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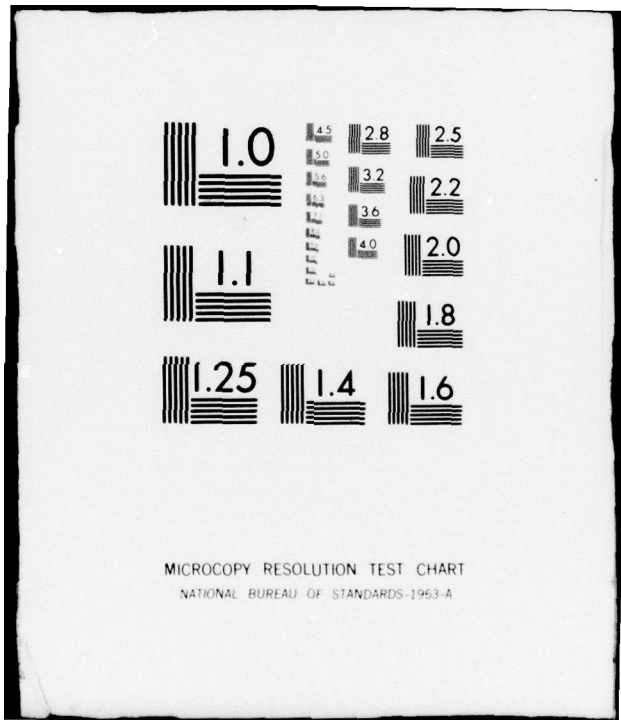
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6 SURVEY OF HUMAN FACTORS IN ARMORED VEHICLES OPERATION

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FOREWORD

SURVEY OF HUMAN FACTORS IN ARMORED VEHICLES OPERATION

Since the beginning of the investigation leading to the preparation of this report, continuing effort has been expended to evaluate the hypotheses and research design in the light of increasing sophistication in this area of research. There have been indications that portions of the research herein proposed are not practical for USAFRO to undertake at this time. The difficulties of obtaining needed facilities and support for research in the armor area have, in fact, necessitated a recommendation to the Chief of Research and Development that the effort as a full-scale task be discontinued, work in progress to validate an experimental selection battery for armor systems personnel being transferred to another task within USAFRO. The report, nevertheless, has been submitted to delineate areas which appear to offer research payoff to the military.

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SURVEY OF HUMAN FACTORS IN ARMORED VEHICLES OPERATION

PURPOSE OF THE SURVEY

Armor has in the past played a prominent role in the successful accomplishment of tactical missions. Without exception, each of the many and varied plans calling for reorganization of the Army's combat force places increased emphasis on the role of armored vehicles such as tanks and personnel carriers. To provide the requisite firepower, mobility, protection, and shock action on the battlefield, the capabilities of armor will be exploited to the fullest. To supply and improve these capabilities, increasingly complex warfare systems have been developed. Optimal exploitation of these systems once they are in operation presents a challenge to the utilization of human skills and abilities. Although developments in guidance systems, automatic weapons, and homing devices can be expected to play an increasing role in armored vehicle operation, the human components remain none the less the controlling elements of the vehicle and its subsystems. Plans for mid-range and long-range time frames, furthermore, call for modifications of combat operations and procedures which may intensify the classic human factors problems associated with armored vehicle operation, including the effects of noise, heat, confinement, and isolation. In line with this thinking, USCONARC has generated a requirement for human factors research in fighting vehicle operation. In order to meet its obligation under this requirement, the US Army Personnel Research Office has conducted this exploratory study to identify problem areas that

1. Focus upon the more critical needs of the Army in the light of current and future requirements.
2. Are observable, measurable, and amenable to research attack.
3. Promise to yield a payoff to the military.

To accomplish this study, USAFRO research scientists became familiar with fighting vehicles, their characteristics and employment. They discussed operational problems with armor personnel and personally observed field activities. They surveyed the literature to become aware of related accomplished, ongoing, and proposed research and research methodology.

BACKGROUND--EVOLUTION OF ARMOR SYSTEMS

The nature of conflict in World War I dictated a need for a weapon to advance across the no-man's land between trenches and destroy the machine-guns that had immobilized infantry. The tank offered a solution to this need for the removal of obstacles. The mission of this tank--to support infantry--required only that it be slow, that it have great crushing power, and that it be capable of withstanding the weapons of the day. The tank was at first only qualifiedly successful. Training in tank warfare was inadequate. In many cases the users were as naive to the potentialities of this new "system" as were the victims. Nevertheless, the new system led men of imagination to envisage a drastic reinterpretation of one element

of combat--the attack. A new type of tank was conceived--made possible by technological advance--which took on the historic role of the cavalry of Napoleonic Armies. Further increase in firepower, in mobility, and in shock-producing capability led to the reorganization of whole units around the tank. Each alteration called for a more capable operator and crew. Propulsion, armament, communication, coordination, all have become exceedingly complex, all making demands on personnel unimaginable in 1916.

With respect to planning for the mid-range and long-range time frames, it is not likely that the basic elements of combat will change. However, once again emphasis on and within various elements has shifted as a result of the tremendous advances in weaponry and the resources of a possible enemy. For the greater part, changes since World War II reflect only marginal improvements in the tank system, suggesting that these new developments are in fact a rebuilding with the same bricks. Current developments in arms, missiles, and tactics suggest further that such rebuilding will prove inadequate.

The greatest changes in armor systems will come as a result of increased kill-power of friendly and enemy weapons and greater mobilization of a possible enemy. Both developments dictate a reinterpretation of the attack phase of warfare. The Army of the mid-range time frame must be prepared to wage war against a well-equipped, highly mechanized, and numerically superior enemy having the capability of nuclear firepower. "Offensive defense" against such an enemy requires a highly mobile Army utilizing principles of defense in depth and counterattack, exploiting its own use of nuclear, chemical/biological, or conventional weapons strike. Anticipated use of nuclear and high yield nonnuclear weapons, as well as an anticipated imbalance of forces, will necessitate dispersion of units to afford the enemy no massed targets for missiles or concentrated attack. Moreover, large tank-heavy forces will have to be kept in reserve to effect crushing counterattacks against the inevitable break-throughs of massed attacks on an extended, dispersed front. Ground will often be controlled through careful surveillance and control of approaches rather than through static occupation.

On this highly mobile, fluid battlefield, heavy blasts from nuclear and nonnuclear ammunition will fill the air with high densities of munitions, which, along with radiation and various types of gasses and other airborne fatal agents, will be extremely lethal to any exposed troops. Widely dispersed concentrations of troops will be massed briefly and redispersed as the situation demands. Friendly strikes of conventional, nuclear, or chemical/biological weapons will be rapidly exploited by vehicles which can carry the attack over the battlefields while offering protection from the immediate and/or lingering effects of friendly and enemy weapons. To wage this type of war, the Army must have weapons and personnel carriers that reflect the principles of firepower, mobility, and shock action. Operators and personnel manning these weapons must also meet new requirements.

VISITS TO FIELD INSTALLATIONS

During visits to field installations (See Appendix A for a list of those visited), task personnel observed exercises and Army Training Tests

and conducted conferences and interviews with enlisted men and officers connected with the Armor School, Combat Developments Units, Training Centers, and Operating Units. Information was developed pertinent to the delineation of research areas which could contribute to an increase in armored vehicle effectiveness.

The prime mission of Armor is to deliver swift, crushing blows utilizing its basic capabilities of firepower, mobility, and shock action. Tanks and other armored vehicles characteristically operate together. It is often upon the skill of the unit commander in coordinating and directing the concerted maneuvers and efforts of his vehicles that the outcome depends. Four basic elements are prerequisite to the effective coordinated performance of an armored unit under the control of an able unit commander: (1) equipment must function; (2) crews must be capable of operating the equipment under the conditions encountered in the field; (3) crews and individuals must be trained and disciplined to respond; and (4) communication channels must be open to allow the commander to issue orders, the vehicle crews to acknowledge or respond to orders. The relative effectiveness of the operation may be stated then, as a function of (1) the design and maintenance of the equipment; (2) the physical capabilities and limitations, the aptitudinal and psychological characteristics of crew members; (3) the developed skills and procedural techniques employed by the crew and crew members in the operation of the machine together with all other factors which might influence the effectiveness of the application of these skills and techniques in the operational situation; and (4) the equipment, procedures, and utilization of communication processes through which orders and information are received, channeled, and fed back through the system.

It is during the relatively brief period of closed combat--in which men are "buttoned-up" within a vehicle--that operations within the tank or armored vehicle are most trying on the crew, physically and psychologically. During this time also factors which might influence the effectiveness of the operator's skills and techniques become most important. Most critical of these factors influencing individual performance are environment, equipment design, and interaction with other crew members.

ENVIRONMENTAL FACTORS IN ARMORED WARFARE

Within the armored vehicle, crewmen are generally either very hot or very cold--reports from crewmen indicate that fans and heaters in present equipment are inefficient and are very seldom used. Noise from the weapons, the engine, and the radio set is at an extremely high level. Vibration and jarring as the vehicle advances over open terrain constitute an unavoidable hazard. Although vehicle crews need be "buttoned-up" for only comparatively short periods of time, as when attacking under cover of air bursts or sniper small-arms fire, reports from crewmen indicate that "buttoning-up" is exceedingly unpleasant, and, further, that performance is affected. Noise is both troublesome and tiring. Combined with the effects of heat, vibration and bouncing, monotony engendered by periods of inactivity on the part of the gunner and loader during tactical movements, noise is held responsible for slowing down reaction time and reducing efficiency within the tank or vehicle at precisely the time when efficiency is most critical. Reports indicate also that

"buttoning-up" results in disorientation, apparent increase in noise, and feelings of confinement. "Buttoning-up" may also increase the crew member's perception of danger, feelings of isolation, and susceptibility to fear. These feelings are akin to those generated by--or may in fact be generated by--sensory deprivation as the result of auditory masking by ambient noise, tactual masking by vibration and jarring, and decrease in visual stimulation through loss of contact with the external environment (particularly in the case of the loader and gunner), blurring caused by vibration, and decreased illumination.

Advances in the art of warfare, as reflected in tactics projected for the mid-range time frame, again have dictated a shift of emphasis within the elements and implements of combat. The use of armored vehicles to move troops and mounted weapons with great speed over comparatively long distances implies extended periods on alert status and greater periods of actual "combat" time than the shorter battle commitments heretofore associated with mounted warfare. Movement across radiologically "hot" areas as well as the threat of unexpected nuclear or nonnuclear missile attack will require that vehicles "button-up" even when not directly committed to combat and that crews remain sealed within their vehicles for extended periods of time. These major requirements can be expected to affect significantly the elements of performance as outlined earlier: equipment must be redesigned to furnish the firepower, mobility, and protection required, as well as to be reliable and easily maintained; crews must be selected, perhaps such as submariners are, to function efficiently under these new battlefield conditions; crews must be trained and disciplined under the new tactics; and communication, now effected almost entirely by radio because of dispersion and isolation within the vehicles, must assume paramount importance. In terms of the human factors requirements introduced, extended periods of mounted warfare on the mid-range battlefield can be expected to increase significantly the effects of noise, vibration, temperature, and sensory deprivation. Reaction to isolation, disorientation, and danger will intensify, and heightened alertness will be required for extended periods of time. Dependence on radio communication will increase.

EQUIPMENT DESIGN FACTORS

Human factors considerations up to this point have dealt only with environmental conditions affecting the interaction of the crew member with his equipment. Equally relevant are the human factors considerations associated with the introduction of new equipment into the vehicle system or the drastic alteration of the system itself. Alterations in weapons and fire-control systems, in propulsion systems, in communications systems, in vision and guidance systems, all will make new demands upon the crew members. With the increasing emphasis on guided and homing missiles, such as the Shillelagh, the system will likely become more complex, and its demands upon the gunner may require aptitudes quantitatively or qualitatively different from those presently required. Proposed missile systems for tanks, for example, all require a great deal more tracking by the gunner than do present systems. Requirements on other crew members are also likely to change. Maintenance problems may increase, functions in the firing cycle may be redistributed, and the loader position may even be eliminated with the introduction of automatic weapons devices. With increasing emphasis on

ability to operate under cover of darkness or smoke while troops and vehicles are being massed, increased dependence will be placed upon covert artificial illumination such as infra-red and automatic position locating devices. Use of such devices will likely make greater demands upon the driver, vehicle commander, and weapons operator(s) in terms of aptitudes and abilities.

INTERPERSONAL FACTORS

Finally to be considered is the interaction of crew members as a variable bearing upon the performance of an individual within the system. Sequences of operations in a system generally require coordination among the several crew members and between crew and vehicle commander. In some instances, several crew members must work together on one subsystem, for example, the fire control subsystem in boresighting. Sometimes the various subsystems on which the individuals work are functionally and/or sequentially linked, as in fire control and propulsion subsystem when vehicles are preparing to move out. Therefore, the influence of interpersonal factors on individual and crew performance may be a subject for investigation. Such variables as number of crew members, relative ability of specific members within the group and the like, will very likely influence the productivity of the group and of individuals within the group. Other hypotheses may derive from prior research on small work groups.

To the extent that the effects of interpersonal factors reflect individual differences, the solution may lie in the development of proper selection instruments and procedures. To the extent that personnel can adapt to the conditions encountered, the solution may lie in the development of appropriate training methods. To the extent that these factors can be eliminated, the solution may lie in engineering redesign of the system or system components. To the extent that the factors can be allowed for and their effects minimized, the solution may lie in the development of new tactics and organizational structure. None of these proposals is independent of the others, however, and none alone will provide an adequate solution to the human factors problems.

Obviously, many of the problem areas uncovered in this investigation have relevance to the basic mission of, and fall within the capabilities of, the U. S. Army Personnel Research Office. Several problem areas which appear critical and researchable have been further developed into specific research plans.

These areas offer many difficulties for the researcher: Future vehicles and equipment are not immediately available for research. Current projections for mid-range and long-range equipment are unstable enough to preclude certainty of payoff for studies which can be accomplished. While mock-up and simulation of this equipment may be satisfactory for human engineering studies, such devices do not generally afford the researcher opportunity to study combat performance either in the field or in a laboratory-simulated combat situation. This is important, for it is the interaction of the various

human factors elements--external and internal environments, crew and equipment characteristics, methods and procedures, that will be significant in the operating situation.

ONGOING HUMAN FACTORS RESEARCH IN ARMOR

In October 1958, USCONARC generated a requirement for a coordinated effort on human factors research in the area of effective performance in fighting vehicles. In response to this requirement, a Working Group of the Army Human Factors Engineering Committee (AHFEC) was formed to generate recommendations for coordinated research on the problems raised by USCONARC with respect to human factors in the design and tactical operation of armored personnel carriers and tanks. Working with this group were representatives of the U. S. Army Personnel Research Office (USAPRO), then the Human Factors Research Branch, TAGO; the Human Resources Research Office (HumRRO); The Surgeon General (TSG); and the Ordnance Tank-Automotive Command (OTAC). From this coordinated effort came recommendations for specific areas of research promising military payoff. Inasmuch as USCONARC's proposal cut across the fields of interest of a number of agencies, the Working Group on Human Capabilities in Fighting Vehicles (HCFV) was established with representation from OCRD, HumRRO, TSG, HEL, and TAG to convey findings and make recommendations to HFEC for endorsement to the Chief R and D.

As a direct result of these early recommendations, a research program was initiated for the purpose of determining: (1) the psychological and physiological limitations and capabilities of individuals and crews operating in tanks and armored personnel carriers; (2) the consequences of the above limitations and capabilities for design of combat vehicles; (3) methods of measuring the aptitudes and tolerances of individuals for purposes of selecting and assigning personnel adapted to the stated conditions; and (4) the training necessary to increase the ability of individuals and crews to operate in tanks and armored personnel carriers for sustained periods of time under battlefield conditions. Within this framework of objectives, research on various human factors problems is presently under way at the several agencies.

HUMAN RESOURCES RESEARCH OFFICE (HumRRO) RESEARCH IN ARMOR TRAINING

HumRRO is engaged in research on armor training requirements at the U. S. Army Armor Human Research Unit at Fort Knox, Kentucky. The research includes studies on human factors related to operations under conditions of limited visibility, tank gunner performance, operational span of control, tank platoon training, vehicle maintenance, and tank crew training. In addition, studies are being conducted at HumRRO's field laboratory at the Presidio of Monterey and at George Washington University on human factors under conditions of stress, controlled isolation, and extreme cold.

ARMOR RESEARCH OF THE HUMAN ENGINEERING LABORATORY (OCD)

At Aberdeen Proving Ground, Maryland, HEL is currently conducting studies on confinement in armored personnel carriers and on the effects on performance of such factors as noise and vibration within currently operational vehicles. Effects of these factors are evaluated against criteria designed to measure ability to perform combat tasks. Also under way at this facility are human engineering studies of several operational and developmental vehicles, studies on problems related to operations under exotic conditions such as arctic and desert environments, and studies on proposed equipment design concepts.

RESEARCH BY THE SURGEON GENERAL

TSG, through its U. S. Army Medical Research Laboratory at Fort Knox, is conducting psychophysical research on the physical, psychological, and psychophysical limitations of personnel in fighting vehicles. Research is concerned with performance effects of vibration, acceleration and deceleration, confinement and isolation, and the interaction of these effects with temperature, low visibility, and the like.

ARMOR RESEARCH IN THE ARMY TECHNICAL SERVICES

Each of the technical services, in line with its responsibility for insuring that its equipment is properly engineered, aims at eliminating the danger of making an operator the bottleneck in a system, and at making certain that within the system the man and machine perform the operations for which each is best suited. Several technical service agencies are engaged in research directly or indirectly related to fighting vehicles performance. Quartermaster Research and Engineering Center Laboratories at Natick, Massachusetts are conducting research on effects on the soldier and on his performance of varying conditions of natural and military environmental stresses. The Ordnance Tank-Automotive Command at the Detroit Arsenal is developing and testing new armor vehicles, including the Armored Reconnaissance Airborne Assault Vehicle (AR/AAV). The Signal Equipment Support Agency at Fort Meade, Maryland is working on human factors related to communications systems the combat armor situation.

In addition to the Army agencies cited above, a number of contract and other Army agencies have for some years been engaged in human factors research which has yielded information having implications for the armor area. The Quartermaster Corps, for example, has carried on continuing investigation of the effects on performance of protective clothing and personnel shielding equipment. In addition, operations research groups, including the former Operations Research Office of the Johns Hopkins University and Ohio State University, have dealt with such problems as the development of new armament systems, considering the human operator as an independent variable in the system.

ROLE OF USAPRO IN ARMOR RESEARCH

As a consequence of the field survey, a program of research, consistent with the needs of the Army and the capabilities and mission of the branch, was developed for the Fighting Vehicles Task. The program gave due consideration to current research in other Army and contract agencies. The USAPRO approach, whenever possible, was systems oriented. Such an approach recognizes the interdependency of factors within the system as well as the variety of relevant disciplines.

A military system, with reference herein specifically to fighting vehicle systems, includes the equipment, personnel skills and aptitudes, and techniques whereby such a composite is capable of accomplishing specified functions in fulfilling an Army mission within the intended operational environment and associated conditions for that mission. The comprehensive study of the operator's role and capabilities involves many technical areas of specialization, including those of psychology, physiology, biophysics, medicine, and engineering. Specifically within the field of psychology, relevant areas include human engineering, performance requirements, proficiency evaluation, selection standards, and training and operations analysis. As new materiel is developed and new tactical and organizational doctrines emerge, the role of the human operator in the armor system will be subject to considerable change. Continuing investigations with respect to future manpower requirements are therefor imperative as a means of effecting optimal utilization and apportionment of human resources.

Within the objectives of improving performance in current systems and estimating future qualitative manpower requirements to ensure a high level of performance in future systems, USAPRO's Fighting Vehicles Task marked out two broad problem areas requiring psychological investigation:

1. HOW CAN THE QUALITY OF PERSONNEL ASSIGNED TO ARMOR BE IMPROVED?
2. HOW CAN WORK METHODS AND PROCEDURES BE IMPROVED TO EFFECT BETTER UTILIZATION OF PERSONNEL?

SPECIFIC RESEARCH AREAS

The suggested human factors studies presented below focus primarily on the manipulation of human resources to optimize the performance of armored vehicle crewmen as an approach to maximizing the output of the vehicle system. (The Fiscal Year 1962 Fighting Vehicles Task work program statement of the US Army Personnel Research Office appears as Appendix B.)

DEVELOPMENT OF SELECTION TECHNIQUES FOR ARMOR CREWMEN

Current procedures for selecting armor crewmen are based primarily on combat Aptitude Area AE (Artillery, Armor, Engineer), a composite of tests

of the Army Classification Battery, which has proved valid for the armor area as a whole. However, no specific measures are used in assignment to vehicle or crew position. Many systems proposed for the future will require personnel who can perform dependably at isolated work locations with a minimum of supervision. Such field conditions would subject the men to adverse environmental conditions, lengthy periods of confinement, and prolonged periods of activity. Selection instruments should therefore include personality traits and motivational characteristics.

An experimental battery of selection tests will be developed and evaluated to serve, perhaps in varying combinations, three objectives:

1. To improve the validity of initial selectors
2. To develop differential predictors of crew-position success, and
3. To furnish the armor unit commander with information to aid in administrative decisions

Selection Measures for Armor Training. Hypotheses were developed regarding the basic skills, abilities, aptitudes, and personality characteristics related to successful performance in armor. Those hypothesized factors which appear more promising will be assessed in terms of their predictive efficiency for the selection of EM who perform well both in training and later on the job. Criteria of training success will be based on operational proficiency tests and task-designed rating scales administered at the end of Advanced Individual Training-Armor. However, since the operational situation often imposes many requirements that differ from those in the school training situation, performance measures will be used for the on-the-job performance evaluations. Proportionally greater emphasis will be placed upon the performance measures in evaluating the predictive measures.

Procedures for Assignment to Crew Position. Under current procedures, MOS 131 is awarded to all EM upon successful completion of Advanced Individual Training-Armor. Assignment of the new recruit to vehicle and crew position is made by the local unit commander after the EM has reported to his duty station. The unit commander must in many cases make this assignment with very little consideration save the expediency of filling vacancies with any available personnel. Moreover, where the unit commander is permitted the luxury of a considered decision, he seldom has sufficient information to guide him in his decision. Tests or test composites developed to provide differential prediction information would assist the commander in making these and other administrative decisions.

Generalization of Findings to all Armor Systems. Initial investigations will be concerned with currently operational materiel and doctrine. Studies will also be designed to determine the extent to which new weightings must be applied to components of predictor composites to meet changing manpower requirements resulting from developments in future time frames. Such a modification of procedures might be occasioned by the introduction of a new firing and aiming subsystem.

End Product. Selection measures which can be used, singly or in combination, to 1) select enlisted personnel for initial assignment to armor training, and 2) assist the unit commander in making the most advantageous assignment of individuals to vehicle and crew position.

DEVELOPMENT OF CRITERIA OF EFFECTIVE PERFORMANCE IN FIGHTING VEHICLES

Subsequent research studies have been planned to investigate performance of crews and crew members under a wide variety of conditions and situations. The research design required instruments affording quantitative and qualitative evaluation of performance. Some of the measures developed would serve as criteria against which experimental predictors would be validated. Furthermore, as tactical planning requires information as to the availability and state of preparedness of troop and equipment resources, a need exists for a realistic scorable performance measure which will differentially assess combat behavior. Three types of criteria will be explored: realistic tactical situational tests; psychometric instruments; and simulated-equipment performance measures.

Situational Performance Studies. The objective is to design field studies to afford objective measures of performance, including broad tactical problems at varying levels of difficulty. These problems will test the performance of crews and crew members for various armored vehicle systems and subsystems under such tactical situations as attack, defense, and withdrawal. Efforts will be made wherever possible to modify and adapt currently operational tests such as the crew proficiency tests and combat readiness tests currently in use. A further objective is to develop tests which reflect demands imposed by anticipated future materiel or doctrinal developments.

Psychometric Techniques. Two categories of psychometric measures are planned to provide economical intermediate criteria: paper-and-pencil achievement tests and performance ratings, by peers and superiors. Where appropriate, previously developed measures will be employed. Specific instruments to be employed include paper-and-pencil proficiency tests, rating scales, checklists, and sociometric indices. Where instruments are not available, appropriate devices will be developed in this task.

Simulator Techniques. Wherever possible, simulation techniques will be employed in the design of performance criteria. Such an approach offers a means of conducting performance evaluation studies that will not entail the high cost, expenditure of time, complex coordination with other Army agencies and commands, or noncontrolled experimental conditions attendant to field research. Currently operational simulators under consideration include the tank turret simulator, the tank gunnery trainer, tracked vehicle driver trainer, and the miniature armor battlefield. Use of simulation techniques might also provide research data on future systems otherwise unavailable for research.

Consideration of Future Systems. As new vehicle systems and subsystems are developed and as combat doctrines change, it is likely that new criterion measures must be developed or old ones adapted to reflect these changes. Although projections using obtained human factors data as a baseline may be used, the development of up-to-date criteria will afford a meaningfulness and confidence in results unattainable by more inferential techniques. A continuing effort will be exerted to keep abreast of current and proposed changes in order that criteria may more closely represent the appropriate time frame.

End Product. A set of instruments to evaluate objectively the performance of armored vehicle crews and crewmen.

CREW COMPOSITION AND INTERPERSONAL RELATIONS

Under projected operation plans, tactical maneuvers for armor will require coordinated interactions among crew members for increased periods of time. Reports from tank commanders in the field and the findings of research studies on team performance in both formal and informal groups suggest that the effectiveness of the crew may to a significant degree be related to the individual personalities of the crew members and to the interpersonal relations within the crew. The unique contribution of the vehicle commander in "whipping his crew into shape" and in developing and maintaining morale and a spirit and condition of preparedness and cooperation has been indicated by crewmen, tank commanders, and platoon leaders as extremely critical to the effectiveness of the vehicle.

Previous studies on small groups have dealt primarily with 1) the identification of combinations of personalities and the patterns of interpersonal relationships which lead to the emergence of leaders or to the effective functioning of groups as teams; or 2) the identification of personality variables which predict or enhance leadership and the generality of the leadership position from one group to other groups of the same character. Research in this area will be conducted to check out hypotheses derived from previous research as well as to investigate the effects of various other social-psychological factors which might relate to effective crew performance.

Crew Composition and Interpersonal Factors. This subarea will be concerned with the determination of the social-psychological factors which contribute to, or determine, the nature of interaction or modification of behavior in the tank crew. Initial investigations will deal primarily with the Loader-Gunner-Driver triad. In assessing the effect of individual personality factors and crew composition factors on tank crew performance, variables to be investigated include length of service or experience of crewmen, informal and formal social structure of the crew, time together as a crew, etc. A corollary research problem is the effect of disruption of established crews. Various sociometric devices, rating scales, interview techniques, and BIB and personality measurement techniques will be developed. Relevant psychological factors will be related to measures of crew effectiveness developed previously.

Role and Contribution of the Tank Commander. The intent of this research is to investigate the vehicle commander's contribution to crew effectiveness and to determine those factors critical to the effectiveness of the tank commander. Personal characteristics of the tank commander as reflected in such interpersonal phenomena as social distance from crewmen, authoritarian vs laissez-faire or democratic leadership, and perceived or actual similarity to crewmembers will be related to ratings of crew and tank commander effectiveness.

Relation of Interpersonal Factors to Other Variables. Relationships existing among the interpersonal factors identified and selection variables, training considerations, and crew work methods and procedures will be investigated. To the extent that social-psychological factors related to effective performance can be isolated and related to manipulable variables these factors can be capitalized upon to improve the performance of vehicle crews. Thus it may be possible to select and organize armored vehicle crewmen partially on the basis of interpersonal factors associated with more effective crew performance.

End Product. A predictor instrument, based upon social-psychological factors related to effective crew performance, which may be locally administered as an aid to the platoon, company, or troop commander in making initial assignment of EM to vehicle crews, and in selecting a vehicle commander for a specific crew.

ANALYSIS OF VOICE RADIO-COMMUNICATION PROCEDURES FOR ARMOR PLATOONS

The communications link among the highly mobile elements of the armor platoon is absolutely essential to the success of mounted warfare. The voice radio set is an effective method of communication between platoon, air and ground support elements, and higher echelons. Preliminary investigations indicate that several researchable aspects of armor communications promise payoff in terms of more effective coordination through improved communications. The objective of this aspect of the research is to examine systematically the conduct of voice radio communications within armor platoons and to determine how optimal utilization of the communications facilities may be attained. Studies will be undertaken on the communications network of the armored tank platoon and the armored cavalry reconnaissance platoon.

Content Analysis of Voice Radio Transmissions. The first step in the research on armor communications will be the monitoring and transcription of typical communications within the armored cavalry reconnaissance platoon and medium tank platoon during simulated combat maneuvers. Such a procedure will permit thorough familiarization of task personnel with communication procedure and analysis of messages transmitted during "combat" maneuvers with respect to type, source, destination, completeness, intelligibility, and other pertinent characteristics. Concurrent observation will be made of field actions. This accumulation of data will afford the opportunity to make several subsequent analyses.

Analysis of Voice Radio Communications Discipline. Adequacy of communication, as defined by communication experts and by quantitative measures to be developed will be related to observable characteristics of the communications flow. The hypothesis is that, for a given period of time, optimal utilization of the network is related to the amount of relevant information transmitted and to the amount of time spent on the net. Factors in the evaluation of information transmittal include completeness, appropriateness, relevance, and timeliness. Factors related to time on the net include brevity, requirement for response or repeat, relevance, and such factors as interruptions or simultaneous transmission that would garble the message or cause it to be lost. The interaction of information and time factors suggest further the investigation of control or discipline factors. Implied by the central hypothesis is a maximally "clear" or message-free net available for use by an appropriate number or combination of information passers, monitors, receivers, and handlers. Utilization of this network can thus be evaluated against adequacy of communication.

Role of Voice-Radio Communications in Tactical Decision Making. The armored cavalry platoon characteristically operates within an "open net" communications system. Any message sent from one element of the platoon to another is monitored by every other element in the platoon, affording the platoon leader access to all information transmitted over the net. Presumably, the more of this information the platoon leader is able to use in making a tactical decision, the more appropriate will be his decision. Usefulness of the information in decision making depends upon whether the information is complete, valid, timely, and appropriate. Laboratory experimentation will be conducted to analyse types, sources and contents of messages useful for decision-making; reasons for not using certain information for decision-making; and methods to improve or augment relevant and appropriate flow of information to the decision-maker.

End Product. Recommendations aimed at the optimization of armor voice radio communications through controlled procedures governing the use of the open platoon network. The objective is to devise procedures which will permit reduction of overloading on the net, transmission of more timely and relevant information to appropriate receivers, and more efficient utilization of the platoon net.

RESEARCH IN RELATION TO FUTURE DEVELOPMENTS IN ARMORED VEHICLES

So great is the research and development pace that it is often difficult to imagine today the concepts and materiel with which we will wage war tomorrow. Much of the research planning outlined in the preceding sections has dealt with problems in the context of current organization and hardware. Continuing efforts will be exerted, however, to research armor problems arising in connection with new developments in doctrine and equipment.

Effects of New Developments on Current Work Methods and Procedures. With each new piece of equipment introduced, the human factors psychologist will seek to determine how the new duties and responsibilities occasioned by the change will affect established functions and duties within the system. For

instance, the introduction of the Shillelagh into the Main Battle Tank will probably necessitate a reexamination not only of the duties of the gunner but those of the other crewmen as well. Wherever possible, research will be conducted during the preliminary planning or research stages rather than after a particular doctrine has been established or production model developed.

Effects of New Developments on Estimated Qualitative Manpower Requirements. The trend toward increasingly complex and more highly integrated equipment, toward heightened alertness and readiness for immediate action, and toward greater dispersal and range of vehicles, implies that the personnel requirements for future systems may differ materially from the requirements of present systems. Some crew positions, for instance, may demand more highly trained skilled personnel, while others may require personnel with a minimum of specialized training. The purpose of research in this area is to estimate, in the light of new developments, the characteristics of personnel who will be required to man future armor systems.

End Product. This area will furnish estimates of the qualitative manpower requirements for armor systems in future time frames. It will enable researchers to contribute to the development of new systems and doctrine by furnishing combat developments agencies with up-to-date data on human capabilities and limitations in fighting vehicles systems.

SUMMARY OF RESEARCH PROPOSED

The proposed five research areas focus on the basic mission of the task-- to improve or maintain the performance of armored vehicle crews and crew members in the context of a rapidly expanding technology of warfare. Within the broad aims of improving the quality of personnel input into the armor area and of optimizing work methods and procedures, improved selection instruments for enlisted men will be developed and selected problem areas of utilization will be studied. The five areas are amenable to research within the mission of the Army Personnel Research Office and can be expected to yield a good return to the military by providing unit or vehicle commanders with means of selecting personnel and techniques that will improve vehicle performance. The research problems and their expected contributions are briefly recapitulated below.

DEVELOPMENT OF SELECTION PROCEDURES FOR ARMOR PERSONNEL

A test battery to identify, prior to training assignment, those enlisted personnel who will perform well in armor training and on the job.

A test or test composite differentially predicting success in various vehicle and crew-position assignments, thereby affording the armor unit commander an aid in the assignment and advancement of armored vehicle personnel.

Improved armored vehicle system performance as a result of improved quality of personnel assigned to the armor area and to specific positions in armored vehicle crews.

DEVELOPMENT OF CRITERIA OF EFFECTIVE PERFORMANCE IN FIGHTING VEHICLES

Quantitative and qualitative performance measures based on simulation techniques and standardized tactical field exercises.

These measures will serve, singly or in combination to evaluate system and subsystem performance, crew and crewman performance, and as criteria against which to validate experimental selection instruments.

CREW COMPOSITION AND INTERPERSONAL RELATIONS

Selection and assignment procedures for use locally by armor unit commanders.

Group approaches designed to maximize crew effectiveness under the leadership of the vehicle commander.

ANALYSIS OF VOICE RADIO COMMUNICATION PROCEDURES

More controlled (disciplined) procedures governing the use of the platoon voice radio communications network.

Improved coordination capabilities for armor units through more efficient utilization of radio communications facilities.

RESEARCH IN RELATION TO FUTURE DEVELOPMENTS IN ARMORED VEHICLES

Estimates of future qualitative manpower requirements.

Distribution of crew functions to maximize effectiveness of vehicle operation.

Human factors data to aid in the development of new doctrine and materiel.

PLANNING CONSIDERATIONS

The scope of the research program presented in this report is extensive, covering many facets of selection, classification, assignment, and utilization of armored vehicle personnel. It is anticipated that, in addition to shedding light on current problems, results of this research will be applicable in future time frames. Such a research program requires many man-years of professional service. The program must therefore be carefully considered to determine which areas to attack first. While such determination is ultimately made by the user agency in the light of operational requirements, research considerations such as the following enter into the picture.

For example, the development of selection procedures and the concurrent development of performance criteria would logically come first, since these efforts will entail comprehensive examination of procedural, physical, and psychological factors related to fighting vehicles operation and will afford the researchers a thorough familiarization with armor as well. A research area that might be given low priority is the study of crew composition and interpersonal relations. A stumbling block in research in this area is the necessity of arranging for the assembly of experimental crews and the large number of personnel involved.

Consistent with operational requirements, therefore, it is recommended that top priority be assigned to the selection and criterion studies and lowest to the crew composition and interpersonal relations study. Concurrent effort should be expended in the communications area, while a continuing effort is under way on the relation of research findings to future requirements.

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APPENDIXES

Appendix A Organizations Visited on Survey on Research in Fighting Vehicles.

Appendix B Identification and Measurement of Psychological Factors Related to Operation of Fighting Vehicles--FIGHTING VEHICLES--Task Statement, FY 62 Work Program.

APPENDIX A

ORGANIZATIONS VISITED ON SURVEY

CIVILIAN AND MILITARY AGENCIES

Ballistic Weapons Laboratory, Aberdeen Proving Ground, Maryland
Combat Developments Group, Fort Knox, Kentucky
Defense and Industrial Division, Otis Elevator Company, New York City
Detroit Arsenal, Detroit, Michigan
Headquarters, U. S. Army Security Agency, Arlington Hall Station, Virginia
Headquarters, U. S. Continental Army Command, Fort Monroe, Virginia
Human Engineering Laboratories, Aberdeen Proving Ground, Maryland
Human Factors Research Department, Lockheed Aircraft Corporation, Marietta,
Georgia
Ordnance Tank-Automotive Command, Detroit, Michigan
Testing and Equipment Laboratory, Intelligence Board, Fort Holabird,
Maryland
U. S. Armor Board, Fort Knox, Kentucky
U. S. Army Armor Human Research Unit, Fort Knox, Kentucky
U. S. Army Armor School, Fort Knox, Kentucky
U. S. Army Desert and Armor Training Center, Fort Irwin, California
U. S. Army Signal R and D Laboratory, Fort Monmouth, New Jersey
U. S. Army Training Center, Camp Pickett, Virginia
U. S. Army Training Center--Armor, Fort Knox, Kentucky

ARMY UNITS

First Armored Division, Fort Hood, Texas
Second Armored Division, Fort Hood, Texas
1st Medium Tank Bn, 1st Cav, Fort Hood, Texas
5th Medium Tank Bn, 40th Armor, Fort Irwin, California
3rd Armored Cavalry Regiment, Fort Meade, Maryland
6th Armored Cavalry Regiment, Fort Knox, Kentucky

APPENDIX B

FIGHTING VEHICLES TASK--STATEMENT
FY 62 WORK PROGRAM

The Adjutant General's Office

1. Task Title: Identification and Measurement of Psychological Factors Related to Operation of Fighting Vehicles--FIGHTING VEHICLES

2. Principal Investigators:

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Sponsor: U. S. Continental Army Command

3. Scope:

- a. Need for and objective of research: A requirement to identify those psychological factors critical in the successful operation of fighting vehicles is dictated by the tactical and organizational concepts of future warfare which make new demands upon the human element in man-machine systems.
- b. Method of attack: Major emphasis is being directed toward those human factors considerations which will be relevant to mid-range and long-range Army planning. The principal effort during FY 1961 was directed toward the identification of critical and researchable problem areas. This objective necessitated, as a first step, thorough familiarization with current fighting vehicles, such as tanks and armored personnel carriers, and their tactical military use. In addition, future combat materiel requirements were studied to give appropriate direction to the research. Finally, currently employed measures for evaluating the performance of individuals, crews, and units were studied and evaluated for inclusion in the research design as criteria of system performance.

As a result of the FY 1961 effort, several areas, including those of communications, target acquisition, and the role of the new main tank armament, were tentatively identified as problem areas for research which might contribute to more effective performance. It is anticipated that in each area of research undertaken, current methods, functions, and procedures will be evaluated with respect to their applicability to future systems and, when appropriate, will be modified. Inasmuch as those performance measures currently available are not judged, on the basis of the FY 1961 investigations, to be suitable as research criteria, the

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initial phase of research will of necessity involve the development of workable criterion measures of individual, crew, and unit performance. Concurrently, research effort will be devoted to a thorough study of human factors related to fighting vehicle operation in order that subsequent identification may be made of those factors related to successful human factors performance.

Research in any particular problem area will involve (1) development of criterion instruments whereby the total effectiveness of an individual, crew, or unit within a given system may be gauged and (2) the identification of those psychological variables which may relate to successful performance on the criteria. The criteria must be based on performance situations with emphasis on those situations which will anticipate requirements of future warfare, considering environmental conditions internal and external to the vehicle. Further, the criteria must emphasize specific behavioral aspects of the particular MOS involved that are critical to the effectiveness of tank operations. These job sample types of performance tasks will be related to each of the specific tactical or environmental circumstances unique to armored vehicle unit operation. Most criterion analysis will have to emphasize the use of small samples because of the complexity of factors studied together with logistical requirements. Further lessening of logistical and materiel requirements will be accomplished through the use of simulation techniques wherever possible.

Other research problems may later be initiated. It is anticipated, however, that maximum fruitfulness of the research may be dependent upon proper selection of individuals to constitute the tank crews and armored personnel carrier teams. These group sociometric and psychological problems will be intensified by the involvement of probable stress and isolation. Another critical area may involve much increased demand for leadership potential on the part of particular positions within the 'team' or unit structure.

- c. Potential military research end-result: (1) Selection instruments and procedures specifically for personnel, (2) Reevaluation of the differential classification system for enlisted input to the Army in terms of ability to identify those individuals who will perform effectively in tanks and armored personnel carriers, and (3) Human factors knowledge concerning optimal composition and organization of personnel within an armored tactical system.

4. Estimated Professional Man-years Required:

FY 1962	6	Beyond FY 1963	undetermined
FY 1963	6		

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5. Coordination: DCSPER
USCONARC
HumRRO
ORD, HEL

6. Summary Forecast:

a. Identification of Psychological Factors and Personal Characteristics Associated with Effective Fighting Vehicle Personnel

FY 1962				FY 1963			
1	2	3	4	1	2	3	4
*P	C	C	C	C	S	S	

b. Development of a Criterion of Effective Performance in Fighting Vehicles

FY 1962				FY 1963			
1	2	3	4	1	2	3	4
*P	C	C	C	C	C	A	A

c. Construction and Validation of Experimental Prediction Battery for Fighting Vehicles

FY 1962				FY 1963			
1	2	3	4	1	2	3	4
*P	P	P	C	C	C	A	A

d. Evaluation of the Relation Between Characteristics of Group Composition or Interpersonal Relations and Successful Performance in Fighting Vehicle Units

FY 1963			
1	2	3	4
*P	P	C	C

e. Analysis of Radio Communication Procedures for Reconnaissance Platoons (Armored Cavalry)

FY 1962				FY 1963			
1	2	3	4	1	2	3	4
P	P	C	C	C	A	A	