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HUMAN FACTORS IN WEAPON SYSTEM EVALUATION (U)

JAMES K. ARIMA, PH. D.

Behavioral and Life Sciences Section

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 MELLONICS SYSTEMS DEVELOPMENT DIVISION
LITTON SCIENTIFIC SUPPORT LABORATORY

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LITTON SCIENTIFIC SUPPORT LABORATORY
PO Box 379 Fort Ord, California 93941

FOREWORD

This paper was presented at the 20th Military Operations Research Symposium, held at the National Bureau of Standards, Gaithersburg, Maryland, on 13 December 1967. It appears in the proceedings of the symposium published by the Military Operations Research Society, Alexandria, Virginia. The proceedings is a classified publication given limited distribution.

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HUMAN FACTORS IN WEAPON SYSTEM EVALUATION (U)

JAMES K. ARDMA

Mellonics Systems Development Division
Litton Industries

Since the beginning of the Military Operations Research (MORS) Symposia there has been considerable change in the evaluation of weapon systems. The change has been away from stereotyped testing under a set of ideal, tightly controlled conditions toward testing in more operationally realistic environments which permit the dynamic interplay of the environment and the system being tested. This change parallels the growth and acceptance of the systems concept in the design and development of weapons. That is, we no longer think of a weapon system in terms of the shooting end of the hardware alone but include the people who man and operate it, the organization and doctrine for its use, and the combat and logistics support necessary for it to be maximally effective.

My presentation focuses attention on how we have improved the evaluation of the human side of weapon systems--the area commonly referred to as human factors. I shall also mention some shortcomings as they exist today and some areas in which considerable improvement might be expected before, say, the 30th MORS anniversary symposium. As a footnote, I might add that much of what I have to say is with reference to Army systems, but I am sure you will be able to think of comparable illustrations in the Navy, Marine Corps, or Air Force.

BACKGROUND

Some of the early influence in getting human factors into weapon system evaluations came, no doubt, with the testing of a very old system--a soldier and his rifle. Information coming out of World War II and the Korean War began to suggest strongly that the way the so-called "average" soldier used his rifle in combat did not have much in common with the skill training he had received. This training resembled more the type of firing one sees in the annual rifle matches at Camp Perry, Ohio. The biggest difference, of course, was that in combat the target could shoot back. Therefore, the firing of his rifle meant that the soldier might reveal his position and draw the fire of the enemy. Moreover, he had only a limited number of rounds of precious ammunition that he felt compelled to save for some unforeseen event that could be extremely critical. And finally, the information being gathered suggested that most rifle fire was not aimed--that is, there was usually no definite, visible target, or, when there was a target, there was often only time to point and fire.

From the training side, these investigations led to the now familiar Trainfire concept with the scientific support provided by Human Resources Research Office, (HumRRO), George Washington University¹. On the evaluation side, experiments such as the SALVO series conducted by Operations Research Office, (ORO), John Hopkins University were instituted.^{2,3} Among other things, these studies attempted to determine the contingencies present when a rifleman fires his weapon in combat and to incorporate the findings into field experimentation. They developed information relative to range, exposure

time, visibility, movement, and signature or disclosure activity of targets in rifle combat, and the role of confusing contexts in which targets appear. They found that the use of these factors in field experimentation critically affected the accuracy of rifle fire, produced more realistic estimates of the effectiveness of rifle fire, and even led to changing concepts about the basic measures of effectiveness for rifle fire.

Target and Range

The SALVO-type approach, which emphasizes targets and target presentation, eventually led to the very sophisticated small arms ranges that were developed at the US Army Combat Developments Command Experimentation Command, (CDEC), Fort Ord, California, with the help of its scientific contractors, the Stanford Research Institute and later, Litton Systems, Inc.



Figure 1 TARGET IN COFFIN

As shown in Figure 1, the basic element of the target range is a coffin-like box set in the ground which contains an instrumented pop-up target with sensors for hits and near-misses and a weapon signature simulator.

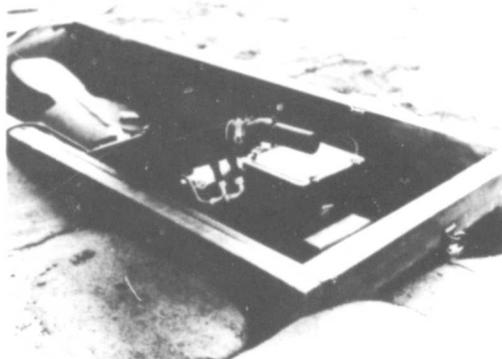


Figure 2 SIMULATOR IN POSITION

Figure 2 shows the firing end of the simulator just to the side of the target.

The range, shown in Figure 3, was one of a defensive posture with the targets appearing first from the rear and progressively "popping-up" until at 40 meters the closest targets appeared as a unit to simulate an enemy assault. The defense remains in a fixed position. The computer van which houses the computer and related equipment to control target presentation, fire simulators, record hits and near misses, and other pertinent data was located just off range. A portion of the console in the van shows the target actions and permits over-ride of the computer in manually controlling the targets, if desired.

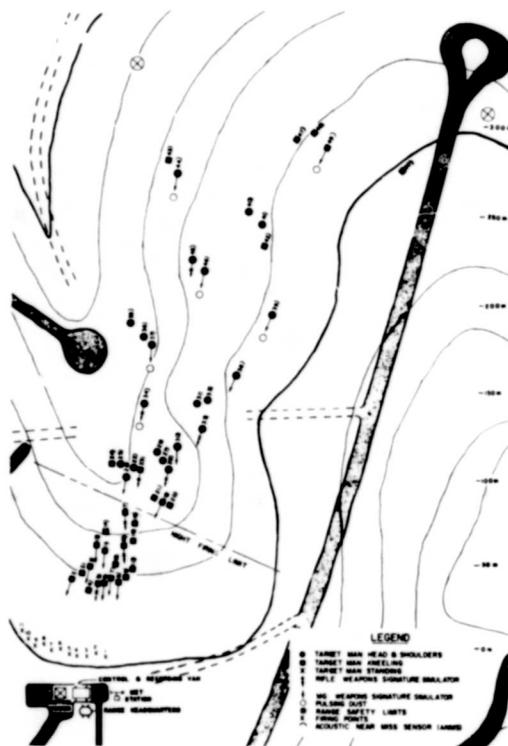


Figure 3 TARGET RANGE

Stressing the Individual

Innovations in evaluating rifle systems have also emphasized the person firing as well as target presentation. I am here speaking of efforts that are usually referred to as "stressing" the individual. The SALVO experiments, for example, included trials in which prone riflemen were instrumented with electrodes inside their boots to shock them. I have been told that the shock was so strong in some instances that you could see their legs jumping, but there were no great differences in rifle fire measures between the shocked and nonshocked trials.

In another study, HumRRO used explosive charges planted in the firing lanes which went off in an approaching sequence so that they came closer and closer to the individual firing down the lane.⁴ The implication was that the charges would eventually go off right at his firing position unless he maintained certain target effects within given time constraints. There were slight differences in rifle fire accuracy between the charge and no-charge conditions, but the differences were attributed to the mud, dirt, and debris thrown up by the charges, rather than to a stress effect.

More recently, the US Army Human Engineering Laboratories, an Army Materiel Command (AMC) agency, conducted a series of studies on rifle fire in which the stressed condition was a frontally located BB gun firing at a standing soldier who fired at pop-up targets beyond the BB gun.⁵

There were two no-BB-gun conditions in the experiment. In one condition, the soldier fired in the normal fatigue uniform

as shown in Figure 4. All soldiers were instructed in, and used, the pointing fire technique.

Figure 5 shows a soldier dressed for firing in the second no-BB-gun condition. He wears the protective uniform that was devised for the experiment. This condition provides a control for the effects of the protective clothing alone on pointing fire.

Figure 6 shows a soldier firing in protective uniform while being shot back at by the BB gun. Note the position of the BB gun located in the small mound between the soldier and the target which has popped up beyond the mound. The results showed that there were no major differences between the first and second conditions, thus implying that the protective uniform did not degrade firing performance under the no-BB-gun condition. However, when the BB gun was activated, performance changes did occur, indicating that the BB gun caused the difference and not the clothing.

Summary

I have used innovations in the evaluation of small arms to illustrate ways in which the contribution of human factors to weapon system effectiveness are now more critically examined. Generally, we employ more tactically realistic situations or settings, use personnel in the evaluations who normally man



Figure 4 SOLDIER IN FATIGUE UNIFORM



Figure 5 SOLDIER IN PROTECTIVE UNIFORM



Figure 6 BB GUN CONDITION

the system, and look for ways to stress the subjects. You will find some attempt at incorporating these principles in weapon system evaluations being conducted over a wide range of activities, such as those at Eglin Air Force Base, Camp Lejeune, China Lake, Point Mugu, Sandia Test Range, Holloman Air Force Base, and the many test sites of the AMC Test and Evaluation Command.

COMMAND CONCERN FOR HUMAN FACTORS

In some instances, there does not seem to be any pressing necessity for incorporating human factors into the evaluation of weapon systems. For example, some systems are less dependent on the human operator than others. Other systems entail less stress on the operator in the combat environment. Some systems, such as those where the human operator's primary function is to monitor displays, can evaluate human factors in simulations that do not exercise the entire system. And then there are systems that are so expensive to operate that genuine firings are devoted almost exclusively to hardware aspects and are very limited in scope. Reasons for not considering human factors, however, are more often than not invoked to sweep a difficult problem under the rug. But today, those who avoid human factors are more frequently being called upon by their superiors to account for their actions, since the maximum, effective utilization of our manpower resources is an absolute necessity.

On more than one occasion, General Abrams, when he was Vice Chief of Staff, queried CDCEC as to its approach and consideration of human factors.⁶ On 5 May 1966, Major General Cagwin, then CDCEC commander, wrote the director of his research office: "During General Abrams' visit the subject of human behavior was raised and discussed several times. The discussions were quite revealing of the need for a valid basis of predicting human behavior under combat stress in a broad range of battlefield events." General Cagwin also said in his letter: "... We are concerned with human behavior as a factor of major importance to our search for 'truth' by combat field experimentation. It is highly desirable--if not imperative--that CDCEC integrate human factors into combat field experimentation as soon as possible."

In January 1966, the Combat Developments Command (CDC) Army Air Defense Agency solicited HumRRO's help to ascertain the effects of the combat environment on persons manning Army air defense systems.⁷ This was after extensive Army air defense studies were criticized by the Harding Committee for not sufficiently considering the human component of the system.

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It is apparent then, that while we may have come a long way in evaluating human factors in weapon system evaluations, there is still considerable concern in the highest places for a much greater and more thorough examination of the role human factors play in weapon system effectiveness.

CURRENT SHORTCOMINGS

What are common shortcomings today? On what points can weapon system evaluations be criticized with respect to human factors? There are several with readily apparent solutions that I shall mention. The ones for which solutions come hard will be left for later.

The majority of problems are associated with the implementation of a realistic combat setting or a challenge to the individual. The most persistent shortcoming lies in going to great lengths to create superficial realities of the combat situation and missing the elements that are critical to the weapon system being evaluated.

Uncertainty in Combat Environment

One important area on the basis of which evaluations might be criticized is the amount of uncertainty presented the player subject. By uncertainty, I am speaking in terms of the entropy concept of information theory. Translated to the quasi-combat scene of weapon system evaluations, uncertainty, then, refers to the number of probable or possible events that confront the individual and the number of possible courses of action from which the individual might have to make a choice. These two aspects of uncertainty in the combat environment have been referred to as "information load" and "response load" with respect to the individual.

Information Load

The higher the information load, the more unpredictable are the events, and the greater the uncertainty. To illustrate this point, let us take as an example the evaluation of a visually sighted, manually operated, antiaircraft weapon system. If the target aircraft might appear from one of two different directions, we have one bit of information load. But if the aircraft always retraces a previous path from the opposite direction, that is, it comes one way and goes back the other way, we no longer have any uncertainty and there is no information load. Information load, in this hypothetical setting, could be increased in any number of ways, such as by having several approach paths, speeds, altitudes, cross-over or fly-by patterns, and types of aircraft. Especially important would be uncertainty as to when the aircraft might appear and the possible appearance of both friendly and hostile aircraft.

Response Load

By response load, I refer to the fact that individuals usually have more than one thing they must do at any one time. Whatever they actually do represents a selection from among several alternatives. When critical acts must be taken in the combat situation, they are often superimposed on the ongoing acts of a fully occupied person. Accordingly, it is usually desirable that individuals participating in a weapon system evaluation be engaged in sustained, quasi-combat operations as a part of the environment for the test.

Another aspect of response load lies in the specific actions of individuals directly related to operating the system under evaluation. For example, multiple targets will present a response load on the individual in that he must decide which target to engage and having decided to engage one, he must attempt to monitor the actions of the others at the same time. Or a display monitor may be required to send information while monitoring his displays. Whatever the situation, the response

loading on individual participants should adequately reflect the load present in the tactical environment. An appropriate response load on system personnel is especially important in weapon system evaluations where system response characteristics such as target selection and reaction times are being investigated.

To summarize, the weapon system evaluation situation should attempt to remove any regularity, repetition, and predictability of events that are not a part of the combat environment of the system. It should also provide adequate and appropriate response requirements on the personnel operating the system. If the situation does not provide adequate information and response loads, system effectiveness may be grossly overestimated.

Overcontrol

Another problem area closely related to those I have been discussing is the matter of overcontrol in weapon system evaluations. This usually occurs because of a misguided interest in reducing variability. The result is a drastic reduction in the information and response loads for the individual and performance that is grossly different from that to be expected in combat. The findings of evaluations conducted under such tightly controlled conditions are therefore very limited in their application. That is, the evaluation has produced large amounts of data that may not be very pertinent to the many ways the weapon is actually used in combat because of the arbitrary decisions of the evaluator. There is, moreover, considerable danger that the results may be erroneously taken to be a valid estimate of the effectiveness of the weapon system simply because of the very labored conditions under which the trials were run. As an example of overcontrol, let us take again the evaluation of a visually sighted antiaircraft system. Overcontrol would include such things as having the individual or crew fire at the approach, overhead, and receding sectors of a fly-by in separate blocks of trials. Overcontrol would also include firing over many successive trials at a single range, a single altitude, and a single cross-over pattern and the like. Such controls create massed learning of a unitary set of responses that may eventually result in stereotyped, unnatural responding.

Overcontrol also destroys the dynamism that is present in the tactical situation or system. For example, the receding aircraft, except for unusual tactical situations or masking conditions, represents a final parting shot that the gunner has after he has failed to damage the aircraft on its incoming and overhead cross-over path. This aspect is completely lost when the receding sector is fired as a separate series of trials.

Player Quality Control

Another area of criticism might be the absence or lack of quality control of the player personnel. Too often, there is a tendency to devote a disproportionate amount of attention and funds to physically measurable facets of a situation while neglecting such important factors as the representativeness of the player sample from the standpoint of individual qualifications and level of unit training. Appropriate and adequate amounts of training assume particular importance for the evaluation of prototype systems where no training doctrine exists. To take for example, an extreme case, let us say that the development of a new system stresses its accuracy, as does the evaluation instrumentation. Let us further say that the old system being replaced emphasized quickness of reaction and that the training of troops was heavily loaded toward this end. The grave error in this type of situation is to borrow trained troops from somewhere, orient them briefly to the new system, and then send them out for the evaluation of the new system. Obviously, the situation does not provide a good evaluation of the accuracy of the new system.

Similarly, there is very often a great amount of attention and money spent on measuring events to an unrealistic degree of accuracy with complete disregard, from the human factors standpoint, of the scope and purposes of the experiment. This situation arises when the critical dependent measures are based almost wholly on the actions of a human being, such as target detection, or when the hardware elements are the same but different ways of utilizing the personnel are being evaluated. In such instances, absolute levels of performance are not important, and the question asked is: "How much better or worse is one condition versus another?" When all these conditions hold, the measure used for comparison is usually a measure of central tendency, and the only concern about distributions of these measures is their relative homogeneity. Under such circumstances, little change in the measures of central tendency could be expected regardless of whether a thousand, ten thousand, or a hundred thousand dollars are spent on the instrumentation. More precise comparisons can be made in such situations by greater effort in the selection and training of the player personnel to reduce variability on their part.

Instrumentation

As long as we are speaking of instrumentation, I would also like to mention that the instrumentation-man interface is too often taken for granted. The instrumentation and data collection activities constitute a system that must be evaluated, too. The hardware might be excellent, but if the hardware interfaces with the ongoing events of an evaluation through a human monitor, the sensitivity of the hardware alone is not the sensitivity of the data collection system. Some time ago, I heard a briefing in which it was alleged that a certain critical event was being measured in one-hundredths of a second. This was a very misleading statement because the truth of the matter was that the event being measured was the thumb of a monitor pushing a button. He eyeballed the event and had to make a decision as to when the event being measured was taking place.

In conjunction with another experiment, we actually did measure the latency of monitor responses to voice commands. In this situation, the weapon operator gave five different commands in sequence, each separated by several seconds. Using three different buttons the monitor made three presses and two release responses. Our analysis showed no statistically significant differences among the responses so they were pooled. In classic laboratory, reaction-time experiments, well-practiced subjects who are given consistently timed warning signals react in the neighborhood of 100 to 200 milliseconds for key pressing or key releasing responses. The pooled results of 2,700 responses in our study showed the distribution graphed in Figure 7.

The mean of the distribution is 418 milliseconds. The shape of the distribution is characteristic of discrimination reaction times and seems to be best fit by a double monomial or displaced gamma function, according to some recent research.⁹ It is obvious that a supersonic aircraft, for example, could travel a considerable distance in 418 milliseconds.

I shall make one final point in regards to instrumentation. This has to do with the use of computers, especially in real time experimentation control and data collection. Errors creep into this type of instrumentation through errors in communication between the designer of the evaluation and the computer programmer or because the computer programmer is forced to make transpositions, simplifications, and other changes to protocols as given him.

MAJOR PROBLEM AREAS

I shall turn now to those areas where the problems of weapon system evaluations loom large and are more difficult to solve. One of these is the need to get into our evaluations the dynamic aspects of two-sided engagements. This need is especially

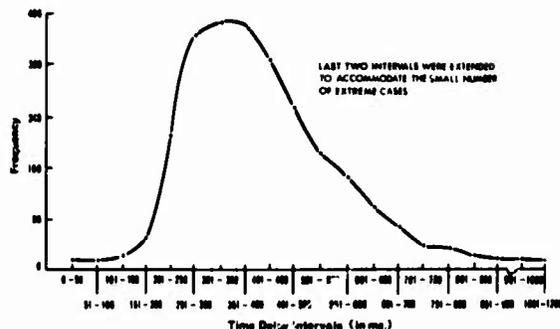


Figure 7 LATENCY DISTRIBUTION

urgent where it can be expected that a weapon system will have to operate in direct confrontation with the enemy.

By way of example, let us go back to the newer infantry ranges I previously mentioned. While they constitute a great improvement in providing a realistic fire situation for player subjects, it is quite obvious that they are still just ranges. That is, all the effects are one way--on the target arrays. While simulators at the targets fire to provide realistic weapon signatures, those firing the weapons do not get killed or suppressed as the targets do.

Under such conditions, with a constant threat programmed in the target arrays and a common scenario or standard schedule of events, it is possible to find that a smaller infantry element will produce proportionately greater target effects than a larger element. The smaller element may also be easier to control, it may distribute its fire better, and it may be more efficient in ammunition consumption. Findings such as these are constantly in danger of being eagerly accepted without due consideration for the limitations present and the many important unplayed factors in the evaluation.

It is obvious, first of all, that there is less redundancy in firers per target for the smaller element, and accordingly, fewer rounds are wasted in overkilling or oversuppressing targets. Also, a small number of firers will create less flying dust and debris in the neighborhood of targets, thus making for better firing conditions. But the most important factor not played is the expectation that, under these conditions of equal threat and common scenario, the smaller unit would be suppressed and killed more readily. For the smaller unit to survive against the uniform threat, it would have to use different and appropriate tactics that would significantly alter its fire characteristics.

Simulating Two-Sided Combat

CDCEC is approaching this problem by evaluating small infantry elements on the livefire range and also on a non-livefire, two-sided combat experimentation course. Fire-effectiveness parameters developed on the livefire range are applied to the blank fire used on the combat experimentation course to inflict casualties. This approach reflects practical necessity, it is a good compromise solution, and it may be a step that will continue to be necessary for some aspects of weapon system evaluations. But it is obvious that problems inherent in obtaining the original livefire parameters are carried over into the combat experimentation course.

A different way to approach the two-sided problem in the same situation might be to play the livefire action sequentially

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on the same or two pieces of very similar terrain for the opposing forces, merge the one-sided action, and then repeat the field situation with computer inflicted kills and suppression of the firing elements. I shall refer to this as the sequential-iterative method for two-sided combat.

Figure 8 explains diagrammatically how this might be done. In step one, blue force using livefire fires on the red force represented by an appropriate target array. The computer stores the results. The roles are then reversed. In step two, red force using livefire fires on the blue force represented by appropriate targets. Again, the computer stores the results.

In step 3, the computer, using rules which have been programmed into it, calculates a tentative schedule of casualties and suppression for both sides in real time.

Figure 9 shows the iterative step where the same action is replayed. Only this time, the computer inflicts casualties, causes suppressions of the firing elements, and controls the simulated actions of targets to represent the fire and movement taken in steps one and two. The computer stores the results and revises the casualty and suppression data to reflect what happens in the iteration. If the results in steps 4 and 5 are too disparate, the situation is reiterated with a revised casualty and suppression assessment program. If the results are reasonably consistent, the action is permitted to go on beyond the first phase and steps one through five are repeated for the next phase, and so on until the entire planned action is completed. When the action is completed, there is a computer record of the entire two-sided engagement in real time which can be used with different weapons, personnel, and doctrinal parameters to assess their effects in a realistic, empirically based simulation.

Another possible way of conducting synthetic two-sided livefire evaluations is through a yoking technique. In concept, the yoking technique is more simple than the sequential-iterative technique, but there are greater demands on the instrumentation. It is also more desirable because it permits realtime, continuous, two-sided action. Because of instrumentation complexity, the technique would seem to be best suited for a duel between two weapons.

As an example, let us take a tank-antitank weapon duel. Two identical pieces of terrain would be required. On terrain

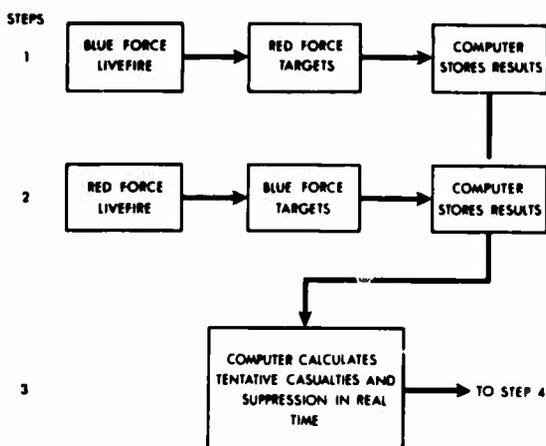


Figure 8 SEQUENTIAL-ITERATIVE LIVEFIRE NO. 1

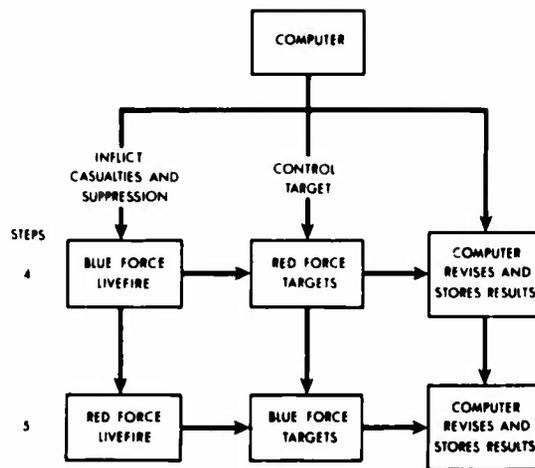


Figure 9 SEQUENTIAL-ITERATIVE LIVEFIRE NO. 2

one, the tank would be live and the antitank weapon a realistic, maneuverable, simulator-firing target. On terrain two, the antitank weapon would be live and the tank the target. The actions of the target in each case would be dictated through telemetry by the actions of its live partner, and this represents the concept of yoking. As the situation develops, there would be two nearly identical duels going on simultaneously.

Nonreactive Testing

The relatively free play that is possible in any of these two-sided methods is representative of a concept termed "non-reactive testing," which has recently come to the forefront in some areas of behavioral sciences research. It is not unlike the concept of nondestructive testing in engineering. The basic idea is that the testing procedures should not cause a reaction in the process being evaluated. The key to nonreactive testing in weapon system evaluations is free play of the system being evaluated with preservation of as much of the two-sided nature of combat as possible and instrumentation adapted to obtain a complete record of events in such a situation.

Motivation

Up to this point, I have assiduously avoided the topic of combat stress since it was brought up earlier in this presentation. I shall continue to avoid the topic. There are too many generalities and biases concerning the so-called "pucker" factor to treat the subject lightly and quickly. It would have to be the subject of a separate paper. Before dismissing the subject, I shall comment that it does not look as if we shall be able to duplicate in any experimental weapon system evaluation the conditions which represent the threat to life and limb found in real combat. Trying to do so with gadgets and tricks have had only marginal success. Moreover, these efforts have often clouded the experimental findings without adding to them. This is not to say that research should not be conducted on how to induce these effects; I am only saying that the state of the art as it presently exists is not conducive to applications.

On the other hand, we can go a long way in making the evaluation situations sufficiently realistic with considerable stress placed on the subjects manning the systems. Loading the individual with information processing requirements, providing difficult and many courses of action from which a response

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must be selected and carried out, forcing the player to reach a decision and carry out an action without sufficient reduction of uncertainty, and adding a time demand on top of all these things provide considerable stress.

The element which is missing from the scheme of things presented so far is the steam, drive, or whatever you might wish to call it to make the subject in an evaluation perform realistically. This is usually referred to as a problem in motivation. However, even more so than terms such as fear, fatigue, and stress, the concept of motivation has fallen into ill repute because so many undifferentiated ideas are included in the term. It is all things to all men.

Incentives and Rewards

Two aspects of motivation that can be dealt with quite specifically are incentives and rewards, and it is these that I would like to finish with.

What is the incentive and what is the reward for a soldier taking part in a weapon system evaluation? Traditionally, it is said that it is his duty, once he has been ordered to do so. When additional incentives or rewards have been proposed, serious objections have been voiced by some unit commanders. They object to giving the soldier something extra for what he is supposed to do. In fact, some unit commanders seem to construe the proposals as a reflection on their ability to get the requisite performance out of their troops. They may fail to appreciate the fact that the words "duty" and "orders" do not bring about results on their own. They are effective because there is a very generalized system of negative and positive rewards that are used throughout the services to differentiate for the man or woman in uniform those acts that are appropriate in response to the concepts of duty and orders. Negative rewards include such items as loss of privileges, extra duty, loss of position in a promotion sequence, reprimand, reduction in grade, loss of pay and allowances, confinement, hard labor, and many other more subtle forms of punishment. Positive rewards include extra off-duty time, medals, citations, promotions, trophies, and the like. The behavior which is molded or shaped by these rewards is some understanding of what is minimally necessary to avoid negative rewards and what is minimally necessary to achieve or acquire certain levels of the positive rewards under a host of typical military situations.

The effort that individuals, as a group, will expend to avoid negative rewards and acquire positive rewards may be used to define their incentive value. The effort that individuals, as individuals, will expend toward the attainment of these rewards can be used to infer their prevailing motivational orientation. At one pole, there are those who are motivated by a fear of failure and at the other end there are those who are motivated by a need for achievement. When it comes down to specific acts that are desired of individuals at more than a minimally acceptable level in the ordinary course of duty, these very general rewards I have mentioned have only minimal incentive value for a large portion of the population that takes part in weapon system evaluations.

Accordingly, over a period of years, the Army, for example, has developed various forms of monetary incentives for specific purposes. There are such things as extra pay for special skills, professional allowances, superior performance pay, reenlistment bonuses, oversea differentials, and hazardous duty pay. For a very long time, the Army had a suggestion awards program in which civilian employees could get monetary awards, but a soldier got a pat on the back. It is only relatively recently that the soldier, too, can receive monetary awards. So there is a history of using tangible incentives in the Army for specific purposes. The usage has become so commonplace that individuals sometimes overlook the fact that they exist.

What is the case with military experiments and weapon system evaluations? Some evaluations require volunteer sub-

jects; a portion of a notice requesting volunteers that appeared in a post daily bulletin reads: "In addition to contributing to our nation's defense efforts, the program offers to accepted volunteers various bonuses: a four-day work week, a three-day pass each week, no fatigue duty, and thirty dollars a month per diem."¹²

In Operation STALK, which took place in the desert at Fort Irwin, the reward for the tank crew with the best record was a 3-day, all expenses paid trip to Los Angeles with free entertainment. The second place crew received an all-expenses paid trip to Los Angeles minus the entertainment.

In other rare instances, cash has been paid to subjects, but it seems that the 3-day pass is the most frequently used award. Escape from the evaluation situation, itself, has also been used, either intentionally or unintentionally, as a powerful incentive. That is, the participants are informed, explicitly or implicitly, that they will be able to leave the field problem when a certain level of performance has been attained or a certain amount of work has been completed.

The first comment I would like to make regarding the use of incentives in this manner is this: Instead of frankly acknowledging the place and purpose of an incentive program in military experimentation and weapon system evaluations and developing a sound program, such things as per diem pay, extra time off, escape from onerous duty, "scrunged up" rewards, and other strictly ad hoc measures are used in a seemingly half-hearted, almost surreptitious manner.

The second point to be made is that these rewards result in only a first and gross level of differentiation from the even more general rewards I have mentioned previously in respect to duty and orders. That is, they are used in an indiscriminate way to boost or maintain an overall level of performance. At the same time, this type of reward accentuates those acts or performance that are directly related to attaining the reward. In civilian commerce, incentive programs for sales are often constructed for such limited objectives as moving certain items out of inventory, getting new clients, or increasing renewal rates. The monies that are spent on such programs are considerable, but they pay off. In a military weapon system evaluation, the criterion may be the total number of hits. One problem with this type of reward is just this--it maximizes certain aspects of the evaluation to the detriment of others. With total number of hits as a criterion, great amounts of ammunition will be used and firing will be indiscriminately sustained as long as the chance for obtaining a hit is there.

Another criticism that might be made is that some sort of secondary system of points is necessary in order to score performance for the overall prize. Usually, the points are only given positively, and negative points are not used. In any case, the player must learn the relationship of his performance to points, but he has no way to determine how much a point counts towards the prize at the time of his performance. He can only determine the value of his points by comparing them with other competitors' points at some time much later when the information becomes available. If he finds that he is quite far behind, even after having given it a good try, he will lose interest and his performance may deteriorate more than in a no incentive situation. Thus, while the reward has succeeded in modifying behavior toward some evaluation objectives, considerable improvement is possible in the reward-incentive system.

Maximum improvement can be attained by having reward units that are meaningful to the performing individual or element scaled for every encounter or aspect of performance that is critical to the evaluation. These reward units should provide both positive and negative rewards (gain and loss) for greatest impact. The combat environment for most weapon systems involves constant decision making with possibilities of loss or gain always a consequence. The incentive system should adequately create these cognitive conflicts for the participant.

HUMAN FACTORS IN WEAPON SYSTEM EVALUATION—J. K. Arima, PhD

The most ready-made, appropriate system of incentives and rewards appears to be trading stamps. They have direct and immediate value to the participant. They occur in small enough units so that cost-gain considerations can be adequately scaled over a wide range of activities. By giving the participant a credit in stamps at the beginning of an evaluation, real loss can be created by taking stamps away as a penalty for wrong decisions and actions. Stamps are flexible enough in providing a variety of prizes to satisfy most individuals. They do not have to be cashed in at any particular time. They are very individual, in that every person can be a winner or loser. Skillful promotion can increase the subjective value of stamps to well over their actual cash value. In fact, purchased in large amounts, stamp plans provide for very cut rate merchandise.

How can they be used? Every round could have a cost. Every second that a target remains undetected could have a cost figure, perhaps exponentially scaled. Becoming a casualty under realistic rules of encounter could be true opportunity loss with a real cost, i.e., the loss of opportunity for gain of stamps plus the loss of the credit that one started with. Positive rewards of stamps can be similarly programmed. An overall victor type of prize can be incorporated into the schedule by putting the penalty stamps into a pool for the top performers. Obviously, the loss of a book of stamps is a poor substitute for the loss of life, but the point is that if the incentive loss were great enough, the penalty severe and appropriate to acts leading to the loss, the actions and decisions of the participant would approximate those made in a combat situation more than without the incentive-reward system.

I have approached a large number of incentive firms with these ideas, and their replies have been most enthusiastically stated, not just because the incentive experts realize that there is potential business in the area, but because they realize that this concept of carefully worked out incentive motivation is quite feasible, has many potential areas of application, and results in the epitome of what I might call "nonreactive control." That is, a great deal of control is possible, but the actions of the individuals represent their way of coping with the problem within the constraints expressed. And this is precisely what is desired for weapon system evaluation purposes.

As a footnote, I must state that the views expressed in this paper are entirely my own and do not necessarily reflect those of the Army or my employer, Litton Industries.

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13. ABSTRACT Weapon systems have at least a materiel component and a human component. Evaluation of the operational effectiveness of weapon systems must fully involve both components. The evaluation situation must be tactically realistic, personnel who normally man the system should be used, and there should be an attempt to stress the participants. To accomplish these goals, adequate information and response loads must be provided participants, over-control should be avoided, and player and instrumentation personnel quality control should be assured. Suggestions are developed for simulating two-sided combat, the concept of nonreactive testing is introduced, and the role of incentives and rewards to motivate and control performance is discussed.		

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