically capable personnel at a time when there is a significant decline in science and math skills and when the reading grade level of eligible youths is much too low and threatens to remain so.

In preparing for future wars, DOD guidance gives an edge to the American system because the United States has an inherent advantage in its ability to combine managerial skills and technology to solve difficult problems. Lt. Gen. Paul F. Gorman, speaking about the possible wars ahead, adds (Gorman, 1981, pp. 19-20):

> I believe that it is possible, looking into the future, to conclude that, almost certainly, a technologically advanced combatant in future warfare will be able to see all elements of an opposing force in real time, and will have at his disposal firepower means for reaching out to strike throughout the depth of the opponent's warwaging apparatus from his theater forces all the way back to his strategic reserves. Some naval officers have found it reasonable to say, vis-à-vis naval warfare, that it will be difficult if not impossible to steam around the seas with forces centered on a large-decked carrier, with protective rings of specialized air and submarine defense ships around that carrier. Some air officers have found it possible to say that we will have to find alternatives to the operation of air forces from large fixed airfields, whereon aircraft are processed for high sortie generation rates on something like an assembly line basis. I can assert for land warfare that the day will soon be gone when massed formations of armored vehicles will be able to swarm over the surface of the earth, trailing behind elaborate logistic tails. Instead we are going to have to move toward something like "distributed force," meaning that in order to provide protection we will have to disperse more broadly and thoroughly than ever before, and thus confuse the enemy as to which elements of the target array before them are particularly significant as threat. Our tactical dispositions will have to confront our foe with a large complex of target elements, each of which is potentially able to deliver punishing firepower, and each element of which could be capable of developing the intelligence requisite to the accurate delivery of that firepower.
>
> Now, there are enormous impediments both technological and cultural to achieving such a capability. But I am convinced that that nation who is first able to achieve the desiderata that I have sketched will exert an enormous superiority over potential adversaries, and I suggest that the excerpt of the Defense Guidance that I just read you is quite right: It would be important for the United States, and any other nations of the free world who wish to assist in the competition with the Soviet Union, to bend their efforts to field first-rate weapons, and invent new tactics and techniques for using them.

In asserting that there is an appropriate technological intervention to deal better with the future battlefield, General Gorman refers to a recent DOD report stating that DOD should support high-performance systems at a level that meets peacetime operating and training requirements and that also provides the base for meeting wartime utilization and sustainment rates. The objective, for both the intense combat of wartime and the surge trials of peacetime, is to move actual field availability (Ao) close to intrinsic availability (Ai). Specific support program goals should be established and be given high priority. Training support goals should relate to higher standards based on advanced technology. Job aids should be designed for simultaneous use in training and on the job. Technical documentation will become difficult to maintain by conventional means, and digital communication, storage, and display of changes will be required. The research community, as well as personnel specialists and commanders, should promote acquisition of advanced training technology.

Emerging technologies and changing military requirements will influence behavioral science research in the coming decade. The modern battlefield will depend on computer-based distributed tactical networks for handling of information and decision making. To capitalize on available technology, a better understanding of human information processes is needed. Advances in cognitive psychology and in artificial intelligence point to new possibilities for assessing the abilities and skills of soldiers. Ability assessment should involve the measurement of nonconventional cognitive capabilities, as well as measurement of conventional knowledges and skills through adaptive testing.

New learning strategies that would rely on computerized instruction as a way to expand skills and overcome "natural" limitations must also be developed. Information engineering to ensure better soldier-system integration is another component required for effective use of new systems technology. Soldier-computer task allocation can help prevent human information overload; computer-based job aids (possibly based on artificial intelligence models) can facilitate decision making. Additional research product needs projected for behavioral research for the distributed battlefield include soldiers trained in multiple skills, faster and less costly "generic" training, computer-based "expert" problem solving, and group decision making. The following paragraphs explore these future research areas from the perspective of ARI and DOD scientists who were asked to examine promising topics for military behavioral science research.

Structure and Equip the Force

Neither soldier performance nor systems performance alone are the proper focus of research for distributed tactical networks. The interface of soldiers and equipment as nodes in an integrated network is more appropriate, along with the study of node events interfacing with network events. Research is moving away from the "one person, one console at a time" and "one system at a time" approaches and instead is looking to develop an integrated systems framework that treats soldier-machine elements as functional, interdependent networks. Variables that change the effectiveness of the user-system interface need to be identified. But first, new kinds of task-analytic methods for emergent situations must be developed to capture the semistructured and instructed activities in such networks (Modrick, 1982).

C^3

One critical function that will change radically as distributed tactical networks evolve is command, control, and communication (C^3). Aids must be developed for targeting, mission planning, and structured analytic activities. No longer are such systems being automated using larger, centralized processors and a hierarchical, structured approach encompassing all functions. A continuing problem with these systems is the mass of data that inundates decision makers, who currently have few aids available. Present systems rarely use natural language or user-oriented dialogues, nor are there decision-support techniques within these systems that emphasize cognitive compatibility and "friendly" interfaces. Other required support tools include graphics, means of organizing and presenting information, and development aids for procedural, computational, perceptual, and cognitive tasks.

The use of automation to support operators in their use of cognitive and perceptual skills will increase in importance in the soldier-system interface, as the Smithsonian report predicted 20 years ago (Smithsonian, 1960). The functions involved are those that currently cannot be done well by computer-based data processing techniques. On the other hand, repetitive tasks that require high reaction and search speeds, as well as accuracy, should be automated. The activities that soldiers and computers perform well together are those interdependent components of tasks and functions that cannot be allocated automatically; principles for apportioning activities between users and computers are required. The limiting factor in systems development to date

has been the adequacy of hardware and software for organizing and processing information. However, the increasing transferability and flexibility of software should add capabilities in future years. The extension of automation into the cognitive domain has several research implications, including near-real-time knowledge representation of hierarchically structured data bases and special techniques to encompass tasks that require mixed initiatives and interactive context-dependent dialogues between the user and the computer.

AI

Another broad and promising new area of research involves the merger of artificial intelligence and cognitive psychology. The principal objective of this effort is to develop concepts for smarter systems through automating some human functions. AI is expected to increase productivity, reduce personnel needs, and permit more effective utilization of soldiers. Limitations in software architectures and in specifying psychological behaviors currently impede implementing complex cognitive functions. However, sufficient progress has been made in emulating human perceptual and cognitive processing functions to seek additional advances in the design of more intelligent systems. Research is needed to determine the intelligent functions that can be built into systems; the capabilities that are worthwhile; and the applications that constrain, condition, and determine design requirements. We must also be able to narrow the scope of information processing by selectively filtering data in accordance with an adaptive, goal-directed strategy.

Evolving technology in the development of intelligent terminals and interactive displays will bring about a marked increase in soldier-computer interactions. Pictorial and graphic representation will be transformations of data sensed in the external environment, filtered to remove unwanted information or selectively enhanced. Such displayed environments will consist principally of emergent situations. The user will perform semistructured tasks that emphasize recognizing and diagnosing situations in terms of the action required. Advances in hardware and software have provided capabilities in interactive graphics, dynamic presentation, analytic aids, and symbology. The type of graphics may interact strongly with attributes of the user, such as experience with computers in the subject area concerned. User-friendly interfaces and languages are often proposed for such tasks, but the features of a friendly interface have not been well defined or evaluated. Another key factor in the use of graphics is the extent to which they are compatible with the user's way of thinking. Knowing the user's model of thinking may simplify the process of graphic design in systems. An increase in user-computer interactions can also be expected because of new speech recognition and synthesis techniques that provide ways to reduce visual demands and hand activation of controls. Speech recognition provides faster control input, and speech synthesis permits the user a "heads up" capability. Speech synthesis is currently more advanced; in fact, commercial systems are already available for various military applications.

HARDMAN and MIST

Increased manpower costs and declining availability of skills require a reduction both in the number and skill levels of individuals needed to field military systems properly. Human factors design input in the concept phase of developing systems is therefore even more necessary. Concentrated efforts will be needed to simplify rather than complicate equipment—to use technology to better prepare soldiers to operate and maintain equipment and to better match hardware to the people available. The Navy's Hardware versus Manpower (HARDMAN) and ARI's Manned Integrated Systems Technology (MIST) are both designed to assess the manpower, personnel, and training implications of a new system before it is built. Both use a nearest-equivalent piece of existing hardware to test the ability of personnel with available skills to perform the actions proposed for candidate systems. Both identify where changes can be made to simplify or reduce operator or maintainer skill requirements. This technique has been used on a number of major systems and has been found helpful. More work remains to develop this technique to its full potential.

Man the Force

ARI has developed a program that applies the best techniques known to the behavioral sciences on developing tools and procedures to help decision makers in the Army's personnel system. The system devised for manning the force is broad and complex. Preceding the recruitment process are projection of personnel requirements, identification of requisite personnel resources, and the plan for allocation to meet requirements. Then individual soldiers are recruited, selected, classified, and assigned to training tracks to optimize the fit between requirements and capabilities. Programs for retaining effective soldiers and for providing commissioned and noncommissioned officers are devised to protect the enormous investment in training and experience that an effective soldier represents.

ASVAB vis-à-vis Performance

As mentioned earlier, ARI has initiated a 7-year research program to relate preaccession personnel measurements based upon ASVAB results to actual soldier performance on the job. Such comprehensive research effort is necessary because the current classification system has not been validated against soldier performance for specific MOS with Army-wide applicability. Performance data obtained by tracking soldiers from recruiting through successive tours will be used to develop a longitudinal data base, which in turn will lead to Army models for selecting and allocating soldiers more cost effectively, and may have important implications for criterion-related validity studies in the civilian sector and case law under Title VII of the Civil Rights Act of 1964. An additional applied outcome that can be addressed within the ASVAB validation framework is a more realistic evaluation of the value of adaptive testing and goal programming techniques applied to ability testing and the allocation of jobs. Methodologically, a more comprehensive examination of the appropriateness of validity generalization or transportability can be expected. Also, this program can serve as a vehicle for exploratory efforts that seek to bring the psychology of individual differences closer to classical psychology through convergence with cognitive psychology.

Projecting Manpower Resources

Because the demographics of the civilian population have been changing rapidly, with serious implications for the manpower pool, ARI initiated a study of the situation. The resulting report provided a summary projection of the changing nature of the U.S. labor force during the next 10 to 20 years and included identification of major issues and events that could have an impact on Army manpower. The report was designed as a managment overview to identify issues that need additional research or further analysis to formulate viable policy options (The Futures Group, 1983).

The study provided readily available data on work done recently to forecast labor characteristics. First, a typology of Army manpower issues was constructed to produce a matrix that juxtaposed major labor trends and the most important manpower issues.

Army manpower issues included man-machine mix, career development, separation, skills development, readiness, and family-soldier support. Trends ranged over unemployment, growth, immigration, technology, occupational supply and demand, education and training, standard and nonstandard recruitment age groups, compensation and benefits, households and families, working conditions and attitudes, women in the labor force, migration patterns, and unionization.

Specifically, labor force trends considered in this study included decreases in the numbers of 18- to 21- and of 22- to 34-year-olds; increases in the numbers of blacks and Hispanics; growth in employment benefits as a percentage of total compensation; an increase in participation and retention of women in the labor force; an increase in demand for mathematical and literacy skills and in technical and maintenance jobs, but a decrease in low-skilled jobs; an increase in female-headed households; an increase in participative management and in worker individuality; high unemployment among low-skill and low-literacy workers; population increases in the South and West; an increase in white-collar unionization and more compulsory arbitration in lieu of the right to strike; the growth of white-collar occupations; increased competition for skilled blue-collar workers; and high demands for engineering, computer science, and medical technology specialists. "Wild card" trends examined were prolonged recession and unemployment; a high economic growth rate exceeding 3.5 percent annually; and heavy waves of legal immigration, but stringent limitations on unskilled immigration.

The Changing Age Structure

The most important change anticipated in the labor force over the next two decades will be the age structure shift of the U.S. population. The 18- to 21-year-old group will decline from 12.3 percent of the labor force in 1980 to 9.5 percent in 1990. A decline will also occur among 22- to 34-year-olds, accelerating by 2000. The 35- to 54-year-old group will increase from 35.7 percent of the work force in 1980 to 41.5 percent in 1990 and 51.5 percent in 2000.

Implications for the Army over the next two decades are becoming quite clear: It will be increasingly difficult to recruit 18- to 21-year-olds. Competition from other sectors of the economy may become intense; pay and benefits and training opportunities may require drastic change if qualified candidates are to be available to the Army.

The types of education and training that will be provided in public schools in the near future merit careful study so that Army programs and systems can be designed to be compatible with the skill levels being produced in the educational system. But if the Army recruits from older age groups, it may succeed in enlarging the manpower supply while improving the overall skill levels.

Women in the Labor Force

Women, with or without children and even mothers of children under 6, have become members of the labor force in increasing numbers. By the end of the 1970s, 50 percent of all women had entered the labor force; by 1990, the projected figure is 60 percent. The fact that working women have gained tremendously in social acceptability is only part of the reason for the increase: Divorce is on the upswing, and, consequently, more females have become heads of households. Also, two or more salaries in a household may have become a necessity.

The increasing numbers of women in the labor force cannot be attributed to simple opportunism. Women have begun to view work in terms of "lifetime employment," much as men do now; they compete with men both for compensation and for career advancement. Recruiting women into the Army at the late-1970s rate should help solve the problem of a declining male youth pool.

Because of the anticipated increase of women both in numbers and as a percentage in the labor force, the Army must now determine whether it wishes to rely more and more on women recruits. If women are to be included in greater numbers, will there be barriers placed in their paths to limit training,

placement, and career development? If there are barriers, can it be determined which ones can be most effectively removed at the lowest cost to encourage the participation of women?

Even if women do not form a large segment of the Army force, it may be necessary to design policies and procedures specifically for working women married to soldiers. Such women may pose knotty administrative problems because of the Army's readiness/mobility needs. The male military role may be placed in conflict with women's roles in the civilian labor force and women's expectations of professional careers.

Changing Value of Compensation and Benefits

Compensation and benefits are expected to change radically during the next decade. As a result of the changing age structure and social values, the following are expected to be important shifts: Overall compensation for new entrants into the labor force will increase as their numbers decrease; increased dissatisfaction within the baby-boom generation already at work will result; employers will increase employee benefits as a percentage of compensation to keep pace with inflation and to help solve the growing problems of employee dissatisfaction and lack of motivation. Many employers will offer "cafeteria style" benefits, allowing employees to choose fringe benefits best suited to their current lifestyles and needs.

One of the most likely issues of the next decade will be that of "equal pay for comparable work." Even though current laws require equal pay for equal work, they have not achieved their desired result because the pay scales for traditional female jobs have not increased to compare with traditional male jobs. One argument might suggest that the intrinsic value of the job must be assessed to determine its "true" value in comparison with other jobs, and compensation should be geared toward equal pay for jobs of equal worth. Although it would be difficult to implement, this system could well create a major change in the entire job market.

The Army may find it increasingly difficult to compete effectively with the private sector in the area of compensation and benefits, particularly with new labor force entrants. As the economic health of the country improves, this problem will grow. However, because of wage compression in the baby-boom generation and decreasing opportunity for job advancement, this group of workers will probably experience increased dissatisfaction with current employment. As a result, these workers may be amenable to lateral entry into the military ranks if they could gain a reasonable measure of "psychological compensation."

The Army will need to explore ways to provide "compensation" similar to that offered in the private sector. In addition to monetary considerations, the Army may have an opportunity to provide other compensatory benefits (e.g., specialized training) that will effectively compete with and potentially complement private sector employment.

Because lateral entry may be an important opportunity available for Army recruiting, research should assess, on a skill-level basis, both the disadvantages and opportunities of various lateral-entry programs.

Changing Nature of the Labor Force Skill Mix

The revolution in the communications and computer industries caused by the advent of the microprocessor will have a profound impact on the types of skills required of future workers. Manufacturing and service industries will see rapid advances in automation; low-skilled workers will be displaced. The new jobs created by increased automation will require both literacy and mathematical skills; retraining will thus be difficult for many displaced workers.

The impact of this trend on Army manpower issues is unclear. An increasing number of low-skilled workers may be available for Army recruitment, but actually recruiting them may affect military readiness, since it is expected that the Army systems will also become more dependent on skilled individuals with high literacy and mathematical capabilities.

Research should examine the entire area of technological change and its impact on skill requirements. To determine future manpower requirements, a systematic investigation is needed to determine the interface between skill types and new planned systems, and the degree to which the necessary skills will be available in the labor pool. Alternatively, research should also look at the need to change the new systems to accommodate the expected skill and performance levels of both recruits and current members of the military.

The study concluded that it is important for ARI to establish a long-term monitoring and environmental scanning effort that would track pertinent trends and assess their potential impact on the various Army manpower issues—an "early warning system" for issues and events that are gaining importance. The system would form a framework for analysis of policy options.

The study also called for an in-depth analysis of the following courses of action:

Examine the potential of nontraditional pools of personnel—in particular, the older worker, retirement-bound soldiers, and women.

Design training programs that the private sector recognizes as useful and that also can help fill the Army's need for skilled recruits.

Determine future manpower requirements by undertaking a systematic investigation of the interface between skill types and new planned systems, as well as the availability of necessary skills in the labor pool.

Examine the changing nature of the family as a potential for Army resources.

Project more accurately, as a consequence, both the resource and infrastructural requirements to satisfy emerging family and household needs.

Members of 3d MP Company complete REFWAC questionnaire posttest, involving attitudes toward men and women and leadership as encountered in the Army.

Train the Force

A 1960 Smithsonian study, which described new directions in the technology of human behavior, proved to be a good forecaster of significant trends (Smithsonian, 1960). A new report by the Defense Science Board (DSB) may be even more influential in setting the training research agenda for the 1980s (Defense Science Board, 1982).

The DSB study was initiated in the summer of 1982 by the Under Secretary of Defense for Research and Engineering to assess the importance of training in the operation and maintenance of weapons systems and to recommend actions for improving the effectiveness of military training. Specifically, the study panel was asked to consider how well the services were training, how effectively they evaluated that training, whether they were making adequate use of manpower availability projections in establishing and fulfilling their training requirements, and whether any technologies should be emphasized or introduced to enhance military training. Each of these questions included the requirement to recommend specific actions, identify the responsible agency, and estimate the cost.

The panel consisted of experienced military commanders, industrialists, scientists, and educators. It was cochaired by Admiral Isaac C. Kidd, Jr., USN (Ret.), former Chief of Naval Materiel and former Commander-in-Chief, Atlantic Fleet; and Dr. Walter B. LaBerge, former Principal Deputy Under Secretary of Defense for Research and Engineering.

Defense Science Board

Overall, the panel found that training was good, but not good enough. About $12.8 billion per year was being spent on individual training in schools, with 20 percent of all military personnel involved in the process either as students, instructors, or support staff. But a major disconnect was found between the activities of the "hardware people" and the "people people." Resolving this issue was given the highest priority. The panel suggested that DOD assign authority and responsibility to the "people people" so that human factors contributions could move forward in conjunction with hardware development.

Five major recommendations were identified as high priorities to increase the Army's ability to evaluate and capitalize on new training technology. These recommendations outlined the most critical and implementable steps to improve training and to ensure that weapons systems could be operated and maintained to their full design potential:

> Establish a performance measurement R&D program to develop criteria methodology and equipment for use at all levels of training; set up demonstration projects for new training technology to collect data on performance and cost effectiveness. Training requirements continue to increase in scope and complexity. The traditional approach to training performance measurement is inadequate and fragmented. A systematic program is needed to obtain performance data for the proposed Data Center, to evaluate and support training acquisition and management, and to appraise the potential of new training technology.
>
> Increase exploration and use of current and advanced technology devices (e.g., arcade-like games) to motivate and teach recruits functional skills, including English language and reading skills. New training technologies may be applied to teach basic (language, computation) skills and job performance (functional) skills, while reducing reliance on bulky and ineffective printed matter.
>
> Increase support and funding for research and use of voice recognition and synthesis (including speech storage), interactive display technology, personal microprocessor training aids, and application value of Very High Speed Integrated Circuits (VHIC) to training. These technologies are necessary for a dramatic improvement in the state of the art of military training. Work must be accelerated in these areas to facilitate progress in classroom and unit operational training.
>
> For new weapon and support systems, develop and incorporate embedded training and performance measurement and recording capabilities. Emerging weapon systems with internal microprocessors and computers afford the opportunity for incorporation of embedded training and performance measurement. This capability should be considered early in system development and coordinated with the overall training program for the weapon systems.
>
> Direct future acquisitions of training equipment to use transportable software and to be "user friendly" in meeting instructions. System of computer-specific software complicates operations and training and increases costs. More generalized software designed for the nontechnical (i.e., noncomputer-trained) operator and maintainer will increase operational capability, reduce training scope and complexity, and reduce training costs.

Several other points made by the DSB panel are worthy of note. Microprocessor-based, interactive videodisc systems have revolutionized the instructional industry. Software, including courseware development, is the dominant cost factor for computer-based instructional systems. Advanced software techniques promise gains in software/courseware production efficiency, but they have not yet been applied. Weapons systems based on digital technology can be used to provide more effective training and performance measurement with little additional cost. Satellite communications provide the capacity for remote training, maintenance, updating of technical manuals, and maintenance teleconferencing.

Significant improvements can be expected from the proper application of training technology. In World War II, after 6 months in battle, most units were fighting at an equipment and personnel performance level of roughly 85 percent. Currently, DSB rates our military machine at 40 percent on the same scale. The proper application of training technology, in addition to promised research, can raise that level to 70 percent—in peacetime.

The key to gaining wide support for training technology is to prove, through hard data, how well new training methods work and where they work best; cost-benefits and trade-offs should be demonstrated.

Individual basic skill training has already benefited from some areas of training technology. This technology will be equally applicable for teaching advanced skills. Retraining will be uniform and consistent. The ability to couple computer-based devices with digital communications and picture outputs will provide the possibility of improved initial and refresher training devices, including picture outputs, and should be exploited as quickly as possible.

Simulating Wartime Actions

Many wartime actions are too dangerous for peacetime practice; many cannot be duplicated at all. Simulation offers the potential to explore, define, and, to a degree, experience that which prudence prevents actually practicing. Current training focuses on technical skills; the emphasis should shift to tactical skills. Team performance and training should emerge as a major focus of interest and supplement traditional orientation to individual processes and activities.

Technological efforts to develop training devices and simulation techniques consume the largest portion of behavioral science research funds. Objectives in this area are to reduce initial and life-cycle costs of maintenance and operational trainers through reduced dependence on expensive equipment. This rapidly advancing technology also allows for training at various times and places, with increased safety and more accurate results, as with air-to-air combat simulators and laser engagement simulations. Future research will emphasize more effective team readiness training by simulating the weapons system and its operational environment.

DOD budgets for the services' behavioral science program over the last several years already reflect the DSB panel's emphasis on training technology and training applications.

Develop Units

Unit Rotation and Replacement

Top Army leaders are emulating the British regimental system of unit rotation and replacement as one means of directly ensuring social cohesion and solidarity. Plans, which recognize the more complex environment and size of U.S. forces overseas, are currently under way to implement a version of the British system. Still, many field commanders have strong reservations about this planned change. These commanders are concerned that distributing inexperienced soldiers throughout existing units will reduce operational readiness across the board; that a unit rotation system is unproven in the U.S. Army, while the present replacement system does work (albeit inefficiently); and that the proposed system may limit the flexibility of field commanders.

Janowitz argues that the failure of repeated efforts to alter U.S. personnel replacement and rotation systems exemplifies the inability of large-scale organizations to learn from past failures (Janowitz, 1982, pp. 514-515):

> In order to understand the U.S. military's inability to deal with replacement and rotation problems, one must study generals—their patterns of rotation and their professional perspectives—not just low-ranking enlisted personnel.
>
> If primary group cohesion and unit solidarity are important elements in combat effectiveness, more research attention should have been paid to factors that fashion such cohesion and solidarity. This was not the case, despite continual assertions that the system of personnel replacement and rotation should be closely examined. Specifically, repeated claims were made that stronger cohesion and solidarity would result if the U.S. pattern of individual replacement was altered to group or unit replacement. Even more frequent was the suggestion that there should be a general decrease in the frequency of rotation, to improve cohesion and solidarity. Despite the recognized importance of primary group cohesion and unit solidarity, there is a deficit of micro or macro research on factors that strengthen these two elements of military organization....
>
> This topic lends itself to experimental social psychological research at the micro level. Therefore, one might assume that it would be well developed. In fact, an awareness of the archaic character of U.S. rotation and replacement systems, especially in ground combat forces of the Army and Marines, led to repeated efforts to "break out" of existing patterns. The constant disruption of small units resulted in pressure for change from battalion and regimental commanders. Higher level commanders, isolated from the day-to-day tensions, seem less concerned. Under the current Chief of Staff, E. C. Meyer, new efforts are being made to solve these problems. According to numerous military experts, contemporary efforts of General Meyer are realistic and feasible but have a high probability of failure or abandonment by the next Chief of Staff. The commitment of the present Chief of Staff makes this initiative one of great importance. But the absence of sufficient and effective research both on past failures and on the new efforts has contributed to these difficulties.

Getting the Best Leaders

A leader development system needs to be designed to produce leaders who can build cohesive, disciplined, high-performing units. The changing demands of leadership roles that occur because of technological advances and changes in doctrine, which in turn are necessitated by a rapidly changing geopolitical climate, require a responsive leadership to accomplish the decision-making requirements of the future. While much good work is under way using conventional methods, the use of microprocessors, videodiscs, interactive displays, and telecommunications can significantly enhance flexibility and realism in simulation for leader training.

Time is a crucial resource; modern technology, coupled with current methods, promises better use of precious training time. Development and implementation of campaign, battle, and engagement simulations designed expressly for combat leader training are much needed, along with simulators and associated courseware. These simulators need not be complex or expensive. For example, in a microcomputer-based, tactical action commander's game in antisubmarine warfare, an individual or a command team plays against the machine, which provides not only a tactically realistic opponent but also data on the physical environment and on the execution of the player's decisions. The end-to-end development cost is small, and development time is well under a year.

Although microcomputer games are proven training tools, simple paper simulation might be equally effective. Using paper displays, a game may simulate a commander's decision and display environment and carry the commander through a sequence of operational events and decisions to ensure a complete understanding of threat characteristics, system capabilities, command organization, and rules of engagement. Development time is a few weeks, and development cost is low. Every user can have a copy for pennies.

Unit-level training is perhaps the most vital kind of leadership training. Investments should be made now in implementing on-the-shelf technology to enhance ongoing training efforts. Many scientists are convinced that great possibilities exist for enhancements in the future. New methods and devices will be needed. Trainers have witnessed a fascinating parade of initial attempts at battle and field engagement simulation, training modules built into operational equipment, and, of course, computer-aided instruction for a wide variety of course subjects and topics. Such efforts should be organized, integrated, and intensified. In the Tactical Fire Direction System (TACFIRE), ARI embedded in the crew-station console an automated capability for skill-qualification testing. Such capabilities should be extended to existing and new systems. Portable microelectronics can make training packages "exportable" to teams in the field. Ideally, packages would not need to rely on specifically trained instructors or special equipment. To produce such packages, a greater understanding of performance measurement, evaluations, and training strategies would be required. Effective design also requires a better means of characterizing users and their needs. In conjunction with these developments, emphasis should be given to developing an integrated system for the feedback of performance data from operational units as a basis for upgrading training programs.

The future battlefield may require soldiers or small groups to work away from supporting organizations for extended periods. At the same time, these solitary individuals or units need to remain vigilant under difficult conditions. Such situations call for a much better psychological understanding of sustained performance, work and rest cycles, and the impact of automation on vigilance behavior.

Maintain Force Readiness

ARI has only recently launched its program in this domain. Research focuses on improving the ability of units in the field to manage personnel readiness, maintain proficiency, and use weapons. Because the domain is so new and the current program is already so ambitious, new directions for research are not offered here. But in none of the other four domains is there a greater need for multidisciplinary research skills, nor is there a better example of issues framed in a total systems context. The methods and techniques being developed in this domain will represent a new class of tools of great promise for the behavioral sciences and for practical applications.

Current objectives of research efforts in this domain are as follows:

Identify and define the dimensions of organizational readiness and influencing factors and determine the behavioral, organizational, management, and system requirements needed to achieve and maintain it.

Develop prototype portable electronic job-aiding devices for application to organizational-level maintenance, and develop an authoring system (capable of electronically generating, updating, and distributing technical documentation) for maintenance information.
Develop and validate exportable training and training evaluation materials for use by helicopter units in field (noninstitutional) settings.
Develop an executive-level training information model to support decisions about training programs and policies.

Develop an integrated interface between users/gamers and computerized land-combat models to facilitate the application of advanced techniques to studies and analysis, research, and training.

Develop a multipurpose set of human models that can be quickly linked to Army test and evaluation systems to permit low-cost estimation of the impacts of human factors on system performance.

Identify the proficiencies combat helicopter aircrews need to perform assigned missions with changing systems and equipment.

Devise techniques to help rated aviators, both in the active Army and in the Reserve, enhance and maintain their combat readiness and develop methods for assessing this readiness.

Top Priority Programs

It seems fitting to close this futures section with a description of five programmatic areas designated by ARI leaders as having highest priority for initiation or expansion.

Embedded Training and Evaluation

Modern technology is lighting the way to the development of new weapons systems that will expand leaders' capability to control the distributed battlefield. To keep pace with these emerging systems, operators and maintainers must be trained to use systems effectively as they arrive in units; skills must be maintained at a high level of proficiency; and cross training must be readily available for the distributed battlefield, where units must be fully prepared to fight independently. Electronic technology can also provide more efficient, system-specific "embedded training" as an integral part of the new system itself. Such technology could also be retrofitted into existing systems. During operations, this capability could serve as a job aid to ensure that complex behaviors are carried out properly.

Measurement of Unit Effectiveness and Cohesion

This area of research, which embraces all aspects of human behavior in a military setting—selection and classification, training, total system performance—is a fundamental concern of *all* research performed by ARI. Because objective measurement of individual and collective performance is the quintessential dependent variable against which experimental alternatives are measured, this program must be broadly based, address technology-aided techniques for objectively assessing improved individual competence, measure crew performance and its contribution to total system effectiveness, and measure more precisely than ever the tactical performance of cohesive units on the battlefield of the future.

Very Friendly Soldier - Computer Interface

The application of computers within the Army is accelerating, just as it has in the civilian sector with the use of specialized data processing systems, management information systems, special microsystems, and chip technology applications to clocks, vehicle ignitions, food processors, and so on. Soon, virtually all Army equipment will be computer based. Guidelines are necessary for integrating the soldier into computer-based systems, and principles and methods for designing systems that include "user friendly" interfaces (i.e., soldier-computer interfaces designed on the basis of a soldier's capabilities) are also required. The accelerated development and application of artificial intelligence techniques will permit significant advances in this area.

Human Performance and Logistics

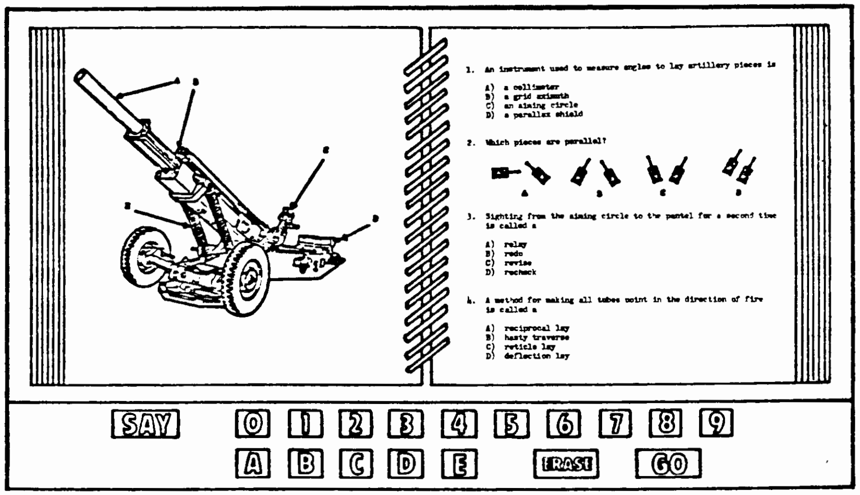
One of the pervasive problems of fielding a modern force using new and available technology is the logistics tail associated with advanced systems. The emphasis is typically on application of technology to the development of new systems, with improved hardware as the goal. Logistics has received secondary emphasis at best. The Army's ambitious plans to field 500 new or improved electronic systems and weapons over the next 10 years could generate a logistical logjam, clogging pipelines from Europe to depots, unless this issue is addressed directly. A people-oriented, total human performance logistics system directed toward "fix forward" maintenance in the field would address, at a minimum, improved diagnostic techniques, advanced maintenance concepts, logistic analyses for weapon systems in a wartime scenario, techniques of logistics management, and automated methods for development and delivery of Tables of Organization/Materiel and Skill Performance Aids (SPAs).

Application of Microelectronics to Leader Development

Secretary of the Army John O. Marsh, upon assuming his position in 1981, stated: "We need leaders who are grounded in the principles of command, yet who are responsive to new ideas; who have not only the flexibility to cope with and direct change, but the audacity to take the measured risk in order to gain victory on the battlefield."

Army leaders at all levels need to enhance and maintain wartime skills during peacetime, particularly as new technology is introduced for the future battlefield. Command post exercises (CPX) and field training exercises (FTX)—the methods typically used for providing such training—are both personnel intensive, require significant amounts of time, and have no utility for training on new systems, organizations, or doctrine before they are fielded. Modern information technology, especially the personal computer, can be used to develop a wide range of leader training techniques, including individualized training for the combat arms NCO on squad/platoon tactics, one- and two-sided battle simulations for the field grade leader, and personalized training for senior leaders to keep them abreast of the changes directed toward the Air Land Battle 2000.

To improve the combat performance of leaders, ARI is developing techniques to assist in: sensing information about the outside and inside environments; communicating information to the right decision makers; decision making; stabilizing (anticipating internal complications resulting from decisions); communicating decisions and orders to those who implement them; implementing decisions and orders; and evaluating feedback.



Display from the ***Hand-held Vocabulary Tutor,*** *a user-friendly portable device that supplements classroom instruction. The trainee reads the booklet and observes its pictures. The Tutor asks the trainee to identify the objects and to enter the correct answer on the keyboard. The Tutor provides both aural and visual feedback, speaking and displaying the correct answers, repeating vocabulary words on request, and allowing the trainee to hear the correct pronunciation.*

In addition, improved leadership competencies of NCOs, warrant officers, and officers will be developed in the areas of professional ethics, soldier-team development, communication, counseling, supervision, planning, decision making, and management technology. Use will be made of formal training, unit training and practice, and self-development/self-evaluation exercises.

Chapter 9

Program Organization and Management of ARI

In recent years, ARI has made several important changes in program management to improve its relationship with the Army's top leaders. To increase its productivity and to help win the endorsement of Army leadership, ARI's programs need Army-wide proponents to ensure that the research can be generalized. Such proponency helps establish delivery systems. Furthermore, programming will be more consistent with research priorities established by the Army leadership at a high level. Equal to wide proponency in importance is adopting a total systems perspective in the conduct of research, including consideration of the impact of policies and incentives. Without such an outlook, research results may be difficult to apply to real problems, and scientific "stovepiping" results. Finally, ARI research must be linked to long-range Army plans.

Relationships between Army Leadership and ARI

Nothing is more important to the Institute's well-being than the informed approval by Army leaders of the goals, objectives, products, and implementation strategies of ARI's research program. Since 1978, ARI has initiated several important changes in program management designed to improve the process of obtaining such approval. One change is to base program development on long-range planning. A second is to structure efforts around five user-oriented programs. A third is to increase involvement of Army leadership to provide direction and coherence in related research activities. As a result of these changes, ARI programs now respond more directly to Army priorities and needs and are more easily communicated to users.*

*ARI is particularly indebted to its last three commanders—Col. William L. Hauser, Col. Franklin A. Hart, and Col. L. Neale Cosby—for their efforts in fostering better relationships with Army leaders. Appendix R reviews the work of these and other commanders and military leaders who have advanced soldier-oriented research through the years.

In the past, programs at ARI were developed based on requests from units in the field. This process produced well-defined problems and is still one source of suggested topics for research. Taken together, however, such grassroots problems often failed to reflect or to consider fully major Army-wide problems and priorities. Because ARI products affect every mission having human performance as a component, developing programs and setting priorities are more suitably carried out from the perspective of the entire Army. A "top down" orientation directly influences the program development process at ARI, based upon the substantial guidance provided by leadership of the Army staff, major Army commands, the Secretary of the Army, and the Chief of Staff. Mission Area Analyses guide ARI technology-based research into priority problem areas.

A major issue to be resolved in keeping ongoing research congruent with Army needs is centralization versus decentralization. Resolution will come through aligning program efforts in such a way that specific research thrusts are pursued by the ARI field unit or technical area with the best resources. The recent organization of a "three-laboratory ARI" has helped create an integrated research plan, with all research requirements falling under one of three planning mission areas—manning, systems, or training. ARI now has a greatly enhanced ability to plan and execute research by permitting each laboratory to focus on a functional part of the total program and to differentiate long-term, mid-term, and short-term planning perspectives. These three laboratories can better respond to mission area deficiencies, technological transfer needs, and Army research requirements in general.

The top-down orientation is most readily implemented through managerial conferences that review and evaluate ARI programs. These reviews, chaired by either the Deputy Chief of Staff for Personnel (DCSPER) or the Assistant Deputy Chief of Staff for Personnel (ADCSPER), address the entire ARI program. Each review is attended by general officers or senior civilians from most parts of the Army staff and two elements of the Army secretariat. Additionally, ARI holds senior-user reviews on its major programs. In each of these reviews, senior officers and civilians representing the principal users discuss the overall scope, priorities, and thrust of a specific program area. Reviews provide valuable feedback to ARI, ensure that the Army's leadership is fully aware of the program area discussed, and increase the likelihood of research utilization.

Resolution of two critical interrelated issues is bound to have a favorable impact on Army research programs—major modernization of the programs and more effective research product utilization. First, the Chief of Staff's call for long-range plans for the Air Land Battle 2000 as a means of driving the activities of Army laboratories means that researchers should deal directly with Army proponents rather than with users. Satisfying Army proponents means that research can be generalized, that its products can count on established delivery systems (complete with formal letters of agreement), and that its priorities have been determined by Army leadership at a high level. But to improve chances for success, research must be linked to the long-range plans of the Army and its major components.

Second, after decades of dealing with isolated and fragmented problems, researchers in people-related areas are finding that the problems given to and accepted by researchers must be approached as total system problems, heeding the incentives or impact of policies on performance. In turn, Army leadership must be urged to avoid narrow problem definition, particularly problems that focus on the individual alone; in other words, the Army must define its people-oriented research requirements within soldier/weapon system/unit configurations. The penalty for not broadening problem scope is scientific stovepiping and loss of opportunity for major system optimization.

Role of Proponents

What is a proponent, and what is the proper role of a proponent in people research? The proponent of a particular research effort is a Department of the Army or a Training and Doctrine Command figure who requests research to solve a problem of general importance and Army-wide scope. The proponent must be in a position to implement and maintain a research product and work with the laboratory, first to ensure proper definition of the problem and then to monitor execution of the research.

Currently, it would appear that almost every uniformed or civilian person in the Army has the opportunity to be a people-oriented research proponent (or has the license to offer himself or herself as such) whether or not the projected product can be foreseeably employed beyond his or her tour of duty. The emphasis, then, tends to satisfy an individual's needs rather than the organization's need.

But, in fact, research undertaken by ARI and by the Human Engineering Laboratories (HEL) is the analog to the hardware research done by other laboratories in the Development and Readiness Command (DARCOM). Much as TRADOC acts as the proponent for the system user in the user's dealings with DARCOM on hardware systems, several major proponents represent users in working with people-oriented research laboratories: DCSPER, the Deputy Chief of Staff for Operations (DCSOPS), TRADOC, and DARCOM, depending on whether the research issue is manpower and personnel, combat developments, training, or system development, respectively. The need to deal directly with a major proponent rather than a user is clear when one considers cost effectiveness, delivery systems, and priorities.

For research to be cost effective over time, it must deal with a concept that can be generalized—one that fits many situations or systems rather than narrow or one-time needs. For research products to be placed into operation and maintained, they need an established Army-wide delivery system, which field commanders are rarely in a position to bring about. For research programs to be responsive, priorities must be established, since there are always more research needs than resources. Army leadership is in the best position to determine program priorities, and to sustain interest in them, since some programs will not come to fruition for several years.

Access to research laboratories, accordingly, must be restricted to the major proponents; in turn, the major proponents are responsible for establishing the research agenda, monitoring progress, and developing transfer of technology mechanisms. Institutionalization of research would terminate Army-wide canvasses that in the past have established the "contractual" basis for conducting research, often directly for one user on a specific problem. Furthermore, it should help ensure the development of systematic and programmatic rather than ad hoc research.

How does the Army facilitate effective dialogue between a proponent and a laboratory? The key is effective long-range planning. Research, if successful, makes future events happen sooner and more efficiently. A successful people-oriented research program demands that its long-range plans be linked directly to long-range plans of the Army and its major commands. These plans need careful review by proponents to ensure agreement about objectives. Recently, senior review groups comprising general officers who have proponency for an area (such as training) have been established to examine the needs and priorities within a research program. The successful culmination of this process requires a long-range plan on which proponent and laboratory concur.

Linking Proponents and Laboratories: Letters of Agreement

A more arduous and critical task is that of obtaining formal written agreements for milestones and products. Letters of agreement are up-front understandings, providing a clear road map of activities for the laboratory. Accordingly, proper research proponents, who can utilize research information and institutionalize resulting products or policies, must be linked to the laboratories through long-range plans and formal review mechanisms for applied research efforts. The likelihood of achieving desirable products would be increased, and research organizations would acquire programmatic stability, which enhances the motivation of individual scientists and can be an important factor in creating an atmosphere of technological innovation, rather than one of selling and coordinating. An important concomitant of programmatic stability is a reduced tendency for action officers to use scientists to conduct their daily actions and staff studies.

Total-Systems Problems, Multidisciplinary Solutions

Historically, the Army's people-oriented research laboratories have been tasked principally with problems stemming from manning the force, training, and human engineering requirements. The broader use of these laboratories is now called for—not only to examine the attributes of the soldier's performance, but to place the soldier in the broader systems context, including policies and incentives. Army goals drive the current eight functional areas, which in turn define the Army plan. Neither the goals nor the functional areas can be worked on independently; it is their interaction that can lead to the best expression of a total Army system concept. That system concept must be in place before the laboratories can suggest the technologies needed for improvement. The problems accepted by researchers should be total-system problems or should be considered with the total system in mind.

Through the years, it has also become clear that people-oriented research should not be performed exclusively by behavioral and social scientists. The expertise of economists, demographers, engineers, systems analysts, operations researchers, computer scientists, and others is frequently needed. Today, most researchers realize the desirability of a diversified, multidisciplinary approach. To implement such a diversified approach, leadership must remove archaic scientific barriers that separate organizations and missions.

Interservice Cooperation

Another significant management issue, although not directly related to the issue just discussed, concerns the trend toward interservice cooperation in research. Both Congress and DOD support efforts to ensure the coordination and, where possible, the integration of service-wide people-oriented research programs to increase effectiveness and reduce overlap. During the past several years, commanders and technical directors of the three major laboratories (ARI, the Naval Personnel Research and Development Center, and the Air Force Human Resources Laboratory) developed their own shared-effort work relationship. Recently, the Office of the Under Secretary of Defense for Research and Engineering (OUSDRE) officially lent encouragement to this development by making new seed money available for cooperative across-service engineering development programs. Individual service control would not be relinquished. Many research problems are naturally amenable to joint activities (e.g., training delivery systems, microelectronic applications for maintenance, and ASVAB systems using adaptive testing). ARI's leadership should continue to encourage jointly conducted, people-oriented research programs wherever possible.

Recommendations

The potential for bringing about significant improvements in the Army through people-oriented research is currently very high, but it could be significantly enhanced if Army leaders and ARI are successful in pursuing the following recommendations:

> Limit research requirements for soldier-oriented research to Army proponents to ensure institutionalization of research and research products.
>
> Link long-range research planning directly to long-range plans of the Army and its major commands, and subject such planning to formal review mechanisms.

Establish letters of agreement for research programs, milestones, and performance.

Involve the Army's research organizations in broad-context, total-system problems.

Encourage and facilitate a multidisciplinary approach to people-oriented research.

Create a total-systems R&D capability tightly tied to manpower, personnel, training, and design problems.

Encourage continuation of cooperative interservice research efforts.

Concluding Remarks

From Measurement to Manned Systems: Focus on the Soldier

In this book we have attempted to trace the development of the behavioral sciences in the Army with special focus on the history of ARI, the Army's major soldier-related research organization. A natural context for understanding the key issues for each designated chronological period were the research issues of the day within academia and industry, as well as within the military services. The practical benefits we sought from this process were better understanding of ARI values and traditions as derived from past programs to guide future ARI developments.

Our history began with an account of mental testing of troops during World War I, particularly the successes and ordeals encountered by Robert M. Yerkes in his dealings with the Army from 1917 to 1919. The ready acceptance of psychological testing during World War II, as well as the broader acceptance of tests during the 1920s and 1930s in industry and academia, could be directly attributed to the work of Yerkes and his psychologists. The supposed hereditary implications of Army Alpha and Beta test results were allowed to influence social policy and federal legislation on immigration in the 1920s. These interpretations were gradually revised by Army psychologists and completely repudiated by World War II.

The Army was able to begin a coordinated program of research well before America's entry into World War II because Army leaders now understood something of the value of testing programs. Scientific leaders succeeded in placing the newly formed Personnel Research Section under the general staff support of personnel managers rather than in the Surgeon General's Office, as in the first war, where these psychological activities had struggled unduly for support and recognition. Before the end of World War II, the Army General Classification Test, a general measure of developed abilities, had been used to classify more than 9 million soldiers. The aggregated success of World War II psychological research in such diverse areas as selection and classification, training, leader development, attitude and value measurement, and diagnosis and treatment of emotional problems stimulated a demand for the same psychological services in the civilian workplace. The World War II experience truly signaled the coming of age for psychology.

After World War II, Army leadership was beginning to understand the new possibilities in the behavioral sciences. A demand arose for strengthening and expanding programs of behavioral research in such areas as training and human engineering. New research organizations were established to deal with these areas while ARI initiated its first comprehensive attempt to broaden its own programmatic objectives by setting the stage for a systems approach to military research. ARI also learned that a broadening of objectives meant a different mix of scientific skills. Concurrently, it began a new type of partnership with the military to develop coherent research programs geared to the ultimate transfer of research findings into operational use. As ARI entered the 1960s, it recognized that its mission had to be more compatible with the changing Army, changing technology, and changing expectations of soldiers at work.

The expanded behavioral science prospectus that emerged in the early 1960s had run its course by the 1970s—the period of Vietnam. Behavioral scientists accepted and helped develop new research thrusts: systems development and utilization, stability operations or civil-military relations, and social issues. While Army leadership initiated a number of social reforms in response to societal changes and lessons learned in Vietnam, research programs were implemented to deal with leadership concept, race relations, and morale and motivation. New methods of selection, assignment, and training to make better use of recruits accepted on the basis of lower mental standards were devised and evaluated.

We called ARI research of the 1970s "information engineering" to highlight the critical role of computer-based aids for enhancing information processing and decision making in operations for the Air Land Battle 2000. Since 1979, ARI's research program has been structured into a taxonomy of five programmatic domains oriented in operational terminology to improve sponsor and user understanding of the research—Structure and Equip the Force, Man the Force, Train the Force, Develop the Force, and Maintain Force Readiness. Also, since 1978, ARI has initiated two important changes in program management to improve the process of obtaining approval to top Army leaders: basing program development on long-range planning, and involving Army leadership in proving direction and coherence in research activities. To improve productivity further and to help win the endorsement of the Army leadership, a number of additional changes appear important: orienting programs around Army-wide proponencies to ensure that the research can be generalized; conducting research from a total systems perspective, including consideration of policies and incentives; and linking research to long-range Army plans.

ARI's heritage of personnel measurement, although possibly outgrown as early as the late 1950s, was never rejected. Leaders of ARI began to recognize that it had to employ a multidisciplinary mix of skills if it was to address

the changing needs of the Army and to harvest the research benefits that changing technology promised. Such broadening of mission eventually met with greater acceptance by military sponsors. ARI's leadership also recognized that not only would the aid of Army proponents be required to ensure the transfer of technology into operation but a genuine partnership between the scientist and the proponent was now mandatory if success and survival were to be ensured. Such a partnership would depend, on the one hand, on support of basic research and exploratory development by the proponent, even when application was projected into the next generation, and on recognition by the scientist that the goal of supported research within the military was to bring about cost-effective change within the Army. To ensure success of this partnership, ARI directs its programmatic thrusts to manned systems, or the soldier in the loop.

There is no more worthy focus of attention.

Glossary

AAF	Army Air Force
ACB	Army Classification Battery
ACTS	Adaptive Computerized Training System
ADCSPER	Assistant Deputy Chief of Staff for Personnel
ADP	Automatic Data Processing
ADSAF	Automatic Data Systems within the Army in the Field
AFHRL	Air Force Human Resources Laboratory
AFQT	Armed Forces Qualification Test
AFWAB – 2	Army Fixed-Wing Aptitude Battery
AFWST	Armed Forces Women's Selection Test
AGCT	Army General Classification Test
AGO	Adjutant General's Office
AI	Artificial Intelligence
Ai	Intrinsic Availability
AIMS	Automated Instructional Management System
AIS	Advanced Instructional System
AIT	Advanced Individual Training
ALAT	Army Language Aptitude Test
ANST	Army Night Seeing Tester
Ao	Actual Field Availability
APA	American Psychological Association
AQB	Army Qualification Battery
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARM	Advanced Rifle Marksmanship
ARPA	Advanced Research Projects Agency
ARTBASS	Army Training Battle Simulation System
ARTEP	Army Training and Evaluation Program
ASARC	Army Systems Acquisition Review Council
ASTP	Army Specialized Training Program
ASVAB	Armed Services Vocational Aptitude Battery
ATLD	Advanced Technology Light Division
AWO	Aviation Warrant Officer
BIB	Biographical Information Blank
BRM	Basic Rifle Marksmanship
BSEP	Basic Skills Education Program

C^3	Command, Control, and Communication
C^3I	Command, Control, Communication, and Intelligence
CAI	Computer-Assisted Instruction
CATB	Combat Arms Training Board
CBI	Computer-Based Instruction
CCC	Civilian Conservation Corps
CDCEC	Combat Development Command Experimentation Center
CIG	Computer Image Generation
CMI	Computer-Managed Instruction
COMBATTS	Computer-Operated and -Managed Battlefield Tactical Training System
COMPASS	Computer-Assisted Assignment of Recruits
CONARC	Continental Army Command
CONUS	Continental United States
CPX	Command Post Exercise
CVI	Combat Vehicle Identification
DA	Department of Army
DARCOM	Development and Readiness Command
DCSOPS	Deputy Chief of Staff for Operations
DCSPER	Deputy Chief of Staff for Personnel
DEROS	Date Expected to Return from Overseas
DOB	Differential Officer Battery
DOD	Department of Defense
DSARC	Defense Systems Acquisition Review Council
DSB	Defense Science Board
DTIC	Defense Technical Information Center
ECFA	Examen Calificacion de Fuerzas Armadas
EEMT	Enhanced Electronics Maintenance Trainer
EFB	English Fluency Battery
EM	Enlisted Men
EPMS	Enlisted Personnel Management System
ER	English Reading Test
ERT	Educational Requirements Test
ESD	Enemy Situation Data
EST	Enlistment Screening Test
FAST	Flight Aptitude Selection Test Battery
FCRC	Federal Contract Research Center
FEBA	Forward Edge of Battle Area
FORSCOM	Forces Command
FPT	Field Problems Test

FTX	Field Training Exercise
GST	General Screening Test
HARDMAN	Hardware versus Manpower
HEL	Human Engineering Laboratory
HELBAT	Human Engineering Laboratory Battery Artillery Test
HFE	Human Factors Engineering
HRTES	Human Resources Test and Evaluation System
HTTB	High Technology Test Bed
HumRRO	Human Resources Research Office
IET	Initial Entry Training
ILIR	In-House Laboratory Independent Research
IQ	Intelligence Quotient
IR	Infrared
JOIN	Joint Optical Information Network
LCSMM	Life-Cycle System Management Mode
LOMAH	Location of Misses and Hits
LPR	Leadership Potential Rating
MAAG	Military Assistance Advisory Group
MACOMS	Major Commands
MACS	Multipurpose Arcade Combat Simulator
MAT	Mechanical Aptitude Test
MDB – I	Motor Vehicle Driver Selection Battery I
MDB – II	Motor Vehicle Driver Selection Battery II
MILES	Multiple Integrated Laser Engagement System
MILPERCEN	Military Personnel Center
MIS	Management Information System
MIST	Manned Integrated Systems Technology
MMPI	Minnesota Multiphasic Personality Inventory
MOS	Military Occupational Specialty/Specialties
MPS	Maintenance Performance System
MPT	Manpower, Personnel, and Training
NATO	North Atlantic Treaty Organization
NCO	Noncommissioned Officer
NOE	Nap of the Earth
NPRDC	Naval Personnel Research and Development Center
NRC	National Research Council
NTC	National Training Center

NYA	National Youth Administration
OCRD	Office of the Chief of Research and Development
OCS	Officer Candidate School
OCT	Officer Candidate Test
ODCSPER	Office of the Deputy Chief of Staff for Personnel
OE	Organizational Effectiveness
OEC	Officer Evaluation Center
OESO	Organizational Effectiveness Staff Officer
OLB	Officer Leadership Board Interview
OLI	Officer Leadership Qualification Inventory
OPFOR	Opposing Forces
OR	Operations Research
OSS	Office of Strategic Services
OUSDRE	Office of the Under Secretary of Defense for Research and Engineering
PATRIOT	Phased Array Tracking to Intercept of Target
PATS	Personnel Awaiting Training Systems
PEAM	Personal Electronic Aid for Maintenance
PLATO	Programmed Logic for Automatic Teaching Operations
POI	Program of Instruction
PPBS	Program, Plans, and Budgeting System
PRS	Personnel Research Section
REALTRAIN	REAListic TRAINing
ROTC	Reserve Officer Training Corps
RPV	Remotely Piloted Vehicle
RQ	ROTC Qualifying Examination
SCOPES	Squad Combat Operational Exercise Simulation
SGO	Surgeon General's Office
SIMPO	Simulation Model of Personnel Operations
SIV	Gordon Survey of Interpersonal Values
SORO	Special Operations Research Office
SPA	Skill Performance Aid
SQT	Skill Qualification Test(s)
SRB	Selective Reenlistment Bonus
TACFIRE	Tactical Fire Direction System
TAG	The Adjutant General
TEC	Training Extension Course(s)
TEPPS	Techniques for Establishing Personnel Performance Standards

TES	Tactical Engagement Simulation
TMI	Training Management Institute
TOE	Table of Organization and Equipment
TOS	Tactical Operations System
TRADOC	Training and Doctrine Command
TSC	Training Support Center
USAREUR	U.S. Army, Europe
USES	U.S. Employment Service
VHIC	Very High Speed Integrated Circuits
VTS	Versatile Training System
WAC	Women's Army Corps
WEQ	Work Environment Questionnaire
WEST	Women's Enlistment Screening Test

References

Note: Where available, Defense Technical Information Center (DTIC) numbers are included with reports.

Actkinson, T. (1980). *Human factors evaluation of the multiple integrated laser engagement system in an operational environment* (Research Report 1322). Alexandria, VA: U.S. Army Research Institute. (AD A129 730)

Baker, J. D. (1970). Acorns in flowerpots: Psychologists in the field. *Proceedings of the 16th Annual U.S. Army Human Factors Research and Development Conference* (pp. 27 – 47). Washington, DC: Office of the Chief of Research and Development.

Baker, J. D. (1980). The Army's match game: Man to machine. *Defense Management Journal, 16*, 20 – 25.

Baker, J. D., Mace, D. J., & McKendry, J. S. (1969). *The transform operation in TOS: Assessment of the human component* (Technical Research Note 212). Alexandria, VA: U.S. Army Research Institute. (AD 697 716)

Banks, J. H., Sternberg, J. J., Cohen, B. J., & DeBow, G. H. (1971). *Improved search techniques with passive night vision devices* (Technical Research Report 1169). Alexandria, VA: U.S. Army Research Institute. (AD 722 236)

Baritz, L. (1960). *Servants of power: A history of the use of social science in American industry*. Middletown, CT: Wesleyan University Press.

Bayroff, A. G., & Anderson, A.A. (1963). *Development of Armed Forces Qualification Tests 7 and 8* (Technical Research Report 1122). Alexandria, VA: U.S. Army Research Institute. (AD 276 622)

Berkowitz, M., & O'Neil, H. F., Jr. (1980). *A formative evaluation plan for the Automated Instructional Management System (AIMS)* (Research Report 1279). Alexandria, VA: U.S. Army Research Institute. (AD A109 194)

Besson, F. S., Jr. (1968). Keynote address. *Proceedings of the 14th Annual U.S. Army Human Factors Research and Development Conference* (pp. 5 – 28). Washington, DC: Office of the Chief of Research and Development.

Bingham, W. V. (1944). Personnel classification testing in the Army. *Science, 100*, 275 – 280

Bingham, W. V. (1952). Walter Van Dyke Bingham. In E. G. Boring (Ed.), *A history of psychology in autobiography*. Worcester, MA: Clark University Press.

Birnbaum, A. H., Sadacca, R., Andrews, R. S., & Narva, M. (1969). *Summary of BESRL surveillance research* (Technical Research Report 1160). Alexandria, VA: U.S. Army Research Institute. (AD 701 907)

Bishop, C. M. (1961). Teaching machines: An overview. *Proceedings of the 7th Annual U.S. Army Human Factors Research and Development Conference* (pp. 237 – 239). Washington, DC: Office of the Chief of Research and Development.

Boldt, R. F., & Seidman, D. (1960). *Aptitude distribution in the combat arms* (Technical Research Report 1119). Alexandria, VA: U.S. Army Research Institute. (AD 240 130)

Bolin, S. F. (1981). A task-based approach to soldier training. *Defense Management Journal, 18*(2), 24 – 28.

Bolin, S. F., Larson, E. E., & Kristiansen, D. M. (1969). *Prediction of disciplinary offense early in Army service* (Technical Research Note 210). Alexandria, VA: U.S. Army Research Institute. (AD 692 306)

Bourne, P. G. (1970). *Men, stress, and Vietnam.* Boston: Little, Brown & Co.

Bray, C. W. (1962). Toward a technology of human behavior for defense use. *The American Psychologist, 17*, 527 – 541.

Bray, D. W., & Grant, D. L. (1966). The assessment center in the measurement of potential for business management. *Psychological Monographs, 80*.

Breznitz, S. (1980). *Studies of effective warning systems.* Unpublished report, U.S. Army Research Institute, Alexandria, VA.

Brigham, C. C. (1923). *A study of American intelligence.* Princeton, NJ: Princeton University Press.

Brigham, C. C. (1930). Intelligence tests of immigrant groups. *Psychological Reviews, 37*, 158 – 165.

Brogden, H. E., Osburn, H. G., Machlin, C. T., Loeffler, J. C., & Reuder, M. (1952). *Improvements of tests and techniques used to select ROTC students* (Technical Research Report 977). Alexandria, VA: U.S. Army Research Institute. (AD 208 283)

Brogden, H. E., & Taylor, E. K. (1950). The dollar criterion—applying the cost accounting concept to criterion construction. *Personnel Psychology, 3*, 133 – 154.

Browning, R. C., Campbell, J. T., & Birnbaum, A. H. (1952a). *A comparison of the validity of officer ratings rendered by hard and easy raters* (Technical Research Report 971). Alexandria, VA: U.S. Army Research Institute. (ATI 170147)

Browning, R. C., Campbell, J. T., & Birnbaum, A. H. (1952b). *A study of officer rating methodology — IX. Validity of ratings by hard and easy raters* (Technical Research Report 908). Alexandria, VA: U.S. Army Research Institute. (ATI 171378)

Burke, R. J. (1966). Are Herzberg's motivators and hygienes unidimensional? *Journal of Applied Psychology, 50*, 317 – 321.

Caylor, J. S. (1968). AFQT testing of Project 100,000 personnel. *Proceedings of the 10th Annual Conference of the Military Testing Association*, Lackland Air Force Base, TX, 11 – 14.

Chase, A. (1977). *The legacy of Malthus.* New York: A. Knopf.

Chesler, D. J., Brogden, H. E., Brown, E. E., & Katz, A. A. (1952). *A study of ratings from raters with aptitude area I scores below 90* (Technical Research Report 933). Alexandria, VA: U.S. Army Research Institute. (ATI 162795)

Cockrell, J. T., & Sadacca, R. (1971). *Training individual image interpreters using team consensus feedback* (Technical Research Report 1171). Alexandria, VA: U.S. Army Research Institute. (AD 747 827)

Cohen, S. L., & Turney, J. R. (1976). *Results of an organizational diagnostic survey of an Army field facility work environment* (Technical Paper 272). Alexandria, VA: U.S. Army Research Institute. (AD A020 934)

Cook, R. F., & Morton, A. S. (1975). *An assessment of drug education-prevention programs in the U.S. Army* (Technical Paper 261). Alexandria, VA: U.S. Army Research Institute. (AD A003 308)

Cosby, L. N., & Zeidner, J. (1982). *The U.S. Army Research Institute for the Behavioral and Social Sciences Annual Report for 1982.*

Cowles, J. T. (1967). Recent personnel research in the academic world. In A. L. Fortuna (Ed.), *Personnel research and systems advancement, Proceedings of the 25th Anniversary Symposium*, Lackland Air Force Base, TX, 1 – 11.

Crain, L. C. (1968). Project 100,000 and utilization of college graduates. *Proceedings of the 14th Annual U.S. Army Human Factors Research and Development Conference*. Washington, DC: Office of the Chief of Research and Development.

Crawford, M. P. (1974). *Research on military training* (Professional Paper). Alexandria, VA: Human Resources Research Organization.

Defense Science Board (1982). *Training and training technology*. Draft report. Washington, DC: Defense Science Board Summer Study Group.

Dick, W. W., Jr. (1963). Keynote address. *Proceedings of the 9th Annual U.S. Army Human Factors Research and Development Conference* (pp. 5 – 7). Washington, DC: Office of the Chief of Research and Development.

Drucker, A. J. (1957). Predicting leadership ratings in the United States Army. *Journal of Educational and Psychological Measurement, 17*, 240 – 263.

Drucker, A. J., & Kaplan, H. (1966). Identifying successful pilots through research. *U.S. Army Aviation Digest*, 29 – 32.

Edgerton, H. A. (1967). Recent advances in personnel psychology in industry. In A. L. Fortuna (Ed.), *Personnel research and systems advancement, Proceedings of the 25th Anniversary Symposium*, Lackland Air Force Base, TX, 13 – 17.

Ehrenreich, S., & Moses, F. L. (1981). Get the message? The problems of abbreviations and battlefield automated systems. *Army Research, Development & Acquisition Magazine*, 14 – 16.

Epstein, S., (1970). Effects of image incongruence on location of common terrain in comparative cover (Technical Research Note 222). Alexandria, VA: U.S. Army Research Institute. (AD 707 441)

Epstein, S., & Jeffrey, T. E. (1973). *Common area demarcation, target annotation, and target lists as aids in change detection* (Technical Research Note 238). Alexandria, VA: U.S. Army Research Institute. (AD 761 128)

Farina, A. J., Wheaton, G. R., & Fleishman, E. A. (1971). *Development of a taxonomy of human performance: The task characteristics approach to performance prediction* (Research Study 71 – 7). Alexandria, VA: U.S. Army Research Institute. (AD 736 191)

Fiedler, F. E., Mahar, L., & Carroll, R. M. (1978). *ROTC Validation Study of Leader Match IV. Programmed learning in leadership for the U.S. Army* (Technical Report 78 – TH2). Alexandria, VA: U.S. Army Research Institute. (AD A056 108)

Fields, V. (1967). Recent personnel research in the Bureau of Naval Personnel: A review. In A. L. Fortuna (Ed.), *Personnel research and systems advancement, Proceedings of the 25th Anniversary Symposium*, Lackland Air Force Base, TX, 19 – 37.

The Futures Group (1983). *Trends in the U.S. labor market and their implications for future Army manpower planning*. Unpublished paper, U.S. Army Research Institute.

Gard, R. G., Jr. (1971). Drugs and the “drug culture” [Executive Summary]. *Proceedings of the 17th Annual U.S. Army Human Factors Research and Development Conference*. Washington, DC: Office of the Chief of Research and Development.

Goldberg, S.C., Castelnovo, A. E., & Goldstein, L. G. (1960). *Construction of the Electronics Selection Battery* (Research Memorandum 60 – 23). Alexandria, VA: U.S. Army Research Institute. (AD B951 285)

Gordon, L. V., & Medland, F. F. (1964). *Values associated with military career motivation* (Technical Research Note 143). Alexandria, VA: U.S. Army Research Institute. (AD 600 037)

Gorman, P. F. (1981). A rumination on wars ahead. *Proceedings of the 23rd Annual Conference of the Military Testing Association, 1*, 17–69.

Gould, S. J. (1981). *The mismeasure of man*. New York: W. W. Norton and Co.

Gregg, L. W. (1962). Computer simulation in human factors research. *Proceedings of the 8th Annual U.S. Army Human Factors Research and Development Conference* (pp. 241–250). Washington, DC: Office of the Chief of Research and Development.

Gross, M. L. (1962). *The brain watchers*. New York: Random House.

Gude, E. W. (1965). Some notes on exploratory research on the genesis of social conflict. *Proceedings of the 11th Annual U.S. Army Human Factors Research and Development Conference* (pp. 91–98). Washington, DC: Office of the Chief of Research and Development.

Guion, R. M., & Gottier, R. F. (1965). Validity of personality measures in personnel selection. *Personnel Psychology, 18*, 135–164.

Haggerty, H. (1955). *Personnel research for the U.S. Military Academy, 1942–1953* (PRB Report 1077). (Originally published October 1953.) (AD 21 600)

Hale, M. (1982). History of employment testing. In A. K. Wigdor and W. R. Garner (Eds.), *Ability testing: Uses, consequences and controversies, Part II: Documentation section* (pp. 3–38). Washington, DC: National Academy Press.

Harries-Jenkins, G. (1977). *Group representation*. Unpublished report, U.S. Army Research Institute, Alexandria, VA.

Helme, W. H. (1960). *Differential validity of the ACB for courses in seven job areas* (Technical Research Report 1118). Alexandria, VA: U.S. Army Research Institute. (AD 240 129)

Helme, W. H. (1971). Leadership research findings as applied to the officer personnel management system [Executive summary]. *Proceedings of the 17th Annual U.S. Army Human Factors Research and Development Conference*. Washington, DC: Office of the Chief of Research and Development.

Helme, W. H., & White, R. K. (1958). *Prediction of success in courses training EM for electronic and electrical maintenance jobs* (Technical Paper 89). Alexandria, VA: U.S. Army Research Institute. (AD 203 734)

Helme, W. H., Willemin, L. P., & Grafton, F. C. (1971). *Dimensions of leadership in a simulated combat situation* (Technical Research Report 1172). Alexandria, VA: U.S. Army Research Institute. (AD 730 315)

Herzberg, F. (1966). *Work and the nature of man*. Cleveland, Ohio: World Publishers.

Hinrichs, J. R. (1978). An 8-year follow-up of a management assessment center. *Journal of Applied Psychology, 63*, 596.

Hollingsworth, H. L. (1915). Specialized vocational tests and methods. *School and Society, 1*.

Howard, C. W., & Reynolds, K. C. (1981). *Tactical initialization training handbooks I, II, and III for the PATRIOT weapon system* (Research Product). Alexandria, VA: U.S. Army Research Institute.

Hyman, A., & Sternberg, J. J. (1969). BESRL field experimentation related to continuous operations. *Proceedings of the 15th Annual U.S. Army Human Factors Research and Development Conference* (pp. 136–156). Washington, DC: Office of the Chief of Research and Development.

Janowitz, M. (1982). Consequences of social science research on the U.S. Military. *Armed Forces and Society, 8*, 507–524.

Jeffrey, T.E. (1973). Effects of photo degradation on interpreter performance (Technical Research Note 245). Alexandria, VA: U.S. Army Research Institute. (AD 763 908)

Jeffrey, T. E., & Beck, F. J. (1972). *Intelligence information from total optical color imagery* (Research Memorandum 72–4). Alexandria, VA: U.S. Army Research Institute. (AD A079 386)

Jeffrey, T. E., Martinek, H., Shvern, U., & Johnson, E. M. (1980). *ARI image interpretation research: 1970–1980* (Research Report 1252). Alexandria, VA: U.S. Army Research Institute. (AD A095 661)

Johnson, C. D. (1968). Matching manpower resources and requirements. *Proceedings of the 14th Annual U.S. Army Human Factors Research and Development Conference* (pp. 117–125). Washington, DC: Office of the Chief of Research and Development.

Johnson, E. M. (1973). *Numerical encoding of qualitative expressions of uncertainty* (Technical Paper 250). Alexandria, VA: U.S. Army Research Institute. (AD 780 814)

Johnson, E. M. (1974). *The effect of data source reliability on intuitive inference* (Technical Paper 251). Alexandria, VA: U.S. Army Research Institute. (AD 784 097)

Johnson, H. K. (1965). Keynote address. *Proceedings of the 11th Annual U.S. Army Human Factors Research and Development Conference* (pp. 82 – 89). Washington, DC: Office of the Chief of Research and Development.

Kamin, L. J. (1974). *The science and politics of I.Q.* Potomac, MD: Erlbaum.

Kamin, L. J. (1976). Heredity, intelligence, politics and psychology: II. In N. J. Plock & G. Dworkin (Eds.), *The I.Q. controversy*. New York: Pantheon Books.

Kaplan, H., & Willemin, L. P. (1956, September). *Effect of shorter acquaintance or of adding cadre ratings on the validity of early buddy ratings of combat aptitude.* Paper presented at the meeting of the American Psychological Association, San Francisco, CA.

Karcher, E. K., Jr., Winer, B. J., Falk, G. H., & Haggerty, H. R. (1952). *A study of officer rating methodology — V: Validity and reliability of ratings by single raters and multiple raters* (Technical Research Report 904). Alexandria, VA: U.S. Army Research Institute. (ATI 171 377)

Katz, M. S., & Drillings, M. (1981). A new direct support maintenance system. *Proceedings of the 1st Annual Conference on Personnel Training Factors in Systems Effectiveness* (pp. 72 – 75). Washington, DC: NSIA, PT 1981.

Kevles, D. J. (1968). Testing the army's intelligence: Psychologists and the military in World War I. *Journal of American History, 55*, 565 – 581.

Kramer, R. C., & Segal, D. R. (1980, October). *Job satisfaction in the U. S. Army: 1943 and 1973.* Paper presented at the annual meeting of the Southern Sociological Society, Knoxville, TN.

Lepkowski, J. R. (1978). *Image interpreter performance as affected by resolution, presentation rate, and scale* (Technical Paper 335). Alexandria, VA: U.S. Army Research Institute. (AD A064 262)

Lepkowski, J. R., & Jeffrey, T. E. (1972). *Some factors affecting mensuration variability among image interpreters* (Research Memorandum 72 – 7). Alexandria, VA: U.S. Army Research Institute. (AD A079 387)

Levine, J. M., & Teichner, W. H. (1971). *Development of a taxonomy of human performance: An information — theoretic approach. (Research Study 71-6). Alexandria, VA: U.S. Army Research Institute. (AD 736 193)*

Levy-Leboyer, C., & Voisin-Vedrenne, B. (1978). *Managerial and organizational determinants of efficiency in research teams* (Technical Report 8 – TH6). Alexandria, VA: U.S. Army Research Institute. (AD A064 277)

Link, H. C. (1919). *Employment psychology: The application of scientific methods to the selection, training and grading of employees.* New York: MacMillan Co.

Link, H. C. (1923). Psychological tests in industry. *Annals of the American Academy of Political Science, 110.*

Lovell, J. P. (1971). Impact of economic and societal change [Executive summary]. *Proceedings of the 17th Annual U.S. Army Human Factors Research and Development Conference.* Washington, DC: Office of the Chief of Research and Development.

Maier, M. H., & Fuchs, E. F. (1972). *An improved differential Army classification system* (Technical Research Report 1177). Alexandria, VA: U.S. Army Research Institute. (AD 748 802)

Martinek, H., Hilligoss, R. E., & Harrington, B. (1972). *Effectiveness of an error key for image interpretation in Vietnam* (Technical Research Note 230). Alexandria, VA: U.S. Army Research Institute. (AD 752 437)

Martinek, H., & Zarin, A. (1979). *The effects of bandwidth compression on image interpreter performance* (Technical Paper 396). Alexandria, VA: U.S. Army Research Institute. (AD A077 840)

Mays, P., & Dyer, F. (1981). Twenty years later: A follow up of the Officer Evaluation Center. *Proceedings of the 23rd Annual Conference of the Military Testing Association, 1*, 789 – 799.

McBride, J. R. (1979). *Adaptive mental testing: The state-of-the-art* (Technical Report 423). Alexandria, VA: U.S. Army Research Institute. (AD A088 000)

Medland, F. F., Green, C. G., & Marder, M. (1965). Psychological factors in selection of Special Forces officers. *Proceedings of the 11th Annual U.S. Army Human Factors Research and Development Conference.* Washington, D.C.: Office of the Chief of Research and Development.

Medland, F. F., Hammer, C. H., & Frankfeldt, E. (1962). *Selection of NCO leaders—Status report* (Technical Research Report 1127). Alexandria, VA: U.S. Army Research Institute. (AD 295 185)

Modrick, J. A. (1982). *A projection of research needs of the Army of the year 2000.* Unpublished paper, U.S. Army Research Institute.

Morgan, G. A., Joynson, K. M. (1981). A matter of action. *Aviation Digest, 27*, 36–39.

Moskos, C. C. (1971). Motivation and discipline in the 70s. *Proceedings of the 17th Annual U.S. Army Human Factors Research and Development Conference.* Washington, DC: Office of the Chief of Research and Development.

Nordlie, P. G., & Thomas, J. A. (1973). *Race relations and equal opportunity in the Army* (Research Problem Review 73–2). Alexandria, VA: U.S. Army Research Institute. (AD A077 751)

Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics (1982). *Profile of American youth, 1980 nationwide administration of the ASVAB.* Washington, DC: Author.

Olmstead, J. A., Christensen, H. E., & Lackey, L. L. (1973). *Components of organizational competence: Test of a conceptual framework* (Technical Report 73–19). Alexandria, VA: Human Resources Research Organization.

Olmstead, J. A., Elder, B. L., & Forsyth, J. M. (1978). *Organizational process and combat readiness: Feasibility of training organizational effectiveness staff officers to assess command group performance* (Interim report IR–ED–78–13). Alexandria, VA: Human Resources Research Organization.

O'Neil, H. F., Jr. (Ed.) (1981). *Computer-based instruction—A state-of-the-art assessment.* New York: Academic Press.

Orlansky, J., & String, J. (1979). *Cost effectiveness of computer-based instruction in military training* (IDA Paper P–1375). Washington, DC: Institute for Defense Analysis.

Parrish, J. A., & Drucker, A. J. (1957). *Personnel research for officer candidate school* (Technical Research Report 1107). Alexandria, VA: U.S. Army Research Institute. (AD 149 319)

Parrish, R., Gates, J. L., & Munger, S. J. (1981). *Design guidelines and criteria for user/operator transactions with battlefield automated systems* (Vols. I–V (Research Product 81–29). Alexandria, VA: U.S. Army Research Institute. (AD A109 454)

Pask, G. (1980). *Current scientific approaches to decision making in complex systems* (Research Note 80–11). Alexandria, VA: U.S. Army Research Institute. (AD A105 171)

Peres, S. H. (1959). *Implications of ranger training for fighting prediction* (Report 1116). Alexandria, VA: U.S. Army Institute. (AD 228 581)

Personnel Research Section, Classification and Replacement Branch, The Adjutant General's Office (1945). The Army General Classification Test. *Psychological Bulletin, 42*, 760–768.

Powers, J. R., III, Brainard, R. W., Abram, R. E., & Sadacca, R. (1973). *Training techniques for rapid target detection* (Technical Research Note 242). Alexandria, VA: U.S. Army Research Institute. (AD 768 194)

REALTRAIN—Tactical Training for Combined Arms Elements (1975). Joint publication of U. S. Army Armor School, U. S. Army Infantry School, and U. S. Army Research Institute.

Ringel, S., Hammer, C. H., & Vicino, F. L. (1963). Information assimilation from command system displays. *Proceedings of the 9th Annual U.S. Army Human Factors Research and Development Conference* (pp. 91-101). Washington, DC: Office of the Chief of Research and Development.

Ritter, J. H. (1967). Recent personnel research in the U.S. Air Force: A review. In A. L. Fortuna (Ed.), *Personnel research and systems advancement, Proceedings of the 25th Anniversary Symposium.* Lackland Air Force Base, TX, 49–55.

Rouse, W.B. (1980). *Human decision making in computer-aided fault diagnosis* (Technical Report 434). Alexandria, VA: U.S. Army Research Institute. (AD A086 457)

Schendel, J. D., Shields, J., & Katz, M. S. (1978). *Retention of motor skills: Review* (Technical Paper 313). Alexandria, VA: U.S. Army Research Institute. (AD A061 338)

Scott, W. D., Clothier, R. C., & Spriegel, W. R. (1961). *Personnel management: Principles, practices, and a point of view* (6th ed.). New York: McGraw-Hill Book Co.

Segal, D. R. (1979). *Structural change in the U. S. Army* (Research Note No. 81–2). Alexandria, VA: U.S. Army Research Institute. (AD A100 887).

Severin, D. G. (1952). *Measures of combat performance in Korea—Criterion on measures for enlisted men* (Technical Research Report 938). Alexandria, VA: U.S. Army Research Institute. (ATI 171 382)

Shields, J. L., Goldberg, S. L., & Dressel, J. D. (1979). *Retention of basic soldiering skills* (Research Report 1225). Alexandria, VA: U.S. Army Research Institute. (AD A075 412)

Shields, J. L., Joyce, R. P., & VanWert, J. R. (1979). *Chaparral skill retention* (Research Report 1205). Alexandria, VA: U.S. Army Research Institute. (AD A069 945)

Shubik, M., & Brewer, G. (1971). Systems simulation and gaming as an approach to understanding organizations. In A. I. Siegel (Ed.), *Proceedings of Symposium on Computer Simulation as Related to Manpower and Personnel Planning*. Washington, DC: Naval Personnel Research and Development Laboratory.

Siegel, A. I. (Ed.) (1971). *Proceedings of Symposium on Computer Simulation as Related to Manpower and Personnel Planning*. Washington, DC: Naval Personnel Research and Development Laboratory.

Sisson, E.D. (1948). The Personnel Research Program of The Adjutant General's Office of the United States Army. *Review of Educational Research, 18*(6), pp. 575–595.

Smith, G. D., & Steadman, L. E. (1981). Present value of corporate history. *Harvard Business Review*, 164–173.

Smith, N. D., & Gividen, G. M. (1981). Friend or enemy? It's all in the cues. *Army, 31*(11), 30–34.

Smith, S., & Osborne, A. (1981). Troubleshooting rifle marksmanship. *Infantry, 71*(4), 28–34.

Smithsonian Institution (1960). The technology of human behavior. Washington, DC: Author.

Snyderman, M., & Herrstein, R. J. (1983). Intelligence tests and the Immigration Act of 1924. *American Psychologist, 38*, 986–995.

Sternberg, J. J., & Greenberg, F. S. (1958). *Enlisted MOS suitable for the physically handicapped* (Research Study 58–6). Alexandria, VA: U.S. Army Research Institute. (AD B951 210)

Stouffer, S. A. (1949). *The American soldier*. Princeton, NJ: Princeton University Press.

Swanson, C. L., & Rimland, B. (1968). Comparison of marginal and control U.S. Navy personnel on biographical information and recruit performance. *Proceedings of the 10th Annual Conference of the Military Testing Association.* Lackland Air Force Base, TX, 25–30.

Terman, L. (1919). The status of applied psychology in the United States. *Journal of Applied Psychology, 5*, 1–4.

Theologus, G. C., & Fleishman, E. A. (1971). *Development of a taxonomy of human performance: Validation study of ability scales for classifying human tasks* (Research Study 71–9). Alexandria, VA: U.S. Army Research Institute. (AD 736 194)

Thomas, E. (1968). Problems in testing new standards recruits. *Proceedings of the 10th Annual Conference of the Military Testing Association*. Lackland Air Force Base, TX, 15–20.

Thorndike, R. L. (1969). The contribution of military testing to psychometric research. *Proceedings of the 11th Annual Conference of the Military Testing Association*. New York, 3–15.

Uhlaner, J. E., & Drucker, A. J. (1967). U.S. Army personnel research in job systems settings. In A. L. Fortuna (Ed.), *Personnel research and systems advancement, Proceedings of the 25th Anniversary Symposium*, Lackland Air Force Base, TX.

Uhlaner, J. E., Goldstein, L. G., & Van Steenberg, N. J. (1952). *Development of criteria of safe motor vehicle operation* (Highway Research Board Bulletin 60). Washington, DC: Highway Research Board.

Uhlaner, J. E., & Zeidner, J. (1961). *The Army night seeing tester—Development and use* (Technical Research Report 1120). Alexandria, VA: U.S. Army Research Institute. (AD 258 349)

U.S. Office of Strategic Services. (1948). *Assessment of men: Selection of personnel for the Office of Strategic Services*. New York: Rinehart and Co.

Van Riper, P. (1958). *History of the United States Civil Service*. Evanston, IL: Row, Peterson & Co.

Wallace, S. R. (1965). The relationship of psychological evaluation to the needs of the Department of Defense. *Proceedings of the 7th Annual Military Testing Conference*. San Antonio, TX, 1 – 10.

Whyte, W. H., Jr. (1954). The fallacies of "personality" testing. *Fortune, 50*, 118 – 119.

Willemin, L. P. (1964). *Prediction of officer performance* (Technical Research Report 1134). Alexandria, VA: U.S. Army Research Institute (AD 600 038)

Willemin, L. P., & Karcher, E. K. (1958). *Development of combat aptitude areas* (Technical Research Report 1110). Alexandria, VA: U.S. Army Research Institute. (AD 153 596)

Willemin, L. P., Sait, E. M., & Weinberg, S. A. (1965). Prisoner behavior in simulated interrogations. *Proceedings of the 11th Annual U.S. Army Human Factors Research and Development Conference*. Washington, DC: Office of the Chief of Research and Development.

Yerkes, R. M. (Ed.) (1921). *Psychological examining in the U.S. Army*. Official report of the Division of Psychology, The Surgeon General's Office. In *Memoirs*. (Vol. 15). Washington, DC: National Academy of Sciences.

Zeidner, J., & Birnbaum, A. H. (1959). *Survey of psychological factors in image interpretation* (Research Study 59 – 1). Alexandria, VA: U.S. Army Research Institute. (AD B951 212)

Zeidner, J., Harper, B. F., & Karcher, E. K. (1956). *Reconstitution of the aptitude areas* (Technical Research Report 1095). Alexandria, VA: U.S. Army Research Institute. (AD 131 534)

Zeidner, J., Martinek, H., & Anderson, A. A. (1958). *Evaluation of experimental predictors for selecting Army helicopter pilot trainees — II* (Research Note 99). Alexandria, VA: U.S. Army Research Institute. (AD 202 033)

Appendices

APPENDIX A

Training and Personnel Technology Research Laboratories and Organizations

Army

Army Research Institute
Army Human Engineering Laboratory
Project Manager for Training Devices

Navy

Headquarters, U.S. Marine Corps
Naval Aerospace Medical Research Laboratory
Naval Air Development Center
Naval Air Systems Command
Naval Electronic Systems Command
Naval Ocean Systems Center
Naval Personnel Research and Development Center
Naval Sea Systems Command
Naval Ship Research and Development Center
Naval Surface Weapons Center
Naval Training Equipment Center
Office of Naval Research

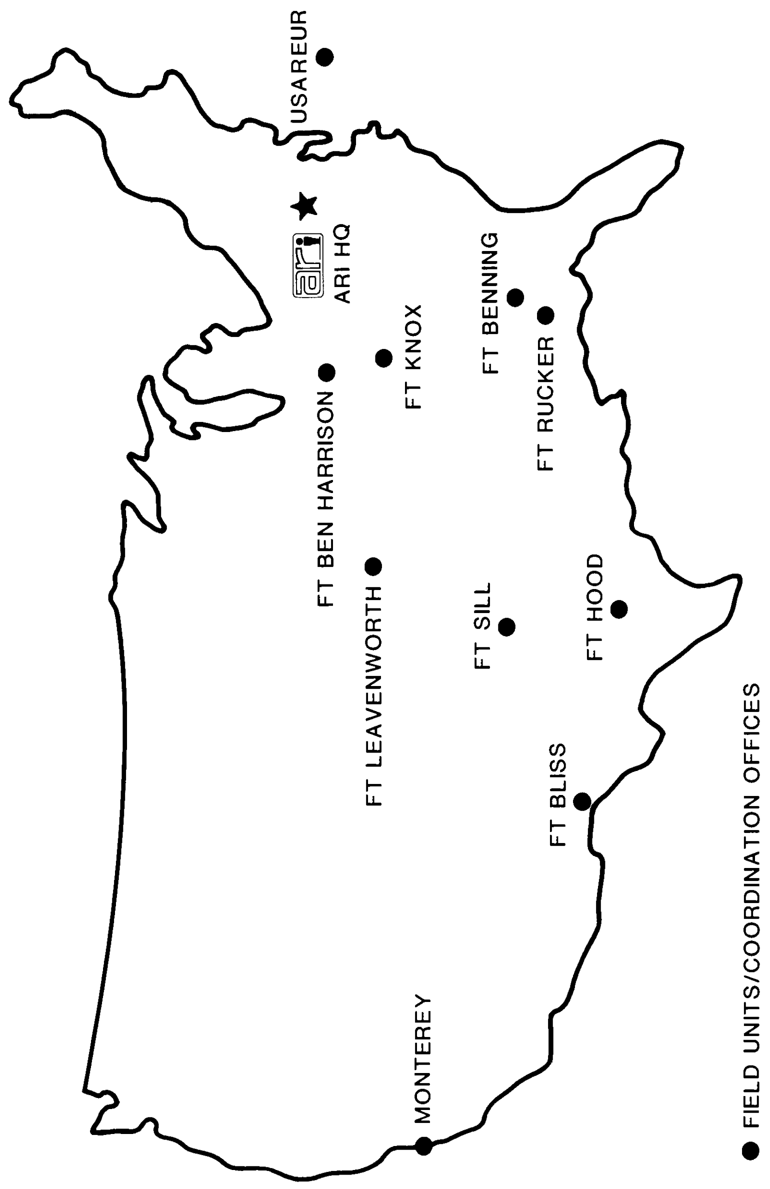
Air Force

Aerospace Medical Division
Air Force Aerospace Medical Research Laboratory
Air Force Human Resources Laboratory
Air Force Office of Scientific Research
Simulation Systems Project Office

APPENDIX B

Geographical Location of ARI Elements

See Appendix F for a description of the evolution of the field unit system.



APPENDIX C

Officer Personnel of the Division of Psychology, Office of the Surgeon General, October 1919

Edwin W. Adams
John E. Anderson
George F. Arps
Isaac E. Ash
Edwin M. Bailor
George M. P. Baird
Bird T. Baldwin
John W. Bare
Gardner C. Bassett
Robert L. Bates
Charles E. Benson
Charles E. Berry
Harold C. Bingham
Edwin G. Boring
Foster P. Boswell
Thomas J. Breitwieser
Carl C. Brigham
Thomas W. Brockbank
Carl R. Brown
Leo J. Brueckner
Edwin M. Chamberlain
Elmer B. Clark
Charles A. Coburn
Harvie D. Coghill
Lawrence W. Cole
Warren W. Coxe
Heber B. Cummings
Karl M. Dallenbach
David F. Deerwester
Lorenzo C. Denslow
James C. De Voss
Edgar A. Doll
Austin B. Edwards
Richard M. Elliott
Horace B. English
Arthur H. Estabrook
John C. Farber
George O. Ferguson
Harry N. Fitch
Joseph K. Folsom
William S. Foster
Elliott P. Frost
Henry D. Fryer
Frederick W. Giesel
Anthony M. Goldberger
Melville E. Haggerty
Clarence F. Hansen
Charles L. Harlan
Joseph W. Hayes
Harley C. Hines
Charles E. Holley
Frazer Hood
John D. Houser
Walter S. Hunter
Edward S. Jones
Harry J. Kefauver
Chester E. Kellogg
Lawrence W. Lane
Daniel W. LaRue
Warren K. Layton

Augustus S. Lee
Edward A. Lincoln
Herbert G. Lytle
Constantine F. Malmberg
Herschel T. Manuel
Lawrence Marcus
William M. Marston
Mark A. May
Roland A. McCrady
William H. Mearns
Paul A. Mertz
John T. Metcalf
Wilford S. Miller
Clyde B. Moore
Henry T. Moore
John J. B. Morgan
Carl A. Murchison
Garry C. Myers
Morris Neifeld
John K. Norton
Arthur S. Otis
Roberts B. Owen
Donald G. Paterson
Louis A. Pechstein
Lawrence D. Pedrick
Benjamin F. Pittenger
Albert T. Poffenberger
Merrill J. Ream
A. E. Rejall
Harold A. Richmond
Ralph S. Roberts
Eugene C. Rowe
Ira D. Scott
Howard P. Shumway
Charles C. Stech
Thomas M. Stokes
Calvin P. Stone
Reuel H. Sylvester
Lewis M. Terman
Paul W. Terry
Charles H. Toll
Marion R. Trabue
Oscar W. Ullrich
Lyman H. Van Houten
Francis A. Wade
Karl T. Waugh
Harry A. Wembridge
Raymond H. Wheeler
Goodrich C. White
William R. Wilson
Benjamin D. Wood
William H. Woodruff
Harry H. Wylie
Robert M. Yerkes
Clarence S. Yoakum

APPENDIX D

Favorable and Unfavorable Conditions in Mental Testing during World War I

To ensure a full understanding of the achievements and failures of his corps, Yerkes listed a number of favorable and unfavorable circumstances or conditions of the work of mental testing.

Distinctly in favor of the work of mental testing were the following: (Yerkes, 1921, pp. 95–99)

Intelligent and active interest of the National Research Council, Army Surgeon General William C. Gorgas, and the Secretary of War.

Those commanding officers and staff who had reasonable familiarity with intelligence ratings.

Favorable reports of the official investigations.

Establishment of a special school for military psychology and training of officers in the fundamentals of military behavior as well as in psychology examining for the Army.

Popular recognition of the importance of classifying soldiers mentally, and the steady stream of requests from commercial concerns, educational institutions, and individuals for use of the Army methods of psychological examining.

The list of disadvantages or handicaps was more formidable:

Misunderstanding of psychology and prejudices against anything done in its name.

Officers who claimed that mental classification was unnecessary because armies had always got along without it.

Resentment in the medical department that psychologists were doing what should have been done by medical specialists.

Charges that testing was interfering with military training.

Inability of officers of the General Staff to evaluate the program from secondhand evidence and hence to lend it the support needed.

Failure of the War Department to issue special orders and instructions concerning psychological examining for the guidance of commanding officers.

Low rank of officers charged with introduction, organization, and direction of the new service.

Placement of the examining in the Sanitary Corps; as a result, the psychologist was regarded by medical officers as professionally inferior.

Lack of general orders for the use of intelligence ratings until near the end of the war.

Confusion with neuropsychiatric work.

Popular misunderstanding concerning materials and methods; to the person unfamiliar with such matters, the tests appeared trivial, absurd, and unfair.

APPENDIX E

Personnel Research Section Staff, 1940 – 1946

Sidney Adams
Earl Alligaier
Jane M. Allison
Carl L. Anderson
Kenneth Ashcroft
Donald E. Baier
Melvin H. Baumhofer
Harold Bechtoldt
Roger M. Bellows
Albert H. Berg
Harold C. Bingham
Walter V. Bingham
Ruth Bishop
Reign H. Bittner
Edward S. Bordin
Hyman Brandt
Louis J. Braun
Robert E. Breden
Hubert E. Brogden
Keith L. Broman
Emma E. Brown
Harry W. Bues
James W. Burns
James W. Campbell
Launor F. Carter
Frank C. Cassens
David J. Chesler
Charles L. Christiermin
Ruth D. Churchill
Kenneth E. Clark
Vernon E. Clark
Earl A. Cleveland
Charles W. Collins
Clyde H. Coombs
Herman A. Copeland
Horace H. Corbin
Robert E. L. Crane
G. Hamilton Crook
Edith Cummins
Edward E. Cureton
Manuel M. Cynamon
Karl M. Dallenbach
Tamara Danish
Jeanne C. Davis
D. M. Depew
Helen C. Dondy
Mitchell Dreese
Hilda F. Dunlap
Walter N. Durost
Robert F. Earhart
Jane L. Eastman
Marian B. Eller
Alvin C. Eurich
Solomon D. Evans
Dorothea W. Ewers
Ray Faulkner
Forrest Forcum
Fred C. Ford
Douglas H. Fryer
Richard H. Gaylord

John H. Glass
Eleanor W. Gluck
Norman I. Greenfield
Winslow Hallet
Wilfred Hamlin
Paul J. Hansen
Thomas W. Harrell
Wells Harrington
Betty B. Hemmelman
Edwin R. Henry
Charlotte G. Honig
Reuben Horchow
Reuben S. Horlick
Robert Iglebart
Mary C. Jarrett
Donald M. Johnson
Thornton C. Karlowski
Raymond A. Katzell
Walter Kelly
William M. Kephart
Philip M. Kitay
Richard Klamon
Celia M. Klinger
David R. Krathwohl
William C. Kvaraceus
Russell G. Leiter
Harry Levtow
Sidney Lind
Floyd H. Lofquist
James M. Lynch
Grace E. Manson
Stanley C. Markey
Dorothy Mathis
Harold McAdoo
Gordon L. McDonald
Joseph L. Melcher
Marilyn R. Mendley
Gerard S. Napoletano
Belford B. Nelson
Philip Nogge
Margaret Norgaard
Joseph V. O'Rourke
Bernice Orshansky
Stanley W. Osgood
Charlotte M. Panimon
Richard H. Paynter
Ruth A. Pederson
Edwin B. Petersen
Watson O. Pierce
Adam Poruben, Jr.
Bronson Price
Barbara M. Quiat
Evelyn Raskin
Arthur E. Rasmussen
Mary K. Reddington
Prentis Reeves
Alexander B. Reid
Marion W. Richardson
Carmeline Roman
Edward A. Rundquist
James R. Russell
Willis C. Schaefer
William A. Schraeder
William J. Schulz
Janet B. Schwinger
John F. Scott
Robert B. Selover
William Shanner
James U. Shea
Winifred Shepler
Edward M. Sherbourne
Morton A. Siedenfeld
Meyer S. Siegel
Clement H. Sievers
Catherine Romano Sisson
E. Donald Sisson
Charles R. Sparks
Joseph L. Speicher
Naomi S. Stewart
Philip M. Stone
Ralph J. Strom
Margaret Strong
W. S. Studdiford
Calvin W. Taylor
E. K. Taylor
Helen D. Telford
James D. Teller
John T. Thomas

Robert M. W. Travers
Otis C. Trimble
Lillian E. Troll
Read D. Tuddenbam
Harold S. Tuttle
Howard F. Uphoff
Arnold R. Verduin
Edgar C. Virene
Virginia W. Vocks
Florence S. Volkman
John L. Wallen
Arthur C. Ward
Robert J. Wherry
Lawrence Whisler
Carlton E. Wilder
Louis P. Willemin
John M. Willets
Nannie Mae Williams
William R. Wilson
Miriam Winthrop
Beryl B. Wisman
Louise R. Witmer
Kenneth Wood
Sarah Zakin
Edwin Ziegfeld
Ernest H. Ziegfeld

APPENDIX F

Location Shifts and Geographical Expansion of ARI, 1951 – 1982

Shunted from the Pentagon to New York City in 1943, and back to the Pentagon in 1947, ARI finally felt sufficiently stabilized by 1951 to establish its first "brass instrument" laboratory—a night vision facility requiring not only hard-to-get Pentagon office space but a space laboriously configured to be completely lightproof. If the reasons for success in establishing such a facility were artifactual ones (reportedly ARI gained support for this project in large part because a general officer concerned about his vision needed frequent testing), at least the effort to establish the facility illustrated the eagerness of the staff to be outwardly more "scientific" in its research programs and approaches. But competing demands for Pentagon space soon overrode the requirements of personnel research; in March 1951, ARI was invited to move to the Wake Building in Northeast Washington, D.C.—the living quarters of Navy nurses during World War II.

In November 1958, ARI was evicted from Wake just ahead of the demolition crews intent on making room for a portion of the Memorial Stadium parking lot. The organization now moved to the Tempos adjacent to the National Military University at Fort McNair, although the Tempos had been scheduled for demolition only a few months prior to the move. However, ARI's stay at Tempo A lasted 10 years. (The Tempos were still standing in 1983.) In June 1968 a move to new Commonwealth Building accommodations in Rosslyn adjacent to the DARPA Building was directed. This occupancy lasted until May 1977, when the opening of the Rosslyn Metro Station was imminent. ARI then moved to the DARCOM Building on Eisenhower Avenue, the home of the headquarters of the Army R&D Materiel and Readiness Command. ARI's nomadic existence thus lasted 40 years.

During the last decade, ARI headquarters expanded as well as moved. Starting in the late 1960s, the field unit structure began to take shape; the first field unit was established in July 1969 at the Presidio of Monterey, California, and the second at Fort Hood, Texas, in November 1971. Units were then established in August 1974 at Fort Benning, Georgia; Fort Bliss, Texas; Fort

Rucker, Alabama; and Fort Knox, Kentucky. In each of these cases, ARI took over training research units formerly associated with HumRRO. Additional field units were established at Fort Leavenworth, Kansas, on October 23, 1974; at USAREUR in Heidelberg, Germany, on October 7, 1975; and at Fort Sill, Oklahoma, on October 26, 1976. Scientific Coordination Offices were established in London, England, in March 1973; at TRADOC, Fort Monroe, Virginia, on August 19, 1975; at FORSCOM, Fort MacPherson, Georgia, on June 2, 1977; and at the Administration Center, Fort Benjamin Harrison, Indiana, on August 18, 1977. In September of 1982, five field units were designated as Centers of Excellence—centers that would be expected to grow in time in scope, diversity, and scientific personnel. These were Fort Bliss, Fort Knox, Fort Leavenworth, Presidio of Monterey, and Fort Rucker.

APPENDIX G

HumRRO's Major Areas of Research for the Army

HumRRO has concentrated on improving individual performance. Research has produced training programs for several enlisted military jobs: missile operators; electronics repairmen; radio operators; medical corpsmen; and tank gunners, drivers, and loaders. Other instructional programs have been prepared to fit into existing courses such as rifle marksmanship, tank gunnery, air-to-ground and ground-to-air observation, vehicular maintenance, techniques of night observation, and various aspects of electronic maintenance. Background data for this kind of development have come from detailed studies of job performance and the measurement of military proficiency in a variety of situations (Crawford, 1974).

Job manuals and aids have been substantially revised in form and content to make them more effective from the user's point of view. Considerable research has been done on design principles as they relate to training and on efficient utilization of devices for instruction in fixed procedures, motor coordination of vehicle operators, electronics troubleshooting, and piloting aircraft. A concept for a computer-based, synthetic flight-training system arose from analytical studies of helicopter soldier-machine interactions and research on learning.

Studies of attitudes and changes in attitudes over time have been examined—attitudes toward the Army during the period of first enlistment and attitudes of career soldiers toward various aspects of their assignments. Experiments have contributed to an understanding of how to develop resistance to the stresses of combat. Systems for measuring the growth of confidence during phases of training have been validated. Teamwork and cooperation in small military units have been studied in infantry squads (both in training and in combat), in antiaircraft batteries, in tank platoons, and in combat patrols. An attempt has been made to isolate the relative effect of individual competence, group cohesion, and team spirit. There is some evidence that training can produce habits of cooperation that will transfer to other situations.

Training for Leadership, Command, and Control

To explore leadership requirements and behavior, a program of instruction has been developed for selected graduates of basic combat training. The program enables its graduates to take positions of leadership in later stages of training and also prepares them for formal NCO status and duties later in their careers. Duties and responsibilities of infantry officers have been studied through interviews under combat conditions and from review of extensive combat reports. Factors determining effective leadership in garrison, as well as technical requirements for junior officers in command of complex radar and missile equipment, have also been examined; these studies provide background for consultation on programs of officer candidate schools, for the determination of objectives of ROTC programs, and for establishing the curricula of Army courses for junior officers. Self-instructional materials covering complex system checks have been developed for on-the-job use by junior air defense officers. For senior officers, experiments have dealt with decision making, span of control, and requirements for manual override in the monitoring of complex automatic weapon systems. A comprehensive review of the social science and military literature on leadership at higher levels of command has been summarized in the Army publication, "Leadership at Senior Levels of Command."

Training Technology

Job sample proficiency tests were developed to measure job skills of course graduates and thereby to assess the efficiency of the training program. Absolute performance standards for the job, derived from the minimum performance required for effective system output, are necessary for assessment of the cost effectiveness of the training. Projects have been specifically set up to gather general methodological information: retention of knowledge and skill over different kinds and periods of military duty; effects of traditional variables such as massed and distributed practice and spaced learning; basic research on the taxonomy of training variables; methods for visual presentation; and management of reinforcement in learning.

Programmed instruction has been given substantial attention, both in the building of specific programs and in the study of basic variables. Job capability of soldiers who had lower-than-average aptitudes was studied through comparative measurement of performance of trained soldiers in lower, middle, and upper ranges of aptitude in common Army jobs. Relationships between aptitude levels and learning achievement have been studied under various methods of instruction; such research has direct relevance for civilian programs for training and educating the disadvantaged.

Variables affecting student performance in Army schools and training centers, including attitudes and motivation toward entering certain training programs, variations in management practices in training centers, and the effectiveness of an orientation program were studied. Research on human factors requirements early in system design have implications not only for the configuration of hardware components but also for the development of necessary knowledge and skills in potential human components. Studies have explored training on new equipment and have prepared models of the training and human factors considerations in system development.

HumRRO publishes an *Annual Cumulative Bibliography,* which contains annotations of its more important reports.

APPENDIX H

Organizational Lineage of the U.S. Army Research Institute for the Behavioral and Social Sciences

Organizational name	Affiliation*	Date
Psychological Examining	Medical Department	August 1917
Division of Psychology	Surgeon General	January 1918–1919
Personnel Testing Section	AGO	April 1939
Personnel Research Section	AGO	July 1940
Personnel Research Branch	AGO	January 1953
Human Factors Research Branch	AGO	October 1959
Army Personnel Research Office	OCRD	December 1961
Behavioral Science Research Lab	OCRD	March 1967
Behavior and Systems Research Lab	OCRD	December 1969
Army Research Institute	OCRD	October 1972
Army Research Institute	ODCSPER	May 1974

*AGO—Adjutant General's Office
OCRD—Office of the Chief of Research & Development
ODCSPER—Office of the Deputy Chief of Staff for Personnel

APPENDIX I

Partial Roster of Scientific Personnel, 1947 – 1959

Alan A. Anderson
Sidney J. Armore
Donald E. Baier
Dorothy F. Barnett
Abraham G. Bayroff
Rudolph G. Berkhouse
Mark Biegel
Abraham H. Birnbaum
Claudia D. Bivins
Daniel J. Bolanovich
Robert F. Boldt
Stanley F. Bolin
Harry Bornstein
Kenneth H. Bradt
Hyman Brandt
Hubert E. Brogden
Emma E. Brown
Rufus Browning
Joyce Brueckel
Laverne K. Burke
Joel Campbell
Yolanda Campbell
Frederick O. Carleton
John B. Carroll
Anthony E. Castelnovo
David Chesler
Joyce Cooper
Bertha H. Cory
John E. de Jung
Elaine Deskin
Delany A. Dobbins
Arthur J. Drucker
Samuel Dubin
Adrian Dubuisson
Theodore F. Dunn
Gloria Falk
Herman Feifel
David J. Fitch
Edward Fleischman
Eli Frankfeldt
Edmund F. Fuchs
Richard H. Gaylord
Wilfred A. Gibson
Solomon Goldberg
Leon G. Goldstein
Donald Gordon
Eugene Gordon
Leonard V. Gordon
Frank S. Greenberg
Helen R. Haggerty
Harry Harman
Lindsay R. Harmon
William H. Helme
Marshall Heyman
Richard E. Hilligoss
Arthur C. Hoffman
Thomas J. Houston
William Hoyt
Barry T. Jensen
Cecil D. Johnson

Wayne Jones
Harry Kaplan
E. Kenneth Karcher
Aaron Katz
Carol Kehr
Frank Kellmayer
Samuel H. King
Walter A. Klieger
Leo J. Kotula
Herbert B. Leedy
Sheldon Levin
Milton Levine
Robert F. Lockman
June C. Loeffler
Neil Lovelace
Ardie Lubin
Claire Machlin
Harriet Markey
Stanley Markey
Melvin R. Marks
Joseph E. Marron
Harold Martinek
Harold McAdoo
John J. Mellinger
Mary A. Morton
Charles I. Mosier
John Mundy
Robert Neel
Myrtle Newlin
Hobart Osburn
Jack A. Parrish
Sherwood H. Peres
Robert Perloff
Julius M. Peters
Jack Ranes
John Rawlins
George Retholz
Mary E. Reuder
Seymour Ringel
Albert R. Robins
Nathaniel Rosenberg
Gabriella Rosenberger
Howard L. Roy
Edward L. Rundquist
Eva Russell
Robert Sadacca
Taube Sass
Elaine Saunders
Jack Sawyer
Kenneth Schenkel
Albert I. Schwartz
Leonard C. Seeley
Dennis Seidman
Darryl Severin
Harold L. Sharp
E. Donald Sisson
Donald M. Skordahl
James A. Sprunger
Jack J. Sternberg
Dorothy Stevenson
Dorothy Sylvia
Roland Tanck
Erwin K. Taylor
Kenneth Thompson
Robert Tiemann
Naomi Towler
James B. Trump
Velmont Tye
Charles Tyson
J. E. Uhlaner
Neil J. Van Steenberg
Marjorie Walker
Arla Weinart
Robert F. White
Louis P. Willemin
Ben Winer
Irving A. Woods
Henry Zagorsky
Joseph Zeidner

APPENDIX J

U.S. Army Personnel Programs Using ARI Psychological Tests

Program	Test(s)	1962 Personnel Affected
Preenlistment screening of male enlistment applicants	Enlistment Screening Test (EST)	364,800
Screening of male enlistment applicants	Armed Forces Qualification Test (AFQT)	282,400
	Army Qualification Battery (AQB)	197,700
Preenlistment screening of female enlistment applicants	Women's Enlistment Screening Test (WEST)	8,100
Screening of female enlistment applicants	Air Force Women's Selection Test (AFWST) and Women's Army Classification Battery (ACB)	5,400
Enlistment screening of male reserve and National Guard applicants	AFQT (Reserve Components Edition) AQB (Reserve Components Edition)	290,000
Screening of Selective Service registrants	AFQT	885,300
	AQB	178,400
Detecting deliberate AQGT failures	In terminal screening procedures	44,100

Screening of insular Puerto Rican Selective Service registrants	Examen Calificacion de Fuerzas Armadas (ECFA) English Reading Test (ER)	12,900
Initial classification of enlisted male personnel	Army Classification Battery of 11 tests, converted into aptitude areas	370,500
Initial classification of motor vehicle drivers	Motor Vehicle Driver Selection Battery I (MDB – 1)	370,500
Classification of personnel for Arctic assignment	Self-Description Blank – SA (if Aptitude Area IN not available)	50
Selection of basic trainees for training as acting NCOs	Leadership Potential Rating (LPR)	83,800

Program	Test(s)	1962 Personnel Affected
Licensing drivers of Army motor vehicles	Motor Vehicle Driver Selection Battery II (MDB – II)	216,000
Selection of personnel for foreign language training	Army Language Aptitude Test (ALAT)	72,500
Selection of insular Puerto Ricans for basic military training	English Fluency Battery (EFB) Army Classification Battery (ACB)	5,500
Measurement of foreign language proficiency	Army Language Proficiency Tests*	49,500

*Tests are available in the following languages: Albanian, Arabic Iraqi, Bulgarian, Burmese, Chinese Cantonese, Chinese Mandarin, Czech, Danish, Dutch, Finnish, French, German, Greek, Hebrew, Hungarian, Icelandic, Indonesian, Italian, Japanese, Korean, Lithuanian, Norwegian, Persian, Polish, Portuguese, Romanian, Russian, Serbo-Croatian, Slovenian, Spanish, Thai, Turkish, Ukrainian, Vietnamese, and Yiddish.

Selection of enlisted recruiters	Recruiter Self-Description Blank, Form II	900
Measurement of skill in shorthand and typing	Typing and Dictation Test	Not available
Selection for training and assignment in Special Forces organizations	SF Selection Battery: SF Locations Test, Critical Decisions Test, SF Suitability Inventory	3,500
Selection for fixed-wing aviation training	Army Fixed-Wing Aptitude Battery (AFWAB – 2)	100
Selection of ROTC cadets for fixed-wing aviation training	Army Aviation Test Battery	1,000
Selection for helicopter pilot training	Army Rotary-Wing Aptitude Battery	100

Program	Test(s)	1962 Personnel Affected
Selection of cadets for junior college ROTC training	General Screening Test (GST)	1,000
Selection of cadets for senior division advanced ROTC	ROTC Qualifying Examination (RQ)	50,000
Leadership evaluation of ROTC summer camp trainees	The Field Problems Test (FPT) ROTC	12,400
Selection for admission to U.S. Military Academy entrance examinations	West Point Selection Battery	900
Selection of male personnel for Officer Candidate School	Officer Candidate Selection Battery	148,200
Selection of female personnel for Officer Candidate School	WAC Officer Candidate Selection Battery	50

Appointment of male personnel as Reserve Warrant Officers	Officer Leadership Qualification Inventory (OLI), Officer Leadership Board Interview (OLB), Interview Appraisal Sheet S	1,700
Appointment of female personnel as Reserve Warrant Officers	WAC OCS Biographical Information Blank (BIB), WAC Officer Candidate Application Interview, Interview Appraisal Sheet S	20
Appointment of male personnel to commissions in the U.S. Army Reserve	OLI, OLB, and Interview Appraisal Sheet M	200
Appointment of WAC personnel to commissions in the U.S. Army Reserve	WAC OCS BIB, WAC Officer Candidate Application Interview, Interview Appraisal Sheet M	100
Measuring educational achievement of officer applicants	Educational Requirements Test (ERT)	120
Appointment of male personnel to commissions in the Regular Army	Interview Blank, Form 4 BIB, Form F OLI, OLB, Officer Leader Rating (OLR), ROTC Inventory, ROTC Evaluation Report, Interview Appraisal Sheet S	6,770

Program	**Test(s)**	**1962 Personnel Affected**
Appointment of female personnel to commissions in in the Regular Army	WAC Officer Interview, WAC Officer BIB, WAC Officer Candidate Application Interview, WAC Officer Candidate Application Report, WAC OCS BIB, Board Interview	100

APPENDIX K

Partial Roster of Scientific Personnel, 1960 – 1971

Earl C. Abbe
Alan A. Anderson
Donald E. Andre
Robert S. Andrews, Jr.
Alfred A. Arbogast, Jr.
James D. Baker
Paul A. Banas
James H. Banks
Paul J. Barnes
Henry D. Barton
Abraham G. Bayroff*
Erwin W. Bedarf
D. Bruce Bell
Rudolph G. Berkhouse
Philip J. Bersh
Donald E. Biesenbach
George F. Bigelow
Gean G. Bigler
Abraham H. Birnbaum*
Claudia D. Bivins
Robert F. Boldt
Stanley F. Bolin
Hubert E. Brogden
Emma E. Brown
George G. Burgess
Laverne K. Burke
Anthony E. Castelnovo
Marjorie O. Chandler
Stanley L. Cohen
Royer F. Cook
Bertha H. Cory
Wendy J. Culver
Roberta W. Day
Henry J. de Haan
James J. de Jonge
Barnett Denton
Delany A. Dobbins
James A. Donoghue
Richard D. Doorley
Ronald G. Downey
Arthur J. Drucker
Adrian Dubuisson
George H. Dunteman
E. Ralph Dusek
Robert F. Eastman
William J. Edison
Francis M. Farrell
John P. Farrell
Robert Fink
Myron A. Fischl
Janice Fish
David J. Fitch
Eli Frankfeldt
Margaret E. Franklin

*Chief of a technical area or of a major field unit during most of this period.

Edmund F. Fuchs
Charles S. Gersoni
Wilfred A. Gibson*
George M. Gividen, Jr.*
Leonard V. Gordon*
Frances C. Grafton
Warren R. Graham
Thomas M. Granda
Calvin G. Green
Ann G. Griffith
Stanley M. Halpin
Charles H. Hammer
Guthrie D. Hardy
Kenneth W. Haynam
Emil F. Heerman
William H. Helme*
Richard E. Hilligoss
Robert F. Holz
Joyce L. House
Thomas J. Houston
Aaron Hyman
Thomas E. Jeffrey
Cecil D. Johnson
Edgar M. Johnson
Rudolph L. Kagerer
Harry Kaplan
Michael Kaplan
E. Kenneth Karcher*
Aaron Katz
John J. Kessler
Samuel H. King*
Walter A. Klieger
Leo J. Kotula
Donald M. Kristiansen
Willard D. Larkin
John T. Larson
Eloise D. Lyles
Douglas H. MacPherson
Milton H. Maier
Martin Marder
Robert A. Marion
Melvin R. Marks*
Harold Martinek
Robert L. McMullen
Francis F. Medland
David J. Meister
John J. Mellinger
Martin Mendelson
L. A. Meyer
Charles F. Moore
Mary A. Morton
Marshall A. Narva
Leon H. Nawrocki
Myrtle T. Newlin
Charles O. Nystrom
Jerome L. Olans
Pauline T. Olson
Isaac D. Orleans
Julius M. Peters
John T. Preston
Helen Price
Douglas A. Ramsay
George E. Renaud
Seymour Ringel*
John E. Robinson
Robert T. Root
Robert M. Ross
Arthur I. Rubin
Jesse C. Rupe
Thomas G. Ryan
Sidney A. Sachs
Robert Sadacca*
Edward M. Sait
Michael G. Samet
Bryan A. Sargent
Robert M. Sasmor
Joel M. Savell
Ann L. Schumacher
Alfred I. Schwartz
Linda B. Schwartz
Leonard C. Seeley
Exequiel R. Sevilla, Jr.

*Chief of a technical area or of a major field unit during most of this period.

Raymond G. Sidorsky
Donald M. Skordahl
Paul F. Smith
Richard C. Sorenson
Jack J. Sternberg*
Dorothy J. Stevenson
Eugene P. Stichman
Harold C. Strasel
Michael G. Strub
Joel R. Stubbs
James A. Thomas
John G. Tiedemann
Ernest A. Tracey
Marvin H. Trattner
James B. Trump
John R. Turney
J. E. Uhlaner
Sally J. Van Nostrand
Frank L. Vicino
Marjorie A. Walker
Ruth T. Walton
Carrie J. Waters
Lawrence K. Waters
Solomon A. Weinberg
Robert K. White
Roland A. Wilburn
Roger L. Williamson
Louis P. Willemin
Martin F. Wiskoff
Joanne M. Witt
David W. Witter
Larry E. Word
Louise G. Yates
Joseph Zeidner

*Chief of a technical area or of a major field unit during most of this period.

APPENDIX L

Training and Personnel Technology Program Elements

Army

Training, Personnel, and Human Engineering
Human Factors in Systems Development
Human Performance Effectiveness and Simulation
Manpower, Personnel, and Training
Non-Systems Training Development Technology
Synthetic Flight Simulators
Manpower and Personnel
Non-Systems Training Devices Development
Human Factors in Training and Operation Effectiveness
Education and Training
Training Simulation
Synthetic Flight Training Systems
Non-Systems Training Development Engineering
Educational and Training Systems

Navy

Behavioral and Social Science
Human Factors and Simulation Technology
Personnel and Training Technology
Human Factors Engineering Development
Manpower Control Systems Development
Man–Machine Technology
Education and Training
Navy Technological Information for Present Systems
Medical Corps Advanced Manpower Training Systems
Training Development Technology

Training Prototype Development
Prototype Manpower/Personnel Systems
Air Warfare Training Development
Surface Warfare Training Development
Submarine Warfare Training Development

Air Force

Human Resources
Aerospace Biotechnology
Training and Simulation Technology
Personnel Utilization Technology
Advanced Simulator Technology
Innovations in Education and Training
Flight Simulation Development

APPENDIX M

Examples of Manpower and Personnel Research in the Services

Army Research

Develop alternative methodologies for estimating the manpower supply-and-demand implications of new systems design. Models and predictive techniques will be used to match the impact of the decreasing national manpower pool against the apparent increase in numbers and quality of manpower required to operate and support increasingly complex and sophisticated weapons systems. A system will be developed that integrates manpower, personnel, and training considerations throughout the weapons system development cycles.

Develop methods to optimize the career progression patterns of officers. Factors include individual experience, competence, and career goals. Army utilization requirements are collected in a data base to present information on alternative career paths. Improved retention is expected, based on better person-to-job match and increased job satisfaction.

Improve and revalidate a performance-based rotary-wing aviation selection process based on psychomotor, perceptual, and cognitive capabilities required in the performance of flight maneuvers, using an existing UH-1 helicopter simulator as the evaluation device. Tasks, skills, and specialized aptitudes necessary for the Army's four distinct aircrew mission specialties will be used as criteria for this test battery.

Construct a battalion command competency model and produce improved techniques for leaders and commanders in integrating soldiers into their units. Develop a program for improving officer decision-making skills.

Develop systems that use the latest automated techniques to counsel, classify, and commit desired positions to potential recruits.

Quantify effects of crew turbulence on tactical performance of armor units and develop techniques to reduce these effects through field validation.

Navy Research

Develop and validate methods to forecast Navy support manpower requirements based on size and mix of fleet units and weapons systems.

Develop a composite input-output model that allows accurate prediction of changing fleet size, mix, and operating tempo on shore activity workloads.

Develop improved procedures for making recruitment, selection, and assignment decisions based on new developments in personnel measurement technology such as computer-based testing, job sample assessment centers, and job-task measurement.

Improve future ability to recruit, manage, and retain personnel by determining how heterogeneity in work groups relates to group productivity of Hispanics.

Conduct personnel performance measurement and evaluation research for occupational and career development, training, and education.

Develop and test a set of interventions designed to reduce attrition, nonjudicial punishments, and desertions.

Conduct a requirements analysis for a Marine Corps computer-based instructional system.

Air Force Research

Develop management procedures to improve accommodation and utilization of Air Force personnel interests, experience, and career orientation. Specific attention will be focused on reassignment to compatible jobs, correcting manning imbalances, and retention.

Determine and demonstrate significant relationships between vocational interest and job satisfaction. (Use of vocational interest in the assignment algorithm is expected to affect favorably career decisions and completion of first-term enlistment.)

Continue development of an automated adaptive testing system with experimental demonstration of the feasibility and utility of using this methodology in an operational setting. (Other studies in adaptive testing have provided significant advances in item calibration theory and technology.)

Define physical characteristics of individuals in terms of their qualifications to perform physically demanding Air Force jobs.

Develop and evaluate prototype computer-based technical data systems to facilitate the productivity of Air Force maintenance personnel.

APPENDIX N

Examples of Education and Training Research in the Services

Army Research

Improve the efficiency of the Basic Skills Education Program (BSEP) through the development of new prototype, technology-based delivery systems for basic skills.

Study the appropriate division of labor between computers and human operators through use of basic problem-solving skills involved in diagnostic procedures.

Improve learning strategies for soldiers with varying skills.

Develop methods that enable embedded training systems to administer and score operator performance tests and to provide training for teams as well as for individuals.

Determine the applicability of CAI for teaching psychomotor skills (i.e., heavy machinery operation and transfer of training to actual equipment operation).

Investigate the effects of context-free troubleshooting training on the performance of situation-specific troubleshooting and interaction with the presence or absence of computer aids.

Continue development of inexpensive methods and materials for weapons system training such as the "Handbook for Sight Picture Training." These techniques have provided inexpensive, portable, self-paced training programs for tank gunners and have provided telescope and periscope sight pictures. Preliminary evaluations suggest an increase in tank gunner performance of 22 percent.

Develop, install, and evaluate a unit maintenance performance system in a Direct Support Maintenance Battalion to determine the best way to train and sustain maintenance skills on the job.

Improve tank crew gunnery performance and unit training. Initial efforts will concentrate on developing and testing a set of dry-run exercises to build gunners' skills without moving the tank or firing the gun.

Initiate joint service engineering development of low-cost, training-effective instructional systems, devices, and methods to improve the training capabilities of the Army, Navy, and Air Force. The objective is to apply recent advances in information technology to the education and training needs of the services and to identify technology-based instructional methods that can be used by more than one service. The effort will enhance the performance and proficiency of combat forces by optimizing the development of skills during training.

Navy Research

Develop team assessment methods that permit identification of specific weaknesses in team training and allow appropriate feedback to team members.

Develop performance aids and test evaluation procedures to reduce the dollar investment in formal classroom training during the first enlistment. An initial product will be trade-off criteria for on-the-job versus resident training.

Develop a prototype system for training a wide range of skills for maintaining electronic equipment. The system will be based on the generic concept of "families" of equipment and maintenance tasks to minimize use of operational equipment and maximize transfer of learning.

Develop new training and job simplification methods to reduce the impact of reading comprehension and mathematics deficiencies among recruits.

Design, develop, test, and evaluate a job-performance-aid-based integrated personnel model that accounts for all necessary attributes of a personnel system while ensuring that the use of fully integrated job performance aids yields long-term payoffs.

Air Force Research

Determine how much training time must be invested to retain or reacquire specific flying skills.

Provide new empirical data, evaluation techniques, and management systems for effective enhancement and sustainment of the on-the-job training program

in support of Air Force training policy and combat readiness. Applications to training programs of the other services are expected.

Develop computer-based technical training technology to improve the quality and cost effectiveness of resident and on-the-job training and management.

Develop new methods to enhance maintenance personnel performance, combat proficiency, and repair procedures. Models and predictive techniques for considering logistic implications of early design trade-off studies in weapons systems acquisition are included.

Develop new techniques to enhance the training performance and combat readiness of Tactical Command and Control teams.

APPENDIX O

Examples of Human Factors Research in the Services

Army Research

Develop technology to reduce combat vehicle noise and counter the impact of noise and blast on human performance.

Enhance performance of human operators through the use of new scientific information on peripheral vision.

Conduct field experiments on the performance of complete artillery weapons systems (Human Engineering Laboratory Battery Artillery Test, or HELBAT) to determine system deficiencies.

Refine the prototype development of an artillery training device that requires no live firing. Using dummy rounds, dummy prop charges, and gunfire simulation, training can be conducted 24 hours a day on post without moving into the field.

Validate the *Human Resources Test and Evaluation System (HRTES) Handbook,* which provides a practitioner with general rules for identifying critical issues, measures, techniques, and criteria of human performance.

Develop improved formats, symbols, procedures, and feedback techniques to provide more effective information to combat personnel using automated systems to interpret tactical events.

Develop methods for identifying critical dimensions of human performance in land combat. Develop models using human performance parameters that will contribute to improved command, control, communication, and intelligence processes and other operations that make human performance a factor in combat outcomes.

Develop design guidelines for dynamic displays to analyze task complexity and to determine relationships between skill requirements and task design. This effort will produce decision-making techniques and automated aids for efficient processing of information.

To aid in modernizing the force, develop a methodology for soldier-computer task allocation, design guidelines for soldier-computer transactions, assess display symbology requirements in battlefield automated systems, and make the transition from a manual to a computer-support command and control operator.

Navy Research

Develop common methods and data sources for use by system designers when estimating needed skill levels of military personnel. This effort will reduce instances of task overload and performance degradation and lead to the best use of available personnel.

Enhance human engineering capabilities by developing analytical and experimental methods and models to identify criteria of human performance.

Explore implications of voice technology on human factors to determine parameters for using voice recognition and synthesis technology to enhance training, reduce instructor personnel, and develop interactive systems by which voice requests or commands will secure data or change status.

Develop computer-assisted human engineering methods to design and evaluate weapons systems. These systems will provide designers and analysts with standardized approaches to incorporating considerations of operability and maintainability in the design of weapons systems.

Air Force Research

Integrate, demonstrate, and validate the methods and techniques involved in planning and considering the human resource and logistics factors of a weapons system starting with milestone zero of the acquisition process.

Develop techniques to measure, comprehend, and model human performance under the demanding workload conditions associated with advanced weapons system control.

Develop human factors engineering (HFE) control, display, and design standards and criteria, as well as HFE simulation requirements of complex man-machine systems for strategic and tactical weapons systems; command and control systems; maintenance design; and operational decision aiding.

Specify characteristics of the human visual system in terms compatible with evolving sensor-display processor technology.

Develop and evaluate the utility of a system of automated performance measurement for use in selected operational training programs. The C5A aircraft has been selected as the test system.

APPENDIX P

Examples of Simulation and Training Devices Research in the Services

Army Research

Develop a family of laser engagement systems compatible with the Multiple Integrated Laser Engagement System (MILES) infantry and armor training system. The objective is to provide realistic surface-to-air and air-to-ground weapons simulation for such systems as the Chaparral, VULCAN, REDEYE, STINGER, TOW, and HELLFIRE.

Develop the Army Training Battle Simulation System (ARTBASS), a high-fidelity, computer-driven battle simulator that will train for brigade and battalion arms operation.

Develop engagement simulation techniques for advanced nonsystems training devices using eye-safe lasers. These devices support the Army in training with selected weapons and will evolve into a total battlefield training capability. The Marine Corps has recently modified some of these techniques for its use.

Design criteria for an aviation training research facility and procedures for application of videodisc technology for tactical training and skill qualification testing.

Develop visual simulation components designed to provide full mission training capability for nap-of-the-earth (NOE) flight, navigation, gunnery, and survivability in a combat environment. These simulation devices will enhance the navigational, target recognition, and acquisition skills of rotocraft system crews, thereby increasing the combat readiness and proficiency of the Army's aviation community. Also develop simulation of the combat environment for tactical flight, including NOE, weapons engagement, and enemy interaction, to provide realistic and cost-effective training in a totally safe environment.

Exploit state-of-the-art technology of microprocessors, interactive displays, and computer technology to develop low-cost, multipurpose maintenance trainers.

Navy Research

Develop and demonstrate the feasibility of using simulators to teach "hands-on" maintenance training in lieu of using actual equipment. These coordinated programs will produce experimental models to evaluate the effectiveness and applicability of simulation technology to intermediate maintenance training.

Develop methods to improve air combat performance of Navy pilots. As part of the effort, a special "envelope recognition training program" has tripled the number of "kills" made on the Tactical Aircrew Combat Training System.

Develop a prototype computerized support package that will help the instructors of both existing and future simulators to conduct routine training through automated monitoring of student performance, measurement and assessment, and automated execution of instructional support functions.

Develop a ship combat trainer capable of simulating a multiship, multithreat environment. The trainer will be used for training the combat system team, subsystem teams, or individual operators of the Combat Information Center and Sonar Control Room equipment.

Develop a Tactical Action Officer Trainer that will provide antiair warfare, surface warfare, and antisubmarine warfare data and display in an authentic manner so that students can practice, achieve proficiency, and be evaluated in decision-making expertise in a variety of single and multithreat tactical situations.

Address the incorporation of small, portable, computer-based job aids in the initial schooling and in the on-the-job training cycle of a maintenance trainee. The job aids would provide procedural guidelines rather than reliance on instructors or supervisors and written text. Additionally, this effort will set the framework for future incorporation of synthetic speech and interactive graphics.

Determine the conditions under which increased realism produces better training, as in evaluating the effectiveness of visual technology on pilot performance and training.

Air Force Research

Develop more cost-effective alternatives to the use of actual equipment trainers for maintenance training. (The trainer failed to meet requirements of reliability, availability, safety, cost, and fault insertion.)

Develop, demonstrate, and test the technology required for high-fidelity, out-the-window visual simulation for tactical aircraft. The display will provide high-resolution targets with an enriched ground image. Advanced computer-image generation (CIG) employing texturing and contouring of the ground plane will be used for the image sources.

Conduct flight simulation research and demonstrate the cost effectiveness of using advanced aircraft simulators for pilot training research.

Enhance flight training programs through development and application of new instructional methods, techniques, and devices for both undergraduate and combat crew levels. Emphasis will be on investigating improved uses of simulation and innovative training media and instructional strategies with the greatest potential for cost reduction.

Develop alternative techniques of simulation with sufficient fidelity for aircrew training and the exercise and assessment of weapons systems. This research includes the development and evaluation of advanced concepts and psychophysical and perceptual design criteria for simulation.

APPENDIX Q

Partial Roster of Scientific Personnel, 1972–1983

Earl C. Abbe
Charles Abzug
Irving A. Alderman
Donald E. Andrew
Robert S. Andrews*
Donna C. Angle
Jane M. Arabian
Alfred A. Arbogast, Jr.
Joyce I. Ardale
Nahama E. Babin
James D. Baker*
Richard M. Balzer
James H. Banks
Herbert F. Barber
Paul J. Barnes
Helena F. Barsam
Henry D. Barton
Robert W. Bauer
Erwin D. Bedarf
David B. Bell
Melissa S. Berkowitz
David W. Bessemer
Robert E. Betty
William R. Bickley
Donald E. Biesenbach
Gean B. Bigler
Abraham H. Birnbaum*
Helen J. Biscan
Claudia D. Bivins
Barbara A.. Black
Arlene D. Blose
Douglas J. Bobko
John A. Boldovici
Stanley F. Bolin
Alan C. Boneau
Larry W. Brooks
Denna J. Brown
Emma E. Brown
William R. Brown
Beverly A. Buford
George G. Burgess
William P. Burke
Susan L. Burroughs
Brian J. Bush
Ralph R. Canter*
Leonard B. Cardwell
Carolyn A. Carroll
Robert M. Carroll
Richard J. Carter
John A. Cartner
Anthony E. Castelnovo
Randall M. Chambers
Stanley L. Cohen
Jay S. Coke

*Chief of a technical area or of a major field unit during most of this period.

Royer F. Cook
Stephen M. Cormier
Bertha H. Cory
Lloyd M. Crumley
Wendy J. Culver
Charles J. Dale
Edward J. Dawdy
Robert N. Daws
Roberta W. Day
Henry J. de Haan
John A. Dohme
Richard D. Doorley
Kate D. Dorrell
Ronald G. Downey
John D. Dressel
Michael Drillings
Arthur J. Drucker
Neil S. Dumas
E. Ralph Dusek
Frederick N. Dyer
Jean L. Dyer
William K. Earl
Robert F. Eastman
Newell K. Eaton
William J. Edison
Douglas C. Edwards
Timothy W. Elig
Judith A. Englert
Robert A. Evans
Beatrice J. Farr
Francis M. Farrell
John P. Farrell
Theo-Dric Feng
Alison S. Fields
Michael Fineberg
Dorothy L. Finley
Joyce M. Firsching
Myron A. Fischl
James L. Fobes
Eli Frankfeldt
Edmund F. Fuchs

Paul A. Gade
Charles A. Gainer*
Richard M. Gebhard
Arthur C. F. Gilbert
Curtis L. Gilroy
George M. Gividen*
Dwight J. Goehring
Stephen L. Goldberg
Frances G. Grafton
Thomas S. Granda
Mary J. Granier
Wayne D. Gray
Donald F. Haggard*
Joseph D. Hagman
Stanley M. Halpin
Martin A. Hammer
Lawrence M. Hanser
Guthrie D. Hardy
Joan Harman
Robert S. Harold
Frank J. Harris*
Roland A. Hart
Christine Hartel
William E. Hartung
John F. Hayes
Kenneth Hayes
Robert T. Hays, Jr.
William W. Haythorn
Allyn Hertzbach
Otto H. Heuckroth
Jack M. Hicks
Jack H. Hiller
Patty Hoke
Garvin L. Holman
Douglas S. Holmes
J. E. Holmgren
Robert F. Holz
Jean Hooper
Clifton Houston
Thomas Houston
Charles W. Howard

*Chief of a technical area or of a major field unit during most of this period.

Ralph E. Howard
Aaron Hyman*
Robert Iadeluca
Thomas O. Jacobs*
Thomas E. Jeffrey
Cecil D. Johnson*
David M. Johnson
Edgar M. Johnson
Richard M. Johnson
Daniel B. Jones
Thomas L. Jones
Charles G. Jorgensen
Otto I. Kahn
Harry Kaplan
Ira T. Kaplan
Michael Kaplan
Richard A. Kass
Milton S. Katz*
Judah Katznelson
Carol Keegan
Robin L. Keesee
Richard P. Kern
Susan E. Kerner-Hoeg
John J. Kessler
Melvin J. Kimsel
Nora Kinzer
Beverly G. Knapp
Bruce W. Knerr
Claramae Knerr
Stanley J. Kostyla
Brian L. Kottas
Ronald E. Kraemer
Donald M. Kristiansen
Marcie S. Kronberg
Enrique J. Lamas
John J. Larson
George A. Lawton
Michael P. Letsky
John M. Lockhart
Leland D. Lucas
Eloise Lyles

Arthur J. Lynch
Douglas MacPherson
Milton H. Maier
Arthur Marcus
Robert A. Marion
Clessen J. Martin
Marjorie A. Martin
Harold Martinek
Terry T. May
Pamela V. Mays
Michael McClellan
John M. McConnell
Jack H. McCracken
John F. McGrew
Francis M. Medland
David J. Meister
Larry L. Meliza
John J. Mellinger
Rex R. Michel
John L. Miles, Jr.
Angelo Mirabella
Karen J. Mitchell
Nancy B. Mitchell
Richard B. Modjeski
Richard G. Moffett
Charles A. Moore
John C. Morey
John E. Morrison
Franklin L. Moses
Marshall A. Narva
Leon M. Nawrocki
Karen L. Neff
Abraham Nelson, Jr.
Glenda Y. Nogami
Charles O. Nystrom
John W. O'Hara
Laurel W. Oliver
Darlene M. Olson
Pauline T. Olson
Frank O'Mara
Harold T. O'Neil

*Chief of a technical area or of a major field unit during most of this period.

Ann C. Orr
Rebecca Oxford-Carpenter
Halim Ozkaptan
Richard L. Palmer
Stanley A. Pawlowski
Ruth H. Phelps
Robert J. Pleban
Beverly A. Popelka
Helen Price
David M. Promisel
Joseph Psotka
Douglas A. Ramsey
K. C. Reynolds
Carlos K. Rigby
Daniel T. Risser
Bruce F. Rogers
Frederick T. Rogers
Robert T. Root
Robert M. Ross
Paul G. Rossmeissl
Gail P. Rowan
Michael G. Rumsey
Thomas G. Ryan
James L. Ryan-Jones
Sidney A. Sachs
Edward Sait
Michael G. Samet
Michael G. Sanders
William R. Sanders
Garry G. Sarli
Robert B. Sasmor
Joel M. Savell
Joel D. Schendel
John R. Schjelderup
Edward J. Schmitz
James E. Schroeder
Uldi Shvern
Robert C. Schwalm
Linda B. Schwartz
Thomas G. Scott
Leonard C. Seeley
David Segal
Mady Segal
Joseph P. Severo
Exequiel R. Sevilla, Jr.
Joyce L. Shields
Brian D. Shipley
Rosalyn Shivers
Gary L. Shope
Guy L. Siebold
Zita M. Simutis
Michael J. Singer
Charles J. Slimowitz
Norman D. Smith
Seward Smith
Edwin R. Smutz
Robert E. Solick
Helen M. Sperling
Karen Stack
Jack J. Sternberg*
Dorothy J. Stevenson
Steven R. Stewart
Harold C. Strasel
Michael H. Strub*
Robert H. Sulzen
Bruce H. Taylor
Joseph Taylor
Bettie M. Teevan
Martha S. Teplitsky
Gary S. Thomas
James A. Thomas*
Thomas J. Thompson
T. J. Tierney
Sharon D. Tkacz
Marvin H. Trattner
Truman R. Tremble, Jr.
Daniel R. Tufano
John R. Turney
J. E. Uhlaner
Sally J. Van Nostrand
Paul van Rijn
Carol H. Walker

*Chief of a technical area or of a major field unit during most of this period.

Clinton B. Walker
Marjorie A. Walker
Joseph S. Ward
Mary M. Weltin
Patrick J. Whitmarsh
John A. Whittenberg
Louis P. Willemin
Edward W. Williams
Wayne Williams
Hilda Wing
Robert A. Wisher
Bob G. Witmer
Joanne W. Witt
David W. Witter
Larry E. Word
Robert H. Wright
Louise G. Yates
Elizabeth Yoest
Andrew A. Zbikowski
Joseph Zeidner

APPENDIX R

Military Leaders Who Have Contributed to the Army's Soldier-Oriented Research Program

This history would be incomplete without brief mention of the many military leaders who played vital roles in enhancing, guiding, sustaining, and at times carefully nurturing ARI's research program.

A few of the World War I leaders were W. C. Gorgas, Surgeon General; H. G. Leonard, Adjutant General; John S. Johnston, Adjutant General; and H. P. Birmingham, Brigadier General of the National Army.

Leaders of special note during and after World War II were Col. George R. Evans; Col. Fred C. Milner; Lt. Gen. Arthur G. Trudeau, an early Chief of Research and Development in the Army; General Robert W. Porter, Jr., particularly as Deputy Chief of Staff for Personnel; Col. Robert Storey; General Theodore J. Conway; General James F. Collins, who as DCSPER encouraged development of the aptitude areas; Maj. Gen. Chester W. Clark, particularly when he was Director of Army Research; Lt. Gen. Austin W. Betts, Chief of Research and Development and both a follower and supporter of behavioral science research. Lt. Col. Carroll B. Hodges, Col. Charles S. Gersoni, and Col. Marshall O. Becker commanded what is now the Army Research Institute during that period. Preeminent in providing impetus to training development through HumRRO were General John E. Dahlquist, General Bruce C. Clarke, General Herbert B. Powell, and General Hugh P. Harris.

From the 1960s to the early 1970s important roles were played by the following: Lt. Gen. William C. Gribble, Jr.; Maj. Gen. Charles D. Daniel, Jr.; Lt. Gen. Harold G. Moore, Jr.; Maj. Gen. Robert G. Gard, Jr., particularly in his support of social processes in DCSPER and as head of the Military Personnel Center (MILPERCEN); Brig. Gen. John H. Johns, the first officer knowledgeable in behavioral science to attain the rank of general; and General Bernard Rogers, the leader of the Army's organizational effectiveness program.

From the mid-1970s to the present, dialogues with a succession of Army leaders produced the long-range objectives and research agenda that characterize ARI's program today. Lt. Gen. Paul Gorman emphasized collective training of units in the field; for more than a decade, he worked closely with ARI to encourage the development of high-technology programs as a means of increasing soldier productivity. General Gorman's interests spanned the complete spectrum of ARI's research program; and he continues to be a source of much that is new in the research program. He also continues to be an inspiration for individual scientists as well as an eloquent spokesperson for the program.

General William Depuy reaffirmed that the effectiveness of the unit was a function not only of the weapons and tactics employed but of the proficiency of the unit; thus realistic training was needed. With ARI's help, General Depuy encouraged front-end analysis techniques for assessing the impact of systems on manpower, personnel, and training. From the beginning of his tenure as Chief of Staff, General Edward C. Meyer instituted a program in which ARI had both a natural and very important role: manning the force; training as we fight; and the distributed battlefield. Lt. Gen. Maxwell R. Thurman, in his proactive role as DCSPER, involved ARI in personnel affordability, leadership development, and cohesion/commitment activities. Maj. Gen. William L. Webb, in his concern for more effective communication, helped ARI develop its system of reporting research accomplishments and evaluating utilization of products. Col. Richard A. Rooth served as the first commander of ARI in its current configuration and helped in its transition from a single laboratory to its current structure, including the establishment of field units. Col. William B. Maus was the first commander to focus on soliciting feedback from the user in the field.

The last three officers who commanded ARI served during the period of its most rapid growth in program scope, people, and budget. These officers gave full support to the conduct of basic, exploratory, and applied research, and fully understood the interrelations among these categories.

Col. William L. Hauser concentrated on improving ARI's relations with the Army high command and established a "board of directors" at the Army staff level for program coordination and approval. Col. Franklin A. Hart carried this process further by employing a "Senior User's Review" to refine programmatic issues. He greatly facilitated program structuring to foster better communication, both internal and external. Col. L. Neale Cosby played a central role in "modernizing" ARI by increasing office automation and by encouraging the use of microprocessors in driving laboratory experimentation. He was the central force in bringing the technology of information engineering to the forefront of ARI's program and in taking a total systems view.

During the past several years, ties with the Office of the Under Secretary of Defense for Research and Engineering (OUSDRE) have been consolidated. During the mid-1970s, Col. Henry Taylor, U.S. Air Force, urged the expansion of ARI's programs into simulation and training devices and personally facilitated interservice coordination during his assignment with OUSDRE. Capt. Paul R. Chatelier, U.S. Navy, with equal enthusiasm and dedication to behavioral science achievements, obtained better hearings at congressional and

DOD levels for the service programs during his assignment with OUSDRE. Captain Chatelier endorsed the Tri-Service Commanders/Technical Directors meetings, which have stimulated establishment of joint service programs, especially in engineering development, and also encouraged the development of a taxonomy of behavioral science research and a modernized management information system (MIS) for research and management data.

Index

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
January 1988

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*
September 1982 – March 1983

4. TITLE AND SUBTITLE
Behavioral Science in the Army**:** A Corporate History of the Army Research Institute

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Joseph Zeidner
Arthur J. Drucker

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U. S. Army Research Institute
for the Behavioral & Social Sciences
6000 6TH Street (Bldg. 1464 / Mail Stop 5610)
Fort Belvoir, VA 22060-5610

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U. S. Army Research Institute
for the Behavioral & Social Sciences
6000 6TH Street (Bldg. 1464 / Mail Stop 5610)
Fort Belvoir, VA 22060-5610

10. SPONSOR/MONITOR'S ACRONYM(S)
ARI

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT: Distribution Statement A. Approved for public release, distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The U. S. Army Research Institute for the Behavioral & Social Sciences (ARI) history lies first in understanding the psychological theory and trends surrounding the beginnings of applied psychology, particularly in the military, and in gaining a better understanding of people at work. The broad purpose of this history is to develop a guide for management and employee development for research managers, planners, programmers, and developers today and in the future.

This history can serve a number of different groups: psychologists with a general interest in the history of psychology; scientists with a special interest in areas of emphasis within ARI (such as selection, classification, training, soldier-machine interface, leadership, and microelectronic applications); ARI managers and employees; and proponents and sponsors whose informed involvement is needed in ARI research.

15. SUBJECT TERMS
Behavioral and Social Sciences, Psychology - Military, History, Training - Military

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dorothy Young
Unclassified	Unclassified	Unclassified	Unlimited Unclassified	169	19b. TELEPHONE NUMBER 703-545-2316