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THE ROLE OF HUMAN ENGINEERING IN DESIGNING COMBAT VEHICLES

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HUMAN ENGINEERING LABORATORIES

ABERDEEN PROVING GROUND,
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ABSTRACT

This paper will describe the growth of human factors engineering and show how it is applied in designing combat vehicles, by giving examples of work we perform at the U. S. Army Human Engineering Laboratories (HEL), Aberdeen Proving Ground, Md. It will trace our efforts on two types of vehicles -- tanks and armored personnel carriers. However, these are selected examples; they cannot detail the total human factors effort on combat vehicle programs.

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THE ROLE OF HUMAN ENGINEERING IN DESIGNING COMBAT VEHICLES

INTRODUCTION

This paper will describe the growth of human factors engineering and show how it is applied in designing combat vehicles, by giving examples of work we perform at the U. S. Army Human Engineering Laboratories (HEL), the U. S. Army Materiel Command's research activity at Aberdeen Proving Ground, Md. This paper was read at the "Man···Mobility···Survivability" Forum held at the Allison Division of General Motors, Indianapolis, Ind., on 11-12 April 1967. It will trace our efforts on two types of vehicles -- tanks and armored personnel carriers. However, these are selected examples; they cannot detail the total human factors effort on combat vehicle programs. Besides HEL, other Government agencies and industrial contractors also make enormous contributions to solving man-machine problems in vehicles. It should be emphasized that, so far, the human factors progress in this area has been limited in two ways -- by the body of human factors information that is available, and by designers' reluctance to consider the human element seriously from the earliest conceptual stage of the program. Current trends suggest that in the future the human element will be considered from the very beginning.

ARMORED PERSONNEL CARRIER STUDIES

The history of Armored Personnel Carrier (APC) studies at HEL demonstrates how HEL's work and goals have evolved since the laboratories were organized in 1951. The first APC study, in 1956, on a vehicle that was already assigned to operational units, started with comments and criticisms from the men who used it. Today, we are doing one study about an APC which is only a concept, not yet built. Extending this trend into the future, it appears that we may be working with mission requirements to develop a personnel-carrying vehicle that will fulfill them.

The early APCs were intended to protect troops while carrying them into action. Once at the scene of battle, the troops left the vehicle and moved forward on foot to engage the enemy, just as foot-soldiers traditionally have, while the APC provided cover fire in an over-watching role. Its basic mission was transporting troops securely, rather than fighting.

Today, however, that mission is changing. The Army has gained experience in using the APC; and that experience has been translated into new ways of fighting with APCs, new ways of designing and building them, and inevitably new ways of evaluating their design and use. Changing the mission changes the whole picture -- requiring a fresh analysis of the problems and fresh approaches to solving them.

And so we have progressed -- from the initial survey of users' opinions, through static and dynamic evaluations of operational or pilot-model vehicles, to evaluation of vehicles that are still on the drawing board. We have also made concentrated studies of specific problems. We have found that men can adapt to some problems, such as confinement. When the men cannot adapt, as with noise, we have found ways to deal with the problem itself. We must still consider these areas in designing and evaluating vehicles, but now we know they can be managed.

At first, we didn't know whether we could solve these problems, so we had to take time to find out. Among other things, we have learned what not to worry about. Today we move immediately to broader and, ultimately, more significant problems, and we are entering design programs at progressively earlier stages. One reason we can come in earlier now is that designers have a better understanding of what human engineering can contribute. Equally important, HEL's growing body of knowledge increasingly equips us to make contributions during early design.

But in 1956, HEL did not have this broad outlook. The M59 Armored Infantry Vehicle was already in the field transporting troops, yet the laboratories knew little about such vehicles. We had to start some place, and the only place available was with the vehicle that troops were already using.

First, we had to find out if the troops had any problems with the M59. Only people who had used the vehicle could tell us, so we asked them. Even to do that, however, we needed some idea of what to ask about. Standard human engineering considerations -- like anthropometric data -- could, of course, be used; but we also needed specific questions about the M59 in particular. Designers, development engineers, and nearly 200 new and experienced M59 crewmen helped assemble a questionnaire and with it we interviewed more than 500 M59 users.

For one thing, this survey produced concrete recommendations for modifying the M59 to make it more effective in accomplishing its mission and safer for its crew. But a more significant product was recommendations for designing future commander stations, driver stations and crew compartments. Most important of all, we had succeeded in compiling a disciplined, if modest, body of information about APCs.

Within a year, we began applying what we had learned from the M59 to studies of the T113 and T117 APCs. We used our M59 data in two ways that have become typical in vehicle studies. First, we used the M59 results to help us define potential problems with the T113 and T117. Second, since we now knew something about personnel-carrying vehicles, we didn't have to rely so heavily on other people's unsystematic experience -- we could begin applying our own experience right in the vehicle itself. That's just what we did in a static evaluation of the T113 and T117.

In both evaluations we studied the driver area, commander area, personnel compartment, and exterior and maintenance areas. We applied both standard measurements from the general human engineering lexicon and the particular insights we had gained from the M59 studies. As in the earlier study, we were able to recommend ways of improving the vehicle.

The following year we moved forward -- by examining the combination of men and vehicle on the move, to see how the organic and inorganic parts of the system worked together in performing the vehicle's actual mission. These dynamic tests were a natural outgrowth of the static studies. Some of the inferences drawn from the static measurements could be confirmed only when the vehicle was in operation -- for example, did the driver's and commander's periscopes really need padding? The static evaluation suggested that they did; but only putting the driver, commander and periscopes to work performing their mission could prove or disprove it. And there were some things we could measure only when the vehicle was moving. How does operating noise affect crew performance -- directly by degrading their performance physically, or indirectly by interfering with communication within the vehicle? The only way to find out is putting both men and machine through their paces. Once more, the studies yielded ways of modifying the system to improve its operational effectiveness.

Next we needed some specifics. Just how, more precisely, did men react to factors like interior noise, heat or confinement? Further, to make really meaningful human engineering contributions to APC programs, we had to define APC problems more specifically and find more concrete answers to them. Beginning in 1962 a series of studies began pursuing this more intensive approach. (See references at end of paper.)

There were several kinds of internal communications in the T114 Armored Command and Reconnaissance Vehicle -- voice, hand signals and the pressure of the commander's foot on the driver's shoulders. A study was outlined to see how vehicle noise would affect voice communications and how the noise leve would affect the crew's hearing. During the dynamic testing, with a commander, driver and crewmen aboard, sound-pressure levels were measured at two key positions while the vehicle moved along a straight, level, hard-surfaced road at speeds varying from 10 to 25 miles per hour. The noise, as it turned out, was so intense it endangered the crewmen's hearing when the vehicle drove at 10 miles an hour or faster for an hour. The noise was also so loud that it prevented voice communication while the vehicle was under way.

A 1963 static and dynamic evaluation of the XM577 Light Tracked Command Post Carrier also focused on noise. As always, where noise is concerned, we wanted to pinpoint and eliminate threats to hearing; but questions of communication within the vehicle were especially critical because of its mission as a mobile command post. The crew had to be able to communicate among themselves and with other stationary and mobile stations. The investigators discovered that at 20 miles per hour or more the vehicle was hazardous to the hearing of personnel who stayed in it longer than one hour per day and that above 10 miles per hour conversation without lip reading would be all but impossible. The stationary vehicle posed no threat to hearing, but even standing still the teletype and generator noise would make prolonged conversation difficult.

During the summer of 1964, Operation Swamp Fox II in Panama provided an opportunity to assess the effects of tropic heat on men in general and on the crewmen of APCs in particular. A study of the "human thermal environment" provided a description of tropical conditions and made it clear that solar radiation primarily determines whether environmental conditions are stressful for humans. A related study examined men confined in an M113 Armored Personnel Carrier for as long as six hours and men exercising under similar environmental conditions in the open air. The results indicated little danger of heat casualties of men confined in APCs operating in tropical environments.

Operation Swamp Fox II also provided the occasion for one of the final studies in a series initiated several years before. As early as 1960, concern arose about the effects of confining men in the constricted internal environment of an APC. How well would these men fight after they debarked from the vehicle? Static and dynamic studies of men confined for varying periods under various climatic conditions sought the answer. The Swamp Fox tests, for example, studied the effects of confinement under tropical conditions. The series wound up in 1964 with the conclusion that confinement effects on the performance of infantrymen are transitory, that men adapt to confinement with repeated exposure, and that when confinement degrades performance of particular infantry skills the effect can be offset by practicing the affected task.

These studies of specific questions about the APC, all dating from the early 1960's, all explored questions defined in the more general studies that preceded or accompanied them. In almost every case, the specific studies added further recommendations for modifying the vehicles in question and added to the fund of knowledge about APCs.

By 1962 HEL was ready to summarize some of the basic human factors problems uncovered in the M113 APC and did so in a published review. But the same report proceeded to describe a "human factors approach" for designing a new Armored Squad Carrier that was still in the conceptual stage. Some of the design recommendations were fruits of earlier studies but some were developed from work with a concept mock-up built at HEL. The configuration of the conceptual vehicle had already been determined, but there was some flexibility to that configuration -- and HEL was no longer dealing with an existing vehicle, either operational or experimental. The vehicle had gone as far as the drawing board but no further, and by now HEL was well enough acquainted with APCs to join the design and development process at that point.

Only one further obvious step remains in this progression back toward the genesis of APCs, and HEL is taking that step right now. The APC has been assigned a new mission -- to fight in battle rather than merely to transport men to battle.

The new fighting vehicle will be called the Mechanized Infantry Combat Vehicle (MICV-70). This fighting version of the APC will fulfill the traditional role of the foot-soldier -- to clear and hold the ground behind the spearhead of an attack -- but the troops will remain aboard and fight from the vehicle. The greater speed and mobility of the vehicle and the lesser attrition of the protected troops will permit the MICV to occupy more ground with fewer men than have been needed in the past.

Translating this mission concept into an effective system for achieving it requires information on how troops can best fight from such a vehicle, and this is where HEL is working at the moment. The MICV is expected to fight on the move, so designers and evaluators need to know how accurately the primary, secondary, and the individual weapons can be fired by the crew while under way. Using the pilot model from an earlier MICV concept, HEL has conducted field tests to generate the information needed to evaluate the current concept and to obtain the information necessary to describe the effects of vehicle design parameters on accuracy. Specifically, we measured the accuracy of the proposed main armament with and without stabilization, while moving at different speeds over different types of terrain approaching the target at different angles of attack with two types of sights. We also examined the accuracy of the proposed secondary armament under similar conditions with different sighting systems and different ammunition mixes. Individual weapon accuracy as a function of weapon mounts and sighting systems was also measured. The information was used as a part of a package to describe the potential fire power of the MICV concept as a function of such variables as weapon mixes, ammunition mixes, weapon mounts, sighting systems for moving and stationary vehicles approaching the targets at different attack angles. Ultimately, knowing the effects of various system design parameters on fire power will help guide the designer's hand when he plans the first MICV-70 that will actually be built and put through its paces.

Human engineering has come a long way with the APC, starting with an operational vehicle about which it knew little and moving ahead to the point where the human engineer now already knows a great deal about vehicles yet to be designed. The APC itself has evolved from a troop carrier into what will shortly be a full-fledged fighting vehicle. As each system has evolved, the human engineer has stepped further back in the design process because each new study refined his perceptions of the problems and increased his knowledge of where to look for their solutions.

TANK STUDIES

HEL's tank studies have progressed along a similar line.

A 1956 survey of users of the M48 tank paralled a similar APC survey made the same year. The study asked users of an existing vehicle what problems they had encountered with it, what field expedients they had devised to resolve them, and what design changes might eliminate them from future tanks. This survey, in other words, tried to find the M48's specific problems, not rate its overall performance. Ultimately, the study aimed to guide the designers who would plan future vehicles and the human engineers who would evaluate them.

In 1962 HEL turned its attention to the tank user himself. A study brought together information on how the tank user was selected, what his abilities were, and how well he could perform with his vehicle. It concluded that designers of combat vehicles had not paid enough attention to human factors and commented that as weapon systems became more complex, the Army would either have to design them so the available population could use them or else become more selective in choosing that population. Training, the study pointed out, can not overcome the effects of poor design; and worse, the inevitable decline of performance under the stress and fatigue of combat would be exaggerated if equipment was not well adapted to the user in the first place. Human factors, designers were told, establishes minimum requirements we meet to get the best performance out of any vehicle system.

The early 1960's saw the beginning of a series of tank studies directed more specifically toward particular vehicles, components and operating considerations. As with the APC, many of these studies produced recommendations for modifying the vehicles under study; but even these added continually to the human engineer's knowledge of what kinds of problems to look for in tanks and what not to worry about. Other studies pursued more general problems like tank driving, gun loading and target tracking; and these, too, helped formulate human engineering criteria both for designing and for evaluating tank systems.

In 1962 HEL evaluated the M60E1 tank, rating the work space, controls and displays, and seating stations for the commanders, loaders, gunners and drivers. This study also rated maintenance in the light of the skills, tools and supplies available. Recommendations for modifying the still-developing turret and crew spaces were summarized at the end of the report on the study.

One recommendation for the M60E1 was an improved commander's seat assembly. A study published later the same year zeroed in on that specific problem to find out what kind of seat and platform would enhance the commander's overall performance of his tasks. Operating the rangefinder and making periscope, vision-block and open-hatch observations were emphasized; but simplicity, maintenance and cost were also considered. The study produced recommendations for a seat assembly that would not only eliminate the difficulties found in the M60E1 but also resolve similar problems in the other existing and future tank models.

Another 1962 study offers an example of the more basic studies sometimes required before particular problems can be attacked. Information was needed on the performance of tank gunners tracking targets continuously, but required first was a reliable technique for measuring that performance. This study sought such a technique. In a controlled test situation both novice and experienced gunners simulated fire (photographically) from one stationary tank at another tank moving over a prescribed test course. The firing data were analyzed to see how experienced and inexperienced gunners differed in tracking performance and to validate the technique for future application to tank systems requiring continuous tracking. The technique was satisfactory and the results established a baseline for comparative studies.

Later studies concentrated more specifically on other types of tank firing problems. In 1963 HEL investigated the effects of firing shock on gunners in a lightweight armored vehicle with a large-caliber gun. The object of the study was to determine the physical effect of the firing shock on the gunner himself as well as the effect on his subsequent performance. At the same time, the study offered an opportunity for assessing a dynamic ride simulator as an instrument for comparing transient shock and for gunners to compare the test vehicle with operational vehicles like the M60 or M103 tanks. An anthropomorphic dummy equipped with accelerometers was used in firing from the test vehicle, and data collected there with the dummy gave a baseline for further firing-shock studies. But other data collected with the dummy in the dynamic ride simulator were limited by the inability of the simulator to adequately reproduce all the motions encountered in actual firing and by the use of a simulator seat that did not allow for normal gunner position. Human gunners who fired from the test vehicle reported subjectively that it did not differ significantly in firing shock from other tanks operational at the time, but shock measurements made on the helmet did indicate a significant difference. The results allowed the investigators to conclude that the experimental brow pads used in the tests would not transmit a shock causing physical damage to the gunner and that the vehicle provided a platform stable enough for the gunner to maintain his sight picture, but the investigators also recommended more basic research on human tolerance to firing shock and its effect on gunner performance. Here, work on specific problems indicated a need for more fundamental studies.

Gunner performance continues to be a concern in tank studies. In 1966 HEL conducted tests to determine if gunners in vehicles equipped with the Laser Antitank Semi-Active Homing (LASH) weapon system could meet the system's re-laying requirements under favorable conditions. If they could not, there would be no need to evaluate their re-laying performance under more realistic conditions. The tests were conducted in two phases with two expert gunners firing in each phase. The first phase measured re-laying performance with three types of gunner corrections and types of terrain. The second phase measured re-laying performance with and without automatic stabilization. In both phases a boresighted camera recorded time and accuracy of re-laying after firing. Pending a complete system evaluation, the results were interpreted both to reach conclusions about existing tanks and to recommend steps to be taken in designing future vehicles. Meanwhile, HEL had added to its store of information about how gunners behave using various types of equipment under various conditions.

At about the same time HEL took up tank gunner performance, it also began looking into various aspects of tank driving.

In 1953 the need to lower tank silhouettes focused attention on the tank driver's position, since the height of the seated driver helped to determine the minimum height required for the hull. A prone driver would presumably need less vertical space and allow a correspondingly lower hull.

The Air Force had already studied the possibilities of prone pilot position for aircraft, so HEL first tried to determine how much of the Air Force work could be applied to tank driving. A 1953 analysis concluded that the design criteria established for the Air Force pilot bed were not appropriate for designing a tank prone-driving bed and that the kneeling prone position, which would save only about six inches of vertical space, offered no significant reduction in hull height. Laboratory and field studies adapting the Air Force findings to tanks and generating new data were recommended.

A study was undertaken to concentrate simply on seeing whether a prone driver could adequately control a track-laying vehicle and in dealing with that limited objective to develop some insights into the psycho-physiological problems generally involved in the prone concept. Twenty-two drivers with an average of 22 months tank experience drove an ONTOS T166 vehicle from both the seated and prone positions (using an Air Force bed adapted to the T166) over smooth and rough test courses. The subjects drove for a little more than 20 minutes at a time during the normal tests; but four subjects who were given medical examinations before and after drove for six continuous hours in the prone position over the rougher course. The results of the tests showed that, as compared to their seated performance, drivers in the prone position could control and operate the T166 adequately; the examinations of the four men who drove for the extended period revealed no physical ill effects from the prolonged exposure in the prone position. Both the human factors and medical analyses, however, suggested that further information was needed to evaluate the prone driving position for tactical use and more was sought both in the laboratory and in the field.

The laboratory study reported in 1955 compared the effects of the seated and prone positions on psychomotor performance. A task unit was devised to require realistic control movements from drivers steering seated and prone driver-station mock-ups. Total time and error time were the measures of performance. Both mock-ups were built to the inside dimensions of the M41 tank, and they were equipped to provide similar control requirements and fields of vision. A new flat-prone driving bed was designed to use as little vertical space as possible. Its shoulder supports stabilized the driver and brought him into an efficient relationship with both the visual display and the hand controls. Only the accelerator pedal needed to be adjusted to the individual driver. The results revealed no significant difference in performance between the flat-prone and the seated positions.

The M41 tank was adapted for the field study that followed. The study concluded that the M41 could be operated adequately over a wide variety of terrains from the prone position and that drivers could operate in that position for considerable periods of time over fairly demanding terrain.

These studies of the prone driving position for tanks show the same progression that has by now become familiar in this discussion. At the outset in 1953, it was necessary, taking the earlier Air Force work into account, to pin down first of all what kind of questions needed to be asked about prone driving in tanks. Further insights gained by installing the Air Force bed in an existing vehicle were in turn applied to a laboratory test comparing seated and prone tank driving. Finally, a newly designed bed, conceived out of the Army's need to lower tank silhouettes and out of the information collected in the earlier studies, was installed in a modified version of an operational tank to see how well drivers could operate with it. The overall outcome was a body of information about prone driving available to the designer who might be called on to conceive a tank putting the driver in that position.

Meanwhile, other driving conditions were dealt with as HEL's tank studies continued. In 1960, as part of the effort to adapt the tank to the conditions of radiological warfare, HEL undertook a study of "TV driving" -- using television as the driver's primary visual contact with the world outside in a tank fully buttoned up to simulate the crew's protection from radiation.

The results of this study indicated that, even without specially adapted TV equipment, drivers can operate a vehicle equipped with TV for its primary visual system. These results revealed a possible new dimension in future tank design, and they also added to the fund of knowledge about how men can function as drivers.

Our most recent study on tank driving was conducted for the new Main Battle Tank Program, which is under joint development with the Federal Republic of Germany. In this tank the driver is located in the turret in an attempt again to reduce the overall tank silhouette. We conducted tests to determine how well the driver can drive from this position when compared with driving from the hull. Because of the joint nature of the program, this test was conducted in Germany, where both German and U. S. subjects could be found. A series of test courses were used to measure the driver's performance with a test rig, which could be driven from either position. These tests measured the driver-vehicle performance and the combination of the driver-vehicle-commander performance in selected tactical terrain situations. Such is the case when the vehicle goes into the firing position or is backing through difficult terrain.

Some of the methods for evaluating this new driver location grew out of an earlier study conducted in 1965. HEL had proceeded to determine the vibration environment of the M60A1 tank and the effect it might have on driving performance. The question to be answered then was, "Is the tank's cross-country speed limited by the vehicle ride quality?", which in turn implies some relationship between the crew vibration environment and the vehicle speed. HEL proceeded toward a description of this relationship and the formulation of a technique that could be used to evaluate future concepts and other crew functions in this type of environment. The study was conducted in two phases. In the first phase, subjects drove an M60 tank over standard courses at constant speeds to establish a base line for each subject and determine the repeatability of measuring G loads when different drivers were subjected to the same environment. In the second phase of this study, the drivers drove the M60 over a cross-country course at their maximum speed without regard to the test vehicle or instrumentation. The results of this study established a correlation between speed and G loads and determined the maximum G load the drivers would accept. One interesting outgrowth was that the ruggedness of the suspension system of the M60 tank, and not the driver, was the major factor limiting the vehicle's mobility in this type of environment. The difficulties with the suspension system included such things as bending, fatigue and shock failure of various suspension components.

It was also important to determine how the G environment affected other crew tasks in the tank. We, therefore, proceeded to study the crew operation of loading the main armament while on the move. Tank designers have recently delegated this manual task to automation, but no workable automatic loader design existed in 1964 when we conducted our first pilot study. Specifically, the study was designed to determine what effects the G loads the loader experienced while the tank traversed various types of terrain had on the loading of the main armament. This study was also divided into two phases. Again a base-line performance had to be established, this time for our gunners, so that the moving phase could be compared. Three different types of ammunition were used, and their weight and length ranged between 41 and 48 pounds and between 33 and 39 inches. The rounds were placed in different stowage positions in the turret so that all possible conditions due to stowage could be examined. Our second phase was the moving phase. Speeds of five and ten miles per hour were maintained by the vehicle. The loaders proceeded to load three consecutive rounds while cameras recorded their performance. It was not possible from the study to establish loading times because of the number of trials conducted, a problem that often occurs when live firing is required. But the results indicated that loading can be done in this environment, and that the heavier and longer rounds have an effect on the loading time. Since this tank was not designed to load on the move, design refinement in the loader's area of the crew compartment and the incorporation of loader assists were proposed for future study.

HEL's experience with ammunition loading and handling in tanks goes back several years when the tank guns began to fire and launch missiles like Shillelagh. The ammunition grew considerably in size and problems occurred when the missiles were handled and loaded within the confines of limited work space. Studies during this period of time were designed to determine the effects of missile length and weight on loading time. Since the vehicle's interior space had not been established, a loading work space mock-up describing the most limited space foreseeable was fabricated. The weight and length of the missiles, also undetermined, were varied within reasonable limits to simulate the final configuration. Subjects loaded sets of five missiles each from a kneeling position simulating the loading tasks of a fire mission from this restricted space. The results indicated that missile length affected loading time, but the actual time differences involved had to be evaluated in light of the tactical requirements. Our effort was then turned to investigations of specific components in the man-loading task. Two studies were directed to specific problems related to breech configuration. Several breeches had been proposed, and the designers were concerned about the compatibility of the ammunition and man with the new breech systems for an updated M60A1E1 tank. Since the gun-vehicle systems had not been built, HEL turned to mock-up techniques successfully used in the past. The breeches were studied in reference to their opening, orientation and elevation from the turret floor, and with different loading tray configurations in an effort to determine the most desirable breech feature for man-loading.

What if the loader is replaced by an automatic system? Does the human engineer no longer need to concern himself with this operation? This question arose from a revolutionary design change in tank turret design which positions the driver in the turret and eliminates manual loading by utilizing an automatic system. Who loads and how does he load the main gun if the automatic loader fails? How does the automatic loader get resupplied? Does reserve ammunition need to be carried in the turret with the men? How is it stowed? Who is responsible for it? These are the types of questions that had to be answered at the concept stage of the new Main Battle Tank Program. We first began by investigating the new turret position and crew operations and determined that the driver was in the only accessible position to load the weapon manually if the automatic loader should fail. The commander and gunner could provide only limited assistance, if any, in this operation. In the conceptual stage, very little information existed about the interior arrangement; and, in fact, the interior volume had yet to be established. The crude mock-up technique was employed again with the purpose of determining if the task could be done. The task was feasible, but studies would be required along the design development phase. The next step was, in fact, accomplished. An engineering mock-up was fabricated with an operational breech system and a fully operational driver's station. Studies were conducted on manual weapon loading, replenishing the automatic loader system, and resupplying the turret-stowed ammunition. One more step is still required. When pilot vehicles are available, the complete ammunition system must be evaluated under operational conditions.

This series of loading studies demonstrates the need at the concept stage of a vehicle to determine operator-machine feasibility and to focus attention on potential problem areas. HEL has followed this approach for the MBT-70 Program. The ammunition-handling studies just outlined and the driver-in-turret feasibility studies are examples of this approach. Another such area where a human engineering assessment was required pertained to crew vision from a radiological tank such as the MBT-70, where the crew will perform the majority of surveillance tasks from a sealed compartment isolated from the outside environment.

HEL, therefore, directed its effort toward one aspect of crew vision -- namely, establishing target-detection capability for several vision systems which were being considered at that time. Two field experiments were conducted. The first in the summer of 1965 at Fort Knox where tactical support could be acquired in a realistic environment. Four vision systems were selected as having the potential of being the prime vision mode. These systems were installed in separate operational M60 tanks where senior tank commanders and gunners searched and detected targets which consisted of a platoon of tanks with APC support. The targets were deployed realistically to present both attacking and defending positions and were capable of returning simulated fire at the observer tanks. The results of this study emphasized the need for maximum open vision, which is normally provided a commander in conventional tanks via the open-hatch position using hand-held binoculars. This type of vision mode was found superior to a 360^0 vision block cupola, a standard M60 gunner's periscope, and a vidicon television system.

The second study was an outgrowth of the first. It also was conducted under the same tactical conditions at Fort Knox but in the winter of 1966. This study was conducted because additional information was required on target detection from these same vision systems; but this time the observers would perform the detection tasks in moving tanks. Although the vision modes remained basically the same, several of the vision systems themselves were upgraded to reflect some improvements that had been determined from the first study. Specifically, the 360^0 cupola was increased in size, the vidicon television was replaced by an orthocon television (incorporating a stabilizer device), and a gunner's telescope was added. The results of the second study substantiated the results of the first study, and placed additional emphasis on stable magnified viewing for detecting well concealed targets.

A great deal more information is required in just the area of crew vision, needless to say, for all of the areas outlined in this paper. The human factors engineer has only scratched the surface in describing man's performance within our current vehicles. But the body of information is growing, and it is being used by the vehicle designers.

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13. ABSTRACT

This paper will describe the growth of human factors engineering and show how it is applied in designing combat vehicles, by giving examples of work we perform at the U. S. Army Human Engineering Laboratories (HEL), Aberdeen Proving Ground, Md. It will trace our efforts on two types of vehicles -- tanks and armored personnel carriers. However, these are selected examples; they cannot detail the total human factors effort on combat vehicle programs.

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