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Armor Crewmen Assignment Issues and the Use of the Unit Conduct of Fire Trainer (UCOFT) in Performance Prediction

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U. S. Army

Research Institute for the Behavioral and Social Sciences

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This product was developed in response to a request from Seventh Army Training Command and is an aid for military personnel charged with the development and validation of selection and assignment procedures. The report includes a brief review of selection research and methodologies and practical guidelines for avoiding pitfalls during validation research. Variables, aptitudes, and/or skills thought to affect gunner performance are discussed, along with critiques of recent predictor developments. In addition, (Continued)

ARI Research Report 1458

20. Abstract (Continued)

The report provides basic information on the Unit Conduct of Fire Trainer, the UCOFT's training matrices, and potential applications of the UCOFT in tank gunner performance prediction. A description of UCOFT performance measures and limitations is provided, along with recommendations for the development of a UCOFT training data base as part of a comprehensive USAREUR (U.S. Army Europe) data base.

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FOREWORD

Tank gunner assignment has in the past primarily been a trial and error process. Rising costs of ammunition and other training resources, as well as increased threat capability, make it imperative that the Armor force quickly identify soldiers who have potential to become superior tank gunners. In addition, strategies for maximizing the effectiveness of new Armor training devices such as the Unit Conduct of Fire Trainer (UCOFT) must be identified.

This product was developed by the Army Research Institute (ARI) as Technical Advisory Service to the Seventh Army Training Command (7ATC). BG Mallory, 7ATC Commander, and the Chief of the Training Analysis Branch were briefed on the results in August 1986. Input from this product was incorporated into research plans for 7ATC armor crewman assignment scheduled for first quarter FY87.

ARI's Fort Knox Field Unit provides research expertise on a variety of issues, including training and soldier assignment as they surface in the Armor community. This product has been prepared as an aid to military personnel charged with implementing improved soldier assignment procedures at 7ATC and the U.S. Army Armor Center (USAARMC). Guidelines for the development of a comprehensive UCOFT training and performance data base are presented. Such a data base could result in faster turnaround and higher quality answers to a host of personnel, training, and readiness questions.

EDGAR M. JOHNSON
Technical Director

ARMOR CREWMAN ASSIGNMENT ISSUES AND THE USE OF THE UNIT CONDUCT OF FIRE TRAINER (UCOFT) IN PERFORMANCE PREDICTION

EXECUTIVE SUMMARY

Requirement:

To assist the Seventh Army Training Command (7ATC) in the development of tank gunner assignment procedures and to provide the Armor community with a reference document that reviews selection research guidelines and UCOFT issues.

Procedures:

Information for the report was obtained from:

1. a review of selection research conducted by ARI

2. existing operation and training manuals for UCOFT

3. interviews with key personnel involved in implementation of results and updates to UCOFT.

Findings:

The report provides the user a background for understanding selection research, particularly as related to Armor crew assignment. Predictor test development procedures are discussed, along with guidelines for conducting validation research. The paper then presents a review of recent research on the tank crew performance prediction, including job-sample testing, relationships with mental category, and ARI's Project Alpha.

This report also presents background information on the UCOFT, a high-fidelity tank gunnery simulator, and its impact on armor training and selection. The UCOFT training matrices are discussed along with major UCOFT research and implementation issues. The report closes with a presentation of UCOFT data collection capabilities, potential improvements, and the value a comprehensive 7ATC UCOFT/gunnery data base.

Utilization of Findings:

The results have been used by the 7ATC in the development of tank gunner selection research. The results have also been provided to TRADOC Research Analysis Center personnel at Grafenwoehr, FRG, and to the Office of the Chief of Armor, Fort Knox, KY.

ARMOR CREWMEN ASSIGNMENT ISSUES AND THE USE OF THE UNIT CONDUCT OF FIRE TRAINER (UCOFT) IN PERFORMANCE PREDICTION

CONTENTS

LIST OF TABLES

CONTENTS (Continued)

LIST OF FIGURES

ARMOR ASSIGNMENT ISSUES AND THE USE OF THE UNIT CONDUCT OF FIRE TRAINER (UCOFT) IN PERFORMANCE PREDICTION

BACKGROUND

BG Mallory, Cdr, 7th Army Training Command (7ATC) presented a briefing at the US Army Armor Conference in May 86 in which he discussed the potential use of small arms qualification scores for selecting tank gunners. He also indicated that the United States Army-Europe (USAREUR) had noted that numerous gunners and tank commanders (TCs) suffered from some form of color blindness or deficiency which detrimentally affected their ability to operate systems containing color specific information. These issues prompted USAREUR involvement in the development of tank gunner performance predictors. This product was prepared to provide both a brief overview of recent tank crew performance prediction efforts and a discussion of issues regarding the use of simulation for performance enhancement and prediction. This document was completed at the request of 7ATC to serve as a resource and reference document for indivduals interested in tank crew assignment and the Unit Conduct of Fire Trainer (UCOFT). The issues discussed here, while specific to 7ATC's request, are representative of issues ARI routinely addresses for agencies or directorates associated with the Armor Center and School.

PREDICTOR DEVELOPMENT

How are predictor tests developed and what is ARI's role in their development?

The US Army's research agency charged with the mission of developing and validating personnel performance predictors is the US Army Research Institute (ARI) in Alexandria, VA. ARI's Manpower and Personnel Lab conducts research in the area of personnel management for the Deputy Chief of Staff for Personnel (DCSPER). This includes development of all tests used by the Army to place (classify) recruits into Career Management Fields (CMF). By congressional mandate, supported by legal precedent, no tests will be used that have not been validated against on-the-job performance measures. Simply stated this means one cannot develop a test, administer it, and then tell soldiers that they did not score high enough to get into a particular career field or job, unless one has first proven that soldiers obtaining that score, or below, actually have a lower probability of succeeding on the job. The process of obtaining this proof is called validation.

The validation process relies on statistical techniques such as correlation and regression. Correlation procedures determine the relationship between two data sets. For example, two data sets of interest to the Armor community include a data set containing the Armed Forces Qualification Test (AFQT) scores for tank commanders and a data set containing the tank Table VIII scores for those same tank commanders. When a correlation is computed the value obtained can vary between -1.00 and +1.00. If the obtained value approaches +1.00 it means, for example, that tank commanders having high AFQT scores also have Table VIII scores (i.e., more hits) (see Figure 1). If it approaches 0.00 then no relationship exists between AFQT and Table VIII performance for the tank commanders in the study (see Figure 2). When the relationship approaches -1.00 then high scores on one data set are associated with low scores on the other data set (see Figure 3). This can happen when time is used as a measure of performance because shorter times (i.e., smaller numbers) usually represent better performance and can correlate with another data set in which larger numbers represent better performance (e.g., AFQT).

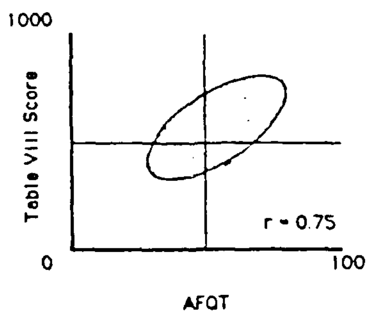

Figure 1

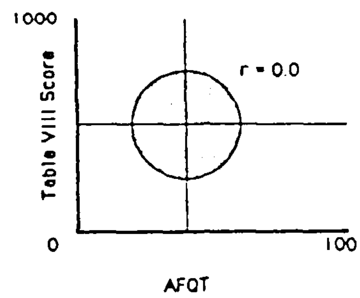

Figure 2

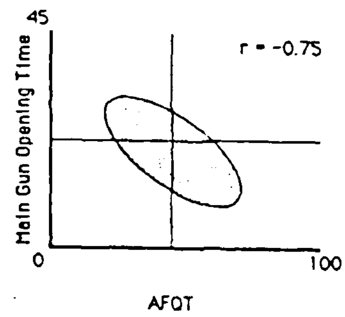

Figure 3

Regression techniques allow the prediction of values for one data set from knowing only the correlation and the actual values for the other data set. For example in Figure 1, if the correlation is .75 and an AFQT score of 90 is selected, one can tell that the Table VIII score for that TC lies between 900 and 950. If the relationship (correlation) between two variables is known and a soldier's score on one variable is known, then a probability can be established that he/she will perform at a certain level on the other variable (i.e., usually the job performance variable). Establishing these statistical relationships is the only fair way to use prediction tests. If one develops and uses a test which has not been validated he/she may wittingly or unwittingly discriminate against persons who may truly be qualified for the job. This inappropriate use of tests has resulted in numerous law suits filed against US corporations as well as city, and state governments. In light of these events, the Armed Forces are spending millions of dollars to re-validate their existing prediction tests, the Armed Services Vocational Aptitude Battery (ASVAB), and to validate new tests.

There are two experimental designs which are primarily used for validation of predictor tests. One is referred to as predictive validity, the other as concurrent validity. These differ as a result of the personnel involved in the validation process. In predictive validity, the researcher uses personnel who are naive, that is, they have had little or no hands-on experience with the job and have not been trained for the job. These individuals are tested, then "hired", (i.e., trained and placed on the job). After several months, the test administrator obtains measures of on-the-job performance and correlates them with the original test scores. This requires a longitudinal study effort. If the obtained correlation is significant, the first phase of the validation effort is complete. If, however, the correlation is not significant, the researcher must either design a new test or detect the flaw(s) in the current test or job performance measure and redo the validation.

Concurrent validation, on the other hand, is used when the researcher cannot afford to spend several months to allow naive personnel to try to perform the new job. In this instance, "incumbent" workers are tested, and then immediately evaluated on their job performance. This approach is often used because it is cheaper and faster than the predictive validity method. However, a high validity correlation from a concurrent design does not guarantee that a high correlation would also have been obtained if the predictive method had been used. Job incumbents usually bring to the testing environment greater knowledge and a better training background than the naive job applicant. This is a critical point to be considered if one wants to conduct a concurrent validation effort and then use the results as if a predictive validation effort had been accomplished. For example, a researcher could establish a relationship between .45 cal pistol shooting performance and tank Table VIII for gunners who are currently serving as gunners. These men are probably E-5s with several years of .45 pistol qualification exercises in their training background. If that researcher attempts to use the same .45 cal pistol shooting test to select gunners from a group of E-2 through E-4 soldiers he/she may find that the test is not valid because these new soldiers do not have the same knowledge or training background as those in the original validation group.

Once a significant validity correlation or coefficient has been obtained, it must be cross-validated. Some people refer to this as replication, however, that is not technically correct because the second phase of the process is not identical to the first. The cross-validation phase is conducted to ensure that value obtained was not significant by chance or as the result of some special characteristics of the people used in the experiment. To cross-validate, the researcher administers the tests to a new group of subjects (either applicants or incumbents depending on who was used in the original design) and then uses regression techniques to derive an estimated job performance score for each subject. The actual job performance measures are then obtained for subjects in exactly the same way they were obtained in the first phase of the validation process. For example, if a forced-choice supervisor's rating for was used, then the same rating format must be used again. Next, a correlation is computed between the estimated performance scores and the actual scores. If this too is statistically significant then the researcher has established that the test or tests are valid predictors of job performance. If, however, the manner in which the test is administered or the duties of the job change, the validation process must be redone.

Several points should be emphasized when preparing to conduct a validation effort. These are presented in the following.

Try to maximize the point-to-point specificity between the predictor and the criterion measures. This means that the researcher should ensure that the test or tests (predictors) capture or look like parts of the actual job (criteria). Past research has shown that the more similar the content of the test to the content of the job (Casio, 1978), the better the chance that the validity coefficient will be significant. For example, if you select tank

Table VIII as a gunner job performance or criterion measure, then the probability of obtaining significant correlations increases as the test you develop captures more and more of the critical tasks the gunner must perform on Table VIII. For example, whether or not a tank gunner can demonstrate how to effectively clear a mine field will probably not correlate with his performance on Table VIII because he does not have to clear a mine field on Table VIII.

Reliability is an important factor. In general the longer the test the more reliable it is; this is also true for criterion measures. There is a mathematical relationship between reliability and validity. Reliability sets a limit on how high the validity correlation can be. Reliability refers to the stability of a measure or score over time, (i.e., if the test is readministered immediately following its first administration what is the probability that the soldier would obtain the same or nearly the same score?) If you have designed the test so that it has a sufficient number of difficult items to allow the really high performers to separate themselves from the poorer performers, when you readminister the test, the high performers should again be differentiated from the poorer performers. If the test has low reliability it may either be too short (e.g., you only allowed soldiers to fire 4 rounds of .45 cal ammo on the test) or you failed to adequately standardized the test administration (i.e., establish the same test conditions for each soldier).

Sample sizes must be sufficiently large to support the statistical analyses required. A rule of thumb is that a minimum of ten subjects are required for every measure you wish to correlate. Thus if you develop a test which has multiple trials and you get a speed and an accuracy measure on each trial from which you then compute the average speed, the average accuracy and the combined average, you should have at least 30 subjects in the validation and another 30 in the cross-validation. If additional measures are taken, additional subjects will be required.

Standardization must be ensured in the validation phases and in the implementation program. The predictor tests must be administered in exactly the same way to all the subjects. The job performance measures should be obtained in exactly the same way for each subject. If ratings are obtained from supervisors, it is advisable to have more than one supervisor rate all the people in the sample or group. Problems are encountered when different subjects are rated by different supervisors or when all the subjects in the group do not work under the same job conditions. No test should even be considered for inclusion in a validation effort unless if implemented, it could be administered at all times and in all locations in exactly the same manner. For example, if one decided that skeet shooting might correlate with tank Table VIII performance, conducted the research, and found that performance, number of hits, on the Grafenwoehr skeet range with a 12 gauge overunder shotgun, using commercial load shot and powder at a distance of 16 feet for targets thrown at a 45 degree angle, actually correlated with Table VIII performance; then the skeet shooting test must be replicable in exact detail at all locations where commanders might use this method to identify or select new gunners.

The use of tests to select for or eliminate people from specific job opportunities must fairly discriminate among the applicants. After the test or tests have been validated and cross-validated, cutoff scores must be determined. These scores set the minimum acceptable performance on the test required for hiring consideration or in the case of the Armor battalion, assignment as a gunner. The cutoff scores can be adjusted over time as the number of job applicants change within the force. In addition, the test administrator/implementer must show, for example, that the test does not unfairly discriminate against minorities. These are but a few of the reasons that test construction and validation should be conducted by individuals trained to ensure these requirements are met.

ARMOR CREWMEN ASSIGNMENT RESEARCH REVIEW

Has any research been done concerning prediction of tank crew performance?

Predictors

Initial efforts to evaluate predictors of performance in tank firing, driving, and loading used paper-and-pencil tests because they are the most cost effective and least time-consuming approach to performance prediction. Greenstein and Hughes (1977) used Armor trainees and limited their effort to the use of paper-and-pencil tests already in the psychological literature or in use by the Army at that time. For example, they include Lauer's (1952) tests of Visual Memory and Attention-to-Detail, as well as the Armed Forces Qualification Test (AFQT) and three composites of subtests from the Army Classification Battery (ACB): 1) Combat Operations (CO), 2) Field Artillery (FA), and 3) Motor Maintenance (MM). While significant correlations were obtained between the paper-and-pencil tests and loading errors and driving performance, none of the 11 paper-and-pencil tests in the study predicted tank firing scores.

In addition to seven of the Greenstein and Hughes tests, Eaton (1978) used Mechanical Abilities and Object Completion tests to predict Table VIII gunnery scores for a sample of TCs and gunners. No significant correlations were obtained for TC performance; only the Locations Test approached significance for gunner performance ($r = -.30$, $p < .10$). Eaton, Bessemer, and Kristiansen (1979) identified six gunnery predictors and seven driving predictors from the Armed Services Vocational Aptitude Battery (ASVAB) subtests and several specialized paper-and-pencil tests. These tests for OSUT soldiers initially correlated with gunnery and driving criterion measures, but the relationships failed to replicate with either a second sample of trainees or a sample of TCs and gunners. Eaton, Bessemer and Kristiansen found no relationship between performance with the .45 cal pistol and performance on tank Table VI ($r = -.043$).

In general, paper-and-pencil tests have resulted in few significant correlations with gunnery scores for either trainees or TOE unit personnel. Paper-and-pencil tests are limited because they tap only perceptual and/or cognitive aptitudes, not the additional perceptual-motor or psychomotor components of gunnery. The utility of these tests can be assessed only if, or when, gunnery tasks become more cognitively weighted.

Recent research efforts have centered on an alternative to paper-and-pencil tests, a technique referred to as job sample testing. This approach consists of hands-on tests built to assess particularly critical aspects of the gunner's and tank commander's jobs. Eaton, Johnson, and Black (1980) used three groups of Armor trainees to test the predictive validity of a battery of gunnery-oriented job sample tests. One group of soldiers was tested prior to training, one at the 10th week of training, and one at the end of training. Tests were validated against end-of-training live-fire exercises. Results indicate that performance on job sample tests administered before or during training (10th week) failed to relate to live-fire performance. However, when tests were administered at the end of training in conjunction with live-fire exercises, significant correlations were obtained. Thus, job sample tests, or at least this set of tests, may have tapped some learned elements in addition to the underlying psychomotor aptitude.

Campbell and Black (1982) administered both the ASVAB and a battery of gunnery-oriented job sample tests, similar to the Eaton et al. (1979) tests, to two companies of M1 trainees before training. Results indicate that the best and most reliable predictor of performance in M1 training was Combat Operations (CO), the ASVAB aptitude area score currently designated as the selector for Armor. However, six job sample tests (two based on the M1 computer panel and four psychomotor measures) did improve upon ASVAB and biographical predictors, some by as much as 15%. Neither job sampled nor biographical measures alone correlated higher than CO with the criteria. The authors point to difficulties in obtaining valid and reliable measures of "success in training" as one possible reason for the low correlations.

Biers and Sauer (1982) documented the development of equipment-oriented job sample tests for M1 gunners and TCs and attempted to validate them against self-reported Table VIII performance history. They noted that ordinary least squares (OLS) combinations of job sample tests for TCs and other test combinations for gunners did account for significant portions of the Table VIII variance. The validation of these same job sample tests against criterion measures collected on these TCs and gunners six months after the original predictor testing demonstrated promising relationships for the job sample tests in relation to success in M1 transition training and live-fire gunnery. However, interpretation of these results is qualified by sample size limitations; for example, only 33 TCs and 55 gunners were available for the evaluation.

Kress (1980) compared performance of USAREUR M60A1 TC/gunner pairs on sub-caliber exercises to performance on tank Table VIII and found significant correlations for both 1/60 scale and 1/20 scale targets. Both opening time and percent hits on the sub-caliber exercises were related to Table VIII performance. These exercises fall into the category of job sample tests which appear to relate to actual live fire exercises more consistently than paper-and-pencil or demographic predictors.

The results of meta-analysis on 15 data sets available from previously published research on predicting tank crewmember performance indicate that job sample tests were, across studies, better predictors of performance by job incumbents than were paper-and-pencil tests (Black & Campbell, 1982). Drawbacks to job sample testing do exist; they are very similar to those identified in the psychomotor testing programs of the 1940s and 1950s: cost, increased administration time, and equipment unreliability (Melton, 1947). However, the advent of microprocessors and the increasing availability of high fidelity simulators may remove or reduce several of the major concerns in the use of job sample tests, specifically, the requirement for special equipment, the need for continuous calibration, and the difficulties involved in unit-collocated testing facilities. Job sample tests developed for incorporation into on-line or forthcoming unit-located simulators such as UCOFT may improve the cost effectiveness of testing, reduce testing time requirements, and eliminate the need for special equipment apart from the simulator itself.

Certain demographic variables have been found to correlate with gunnery scores across numerous studies for the past few years. These findings characterize the successful tank crew as being commanded by (a) a noncommissioned officer (NCO) with more time in the TC position than other TCs, (b) a TC who has trained longer with the gunner with whom he fired (Eaton & Neff, 1978), and (c) a TC who has a history of having qualified crews (Biers & Sauer, 1982). None of these findings is particularly unexpected, but unfortunately, none is useful in the early identification of high-performing TCs. Yet this information is valuable in terms of providing data on variables whose covariance with the predictor measure may obscure the relationship of interest.

Job Performance Criteria

While previous research indicates that certain testing techniques hold promise for Armor crewmember performance and more information is now available concerning important intervening variables, the availability of appropriate and useful criteria against which to validate predictor tests has remained a problem. Criterion measures used in past research include scores from live-fire gunnery exercises, Multiple Integrated Laser Engagements System (MILES) exercises, supervisory ratings, peer ratings, Skill Qualification Tests (SQTs), specially administered hands-on skill tests, and both hands-on and written tests administered during the course of normal Armor training. Efforts to explain the inconsistencies found in past research have brought to light many disadvantages associated with the current job performance criteria available in Armor, especially those associated with gunnery.

Scores obtained from live-fire gunnery exercises often provide data that are not comparable between units or even between tanks. It is conceivable that with a company of tanks firing over a period of several days, the condition of the weather, tank equipment, and range equipment could change to such a degree that no tanks fire the same engagements. In addition, for any specific tank, changes in ammunition characteristics, equipment performance, and firing conditions may reduce the reliability or increase the error variance for within-tank performance measures. Thus, low reliability of the criterion measure may have been a large contributing factor to the relatively inconsistent findings of past research.

In addition, it should be pointed out that tank gunnery tables are collective exercises. Engaging targets and measuring the results of those behaviors in such values as "time to engage" or "proportion of hits" produces a crew-level evaluation or, in the case of Table IX, a platoon-level evaluation. The relative contributions of individual crewmembers are difficult to ferret out. In fact, it is not uncommon for unit commanders who are short on high-quality personnel to pair mature, experienced TCs with novice or ineffective gunners to ensure that the tank crew will be rated "qualified." On the other hand, very effective gunners may find themselves in crews with ineffective TCs and fail to qualify their tanks during annual gunnery. This makes it virtually impossible to use the results of tank table exercises to make statements about individual performance. Many of these comments also apply to MILES exercises, such as those conducted at the National Training Center.

A review of past research suggests that constant time and equipment constraints often force investigators to settle for the available criterion measures rather than the preferred. Therefore, it is not surprising that validation results have failed to identify effective predictor measures. To address this problem, it is necessary to look in two directions: first, to determine what constitutes appropriate criteria; second, to determine how those criteria can be reflected in specific predictor tests. In looking toward the criterion or evaluation side, it is apparent that the Army is interested particularly in predicting combat skill. On the predictor side, previous research supports a job sample testing approach.

The lack of appropriate criteria against which to validate combat skills also denotes the existence of a training gap. If the necessary combat "evaluation" environment cannot be produced, then the necessary combat "training" environment probably cannot be produced either. However, the Army is moving to bridge this gap through the use of high fidelity computer-controlled simulators, which can provide the necessary visual stimulus-and-response devices required for testing tank crewmembers. Simulators such as the M1 Unit Conduct of Fire Trainer (UCOFT) will allow M1 gunners to train against realistic threat arrays using M1 control handles that replicate the responsiveness of the M1 tank. A variety of threat scenarios can be presented, ranging from single-target stationary (easy) to multitarget moving (difficult), up to and exceeding the best estimates of threat capability. Thus, using the M1 UCOFT, a soldier's advanced gunnery skills can be evaluated against realistic combat criteria.

In summary, the UCOFT offers a time- and cost-effective means of using the job sample testing approach for predicting combat performance. Considerable effort will be required to develop tests for implementation on the UCOFT or UCOFT-like simulators that mirror the hands-on requirements for combat-level tank gunnery. Once developed, these tests must be validated against their hands-on counterparts (e.g., skill tests) and against realistic job performance criteria. Furthermore, their relationship to general ability measures, like AFQT, remains to be established. Mental ability tests represent the initial and most abstract predictors of combat performance, followed by skill tests and then tests administered by means of simulators. Live-fire exercises currently occupy positions demonstrating the greatest point-to-point specificity, fidelity, with actual combat. However, future high fidelity devices, including the UCOFT, may provide even greater fidelity using combat simulation than can be achieved in live-fire exercises that are constrained by safety requirements. Thus, it is even more important to develop and evaluate simulation-based, computer-controlled prediction tests in preparation for the delivery of UCOFT or similar devices.

ARI'S PROJECT ALPHA

What is ARI doing about the performance prediction problem now?

The US Army has been directed by Congress to re-validate the tests used to classify/assign recruits to CMF/MOS. The US Army Research Institute (ARI) was directed by the DCSPER to accomplish this for the Army. ARI has long been concerned with the notion that the current system which uses mainly the paper-and-pencil test battery ASVAB, does not tap other aptitudes which could be important determinants of successful job performance. For example, the ASVAB measures mechanical aptitude by presenting pictures of tools and asking the test-taker questions about uses of these tools. Mechanical ability or hand-eye coordination requirements for mechanics might be more accurately measured by some form of hands-on test. In addition, the Army makes a rather large investment in a soldier very early in his or her career, e.g., training costs. It would be advantageous to identify those recruits who have a low probability of completing their first tour prior to this substantial investment. Measures of interest in or commitment to career goals during the recruiting process may be quite useful in identifying those recruits.

ARI has begun addressing these concerns under the program titled Project Alpha. It was not feasible to re-validate predictor tests for each of the 300 odd Military Occupational Specialities (MOS) in the Army. Thus, the MOS were clustered into 20 or so separate groups. Each group is represented by one or two specific MOS for which the ASVAB, psychomotor, AVOICE, and ABLE tests will be validated in a longitudinal or predictive validation effort. New ASVAB aptitude area score computations are being developed to improve on current ones. A psychomotor test battery has been developed to tap hand-eye coordination, tracking and reaction time aptitudes. Figure 4 depicts the various controls used in this battery. The device is referred to as a response pedestal. This battery is administered via a portable microcomputer which is standardized and whose calibration can be maintained. The AVOICE is the Army Vocational Interest Career Examination. It will be validated against tour completion rates and job satisfaction factors. The ABLE is the Assessment of Background and Life Experiences. It will be validated against supervisor ratings of job performance and against hands-on tests of job performance. Preliminary analyses indicate the new test battery has higher validities than the ASVAB alone (Arabian & Hanser, 1986).

The testing for Project Alpha's longitudinal effort in Career Management field (CMF) 19 began in September 1986. All CMF 19 soldiers passing through the Ft Knox reception station will be tested on all Project Alpha tests. The test results will be maintained on an ARI data base along with data from the Enlisted Master File. This large data base offers one of the first opportunities to determine the relationships between initial performance and career goals achieved. Because the data base is by Social Security Number (SSN), soldiers can be tracked across several tours and the data for specific soldiers can be evaluated at any given time.

Numerous research questions have arisen since knowledge of this data base has circulated within the Army. For example, the Assistant Commandant of the Armor School asked ARI to track the graduates of the USAARMS OSUT Excellence

Track. The Commander of the Armor Center asked ARI to compare the performance of Armor Officer Basic (AOB) students (second lieutenants) on the Project Alpha psychomotor battery and the UCOFT. A preliminary analysis of the AOB data shows that the Project Alpha tracking test and a general verbal ability test taken together are strong predictors of initial performance from the TC's position. Additional research will be required to determine whether these tests can be used to place soldiers in system crew positions such as Bradley track commander or M1 gunner. Given the tremendous size and associated possibilities of the Project Alpha effort, it is important to capitalize on this investment.

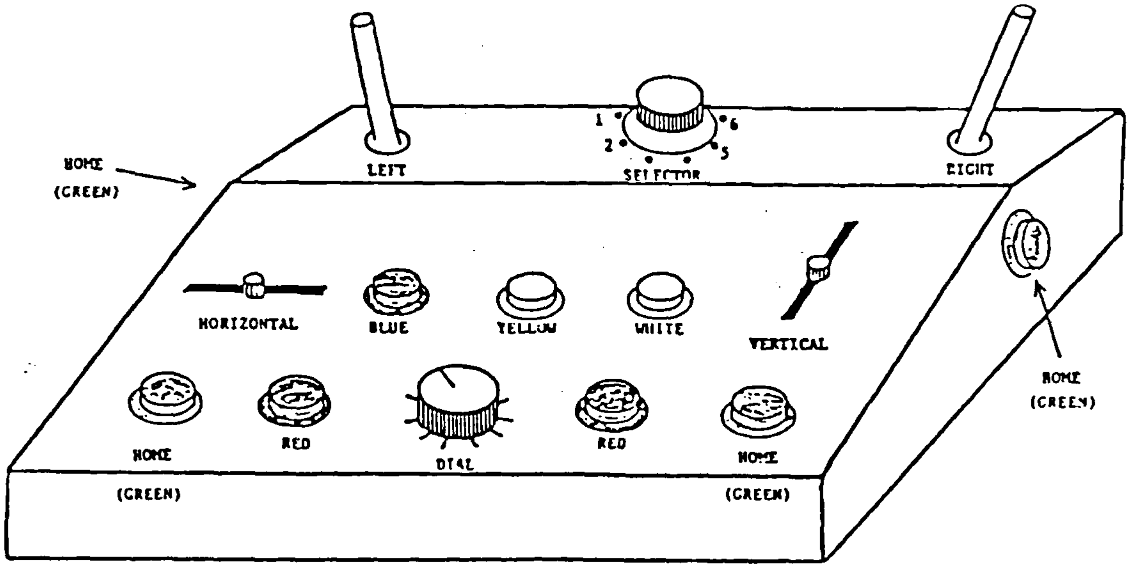

Figure 4. Response Pedestal used in Project Alpha Psychomotor Tests.

TO&E CREWMEMBER ASSIGNMENT ISSUES

Is anything available to assist the unit commander in assigning tank crewman?

No guidelines or procedures currently exist to assist commanders and/or cadre in the decision process of assigning TO&E personnel to vacated gunner or TC slots. In the past, assignment has primarily been a trial and error process, and candidates were weeded out after valuable training time and resources had been expended. Rising costs of ammunition and other training resources, as well as the increased capability of the threat forces, no longer allow the US Army this luxury. The Armor force must identify soldiers early-on who have the potential to become superior gunners and tank commanders and then tailor the personnel system to rapidly move those soldiers to appropriate slots. The process by which these soldiers are identified must rely on an accurate assessment of the skills/aptitudes required for the job they must perform. The following is a sample list of aptitudes/skills and typical gunner tasks for which the skill may be required. (See Table 1).

Table 1

Sample List of Gunner Aptitude/Skill Requirements by Task

APTITUDE/SKILL	GUNNERY TASK
hand-eye coordination	target tracking
visual acuity	target recognition
intelligence	computer procedures
perceptual skills	target identification
reaction time	target engagement

These do not represent the entire range of variables which may affect a gunner's performance on Table VIII, neither do they contribute equally to the quality of his performance. The function of training is to bring all soldiers to a standard performance level, this unfortunately obscures the effects of these innate abilities or aptitudes. However, the problem is that even if we could train any soldier to become a tank gunner, we do not have the time and we cannot afford the resources. We must identify soldiers who demonstrate expertise in a *minimum* amount of time and who require fewer resources to maintain an acceptable level of performance or readiness.

The best way to identify potential gunners and tank commanders is to develop tests based on personal aptitudes which appear to affect job performance. Figure 5 shows the potential gunner as consisting of varying quantities of several variables which may affect Table VIII performance. However, other variables can have a dramatic effect on a gunner's performance on Table VIII and may outweigh, temporarily, the aptitude/ability factors. These variables include: motivation, job satisfaction, command climate, amount of training, and type of training. Additional varibles which can affect performance and may be beyond the control of the tank gunnery include: range condition, tank condition, ammunition log, weather conditions, performance of the tank commander, the loader and the dosier. For these reasons it would be beneficial to maintain a longitudinal data base on soldier aptitudes/abilities and their Table VIII performance. By obtaining annual Table VIII scores for gunners one might begin to ferret out the effects of variables such as command climate, because data would be available for that gunner as he serves under different commanders. Only as we become proficient in determining the relative effects of various pieces of the "aptitude pie" can we reach the point of accurately identifying personnel who will ultimately become superior performers in a given environment (e.g., combat or Table VIII).

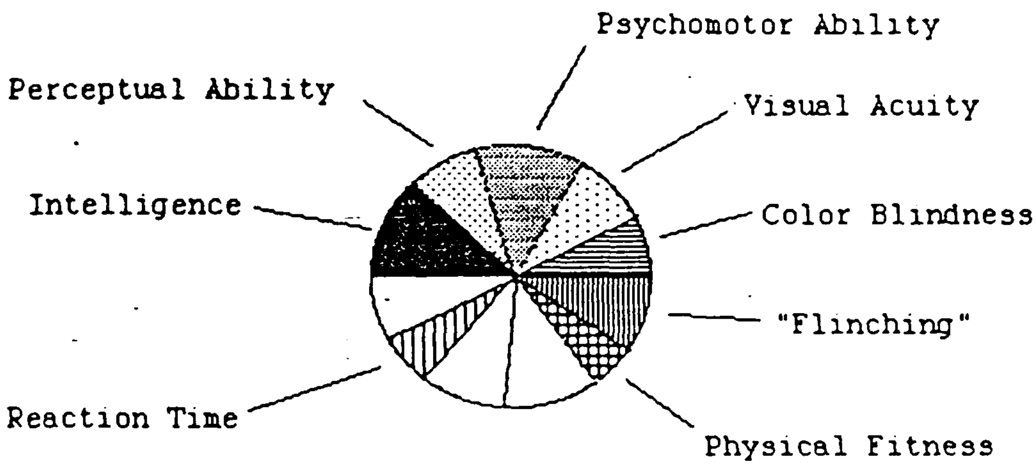

Figure 5. Aptitude/Ability Variables affecting Table VIII performance.

CURRENT 7ATC PROPOSAL TO IDENTIFY "NATURAL SHOOTERS"

What is being done by the Army to develop performance predictors apart from ARI's efforts?

Seventh Army Training Command (7ATC) currently plans to conduct a concurrent validation effort for tank commanders (TC) and gunners in four USAREUR M1 battalions. This effort will consist of a full day of round robin testing at Grafenwoehr, followed by the collection of Table VIII firing data for these TC gunner pairs. The tests to be administered include a .45 cal pistol qualification, a skeet shooting test, a color blindness test and a blood pressure check. Also under discussion for possible inclusion are two UCOFT measures: time on UCOFT and matrix level achieved in the computer recommended mode, and one background variable: length of time the TC and gunner have trained together.

Personnel from ARI-Knox have been asked to review and comment on the proposed plan (see Appendix A) as well as to discuss the role ARI plays in selection research for the Army. The following recommendations are made concerning the "natural shooter" test plan and are general guidelines for conducting research.

1. The plan should include a pilot or dry run of all tests which are to be given. Obtain estimates of time to complete each test.

2. Randomize or counter-balance the order of test performance, e.g., do not push all soldiers through skeet first then .45 cal. There may be an ordering effect, that is, the soldier performs better on one test because he learned something during the previous test.

3. Determine: how many test administrators are required; how many test stations will be needed; and how many soldiers can be tested simultaneously at each station.

4. Obtain numerous copies of each test in order to speed up the round robin process.

5. Put the instructions to subjects at each test station on audio tape and pre-test these tapes during the pilot run. This helps ensure standardization.

6. Do not allow the test administrators to "coach" soldiers during the test. This is another reason for putting all instructions on tape.

7. Obtain estimates of each test's reliability during the pilot by either re-administering the test to each subject or using the split-half reliability approach. Increasing the number of rounds you make them fire or number of items on the test until your reliability correlation is higher than +.70. Reliability estimates also need to be obtained for tank Table VIII, if it is to be used as the criterion.

8. Determine sample size requirements through a power analysis--a rule of thumb is ten (10) subjects per predictor measure. Apparently there are three .45 cal, three skeet, a color vision, an acuity measure, two blood pressure measures, two UCOFT and one background questionnaire type measure. If this is correct a minimum of 130 soldiers will be required for initial validation and 130 for cross-validation. Do not mix officers and NCO's in the same validation effort.

A review of the performance prediction literature revealed only one attempt to use the .45 cal pistol qualification to predict tank gunnery (Eaton et al., 1979). No significant correlations were obtained. However, BG Mallory's contention is that small arms qualification performance may relate to tank Table VIII based on the notion that "natural shooters", regardless of weapon, are people who do not flinch and who hit targets. He believes that flinching is a critical factor in tank target misses on Table VIII and that devices such as the UCOFT do not properly replicate the stimulus that may cause tank gunners to flinch. However, he believes that firing a .45 cal pistol or a shotgun may adequately replicate that stimulus. This is an empirical question and one which the 7ATC test plan will attempt to address.

However, based on the results of numerous research efforts our best estimate is that while the "flinching stimulus" may be replicated with small arms firing, other potentially more important cues are not replicated, e.g., the fine psychomotor control required to aim and track with the M1 or M60 cadillac control handles. These requirements are obtainable from the UCOFT engagements. Following the point specificity rule previously discussed, we would advocate the selection of UCOFT engagements which closely mirror Table VIII engagements and we would support scoring those UCOFT engagements the same way Table VIII engagements are scored, e.g., by opening time and hit/miss. We also advocate obtaining Project Alpha psychomotor battery scores for correlation with the Table VIII performance. What BG Mallory maybe refering to as "flinching" we have noted as a higher than expected "overline" rate for some gunners in both live fire and UCOFT performance. We believe that this may be the result of the human factors engineering of the control handles, cadillacs, which require the gunner to squeeze his index finger to fire. This motion often results in the cadillacs being pulled back and the elevation of the gun tube increased. If this is the case, the problem has a straight forward training fix which can be accomplished on the UCOFT. It is difficult to understand how a flinching response could cause overline rounds because the flinch should take place after the round leaves the tube. Additionally, flinching is a response which should habituate after several stimulus occurances. The results of the 7ATC effort should shed some light on the issue.

Another variable of interest to 7ATC staff is crewmember colorblindness. A recent review of the Army Regulations (AR 611-201, 30 April 86) showed that the visual requirements for CMF 19 are: 1) correctable 20-20 vision in one eye (unspecified), 2) 20-100 vision in the other eye, and 3) normal color vision (no red-green or blue-yellow deficiency). There is no evidence that color blindness is acquired, worsens with time, or is evident only in later years. Soldiers with demonstrable colorblindness or weakness are soldiers who for one reason or another have slipped through the screen at the regional military examining centers. Fort Knox has planned to conduct a screen in both enlisted and officer courses in FY87 to determine if soldiers are arriving at Knox with unidentified color vision problems. The 7ATC effort should give an indication of the severity of the problem in TO&E units in USAREUR.

A third area of interest to 7ATC is that of general physical fitness or "wellness" as represented by systolic and diastolic blood pressure. There is no evidence in existing Armor selection literature that this variable relates to Table VIII performance. Although, some measure of the soldier's ability to cope with stress may be useful, it is doubtful that measuring blood pressure will capture this "stress level" variable. This comment is based on the psychophysiological literature which has shown that response to stress is most often idiosyncratic. Different people respond differently. Some individuals get ulcers, others have cardiac responses, and other individuals break out in rashes. In general, the population of soldiers under consideration is relatively young and in excellent physical condition. It is anticipated that any differences in blood pressure are individual inherited characteristics and will not relate to overall Table VIII performance.

USMA REPORT ON AFQT AND TANK COMMANDER PERFORMANCE

Does the Army really need higher mental ability tank gunners and commanders?

The Economics Department at the United States Military Academy (USMA) became interested in the relationship between tank commander AFQT and performance on Table VIII following Wallace's (1982) report that higher AFQT TCs performed significantly better than low AFQT TCs in the 1981 Canadian Army Trophy Competition. Scribner (1985) from West Point, found a higher correlation between AFQT and Table VIII scores for M60 series TCs than for M1 TCs. These data were presented to Congress by the DCSPER as evidence for a higher AFQT requirement for Armor recruits. ARI later received a Congressional inquiry from Senator Glenn's staff to the effect that if the M1 is more technically sophisticated than the M60 and the AFQT relationship is not as strong for M1 TCs does that mean that technology can make the system simpler to operate and in fact lower the AFQT requirement rather than raise it? If this is true, we should be able to save dollars in the long run by building more sophisticated equipment which can be operated by low quality personnel who require less money to recruit and retain.

There are at least four logical arguments for not lowering AFQT requirements:

1. Technically sophisticated systems are usually harder to maintain. Therefore, the AFQT requirements for maintenance personnel would probably increase.

2. The more sophisticated the device the more likely something may go wrong in the heat of battle. The likelihood is increased that a crewmember may be required to operate in complex degraded modes, (e.g., adjusting for an errant input to the ballistic computer or applying aim-off for a unique combination of sensor failures). The smarter the crewmember the higher the probability he would be able to perform effectively under these conditions.

3. The more automated the operating system, e.g., autolead, cant, etc., the more complex the calibration and pre-ops procedures. Higher AFQT personnel should perform complex procedures better.

4. A basic definition of intelligence is the ability to adapt rapidly in a new environment, a fast learner. In the first hours and days of combat, platoon sergeants will likely become platoon leaders or even company commanders as a result of casualties. These events force reconstitution of crews into situations/positions for which they may not be well trained. The faster the crewmember can cope with change, the higher the probability of survival and mission success.

UCOFT AND ARMOR TRAINING

<u>What impact is the UCOFT having on Armor training and selection?</u>

The Unit Conduct of Fire Trainer (UCOFT) is a high fidelity combat simulator which is being fielded into all Armor and Mechanized Infantry battalions for active and reserve units. Numerous Institutional Conduct of Fire Trainers (ICOFT) are also being installed into the Armor and Infantry schools. Considerable controversy has surrounded the fielding of UCOFT because of its costs ($2.4M per unit), lack of demonstrated training validity, and unit training resource requirements for instructor/operators (I/O) and soldier time. In addition, attempts are being made to justify the UCOFTs cost by reducing the number of annual main gun training rounds. The cost of 120mm training rounds for the M1A1 will be approximately $1200, more than double the cost of the 105mm rounds currently used. Efforts to validate UCOFT training are now being conducted by TRADOC Research Analysis Center White Sands Missile Range (TRAC WSMR).

A major commitment has been made by the Army to incorporate simulation at the core of Armor gunnery training with the UCOFT. While several quick fix research projects are currently being conducted, the true training value of the UCOFT will not be known until training has settled down and longitudinal training and performance data are analyzed. An additional benefit of the

UCOFT besides training is that the device can be used to evaluate gunnery performance and to administer job-sample predictor tests. UCOFT tests offer certain advantages over hands-on tests, including standardized administration and scoring procedures, and the inexpensive capability of building longer tests with various target conditions.

UCOFT TRAINING MATRICES

How is the UCOFT training structured?

Understanding the potential training and testing capabilities of the UCOFT requires an understanding of the two UCOFT training matrices built into the software. One matrix is for the Tank Commander/Gunner pair (TC/G) while the other is for the Commander alone. Once the TC/G begins training, their training or computer-recommended progress is determined by how well they perform in each of three dimensions. The core of the TC/G training matrix is the middle four groups of the Reticle Aim (RA) dimension (Groups 2-5), each with seven levels of difficulty. Altogether there are six RA groups, but Group 1 is not used in sustainment training and Group 6 contains four certification exercises.

Table 2 shows the movement conditions for both the TC/G's own vehicle and the targets within the four primary RA groups.

Table 2

Movement Conditions for UCOFT Reticle Aim Groups

UCOFT RETICLE AIM GROUP	OWN VEHICLE	TARGETS
2	stationary	stationary
3	stationary	moving
4	moving	stationary
5	moving	moving

Seven difficulty levels are contained within each of these Reticle Aim groups. The general conditions for each of these difficulty levels are shown in Table 3.

Table 3

Difficulty Levels within each UCOFT Reticle Aim Group

DIFFICULTY LEVEL	DESCRIPTION
1	Day Full-up precision gunnery
2	Night Full-up precision gunnery
3	Day Full-up precision gunnery wearing NBC mask
4	Stabilization failure, manual lead required, short halt for moving own vehicle
5	Laser Rangefinder (LRF) failure, battlesight gunnery
6	Gunner's Primary Sight (GPS) and Computer failure, emergency battlesight gunnery using Gunner's Auxiliary Sight
7	GPS and Power Control Handle failure, manual elevation, traverse, and blasting machine

Each of these RA difficulty levels must be successfully completed in, for example, Group 2 before moving into Group 3. In some situations it is possible to skip an RA level by scoring a "Rapid Advance." The movement rules, however, prevent a crew from skipping the NBC condition or the level skipped in the previous group. In practice few RA groups are skipped. Normally several exercises must be fired in each RA difficulty level to advance, particularly in RA Groups 2 and 3, i.e., early in training.

An examination of the RA difficulty levels across the four RA groups indicates that there is not a single dimension of skill or difficulty within the matrix. Being required to use only the manual controls is the hardest exercise in each group for most crewman. Moving, therefore, from manual controls in Group 3 to Level 1, daytime full-up gunnery in Group 4 is typically less difficult even though it is farther along in the matrix.

The majority of UCOFT conditions (4 out of 7) train degraded mode gunnery techniques, with a fifth condition training under NBC conditions. Developing degraded mode gunnery skills is of utmost importance as M1 gunners may be forced to use degraded gunnery techniques soon after the battle begins. The UCOFT should result in a better trained Armor force because few opportunities have previously existed to get quality degraded mode training with reliable feedback. The UCOFT was not designed to train only Table VIII-like gunnery but to develop combat skills beyond those required on the current qualifying tables.

UCOFT TRAINING ISSUES

What are the major UCOFT training and research issues?

Several problems have surfaced because of the mismatch between what is trained on the UCOFT and what is evaluated on tank Table VIII. The problems are in the training transfer research and in units seeking an optimum training strategy. The validation researchers are seeking to show that soldiers who have progressed farthest in the matrix are performing best on live fire-gunnery. The chances of finding such a relationship are weakened because the UCOFT was not designed solely as a tank gunnery table trainer. Therefore much of what is trained is not evaluated in live-fire gunnery exercises.

Unit commanders have as their goal during gunnery season to qualify as many tanks as possible. Some commanders have questioned the value of the training matrix which presents 57% of the training in degraded mode. These units have reportedly instituted a training strategy that ignores the training matrix and trains only those UCOFT exercises which are similar to tank Table VIII tasks. If such a UCOFT training strategy persists throughout the year, the majority of the training value of the $2.4 M simulator is squandered.

Understanding the frustration of units using the computer-recommended training matrix is not difficult. Because the matrix does not have a single difficulty dimension, certain crews are hitting a wall early in the matrix, i.e., having difficulty passing a certain exercise. This tends to happen in the higher difficulty levels of Group 2. A crew may take, for example, an entire month of scheduled UCOFT training time to pass RA Group 2-level 7, manual control gunnery. While these skills are ultimately important, other priorities take precedence when a unit is preparing for annual gunnery. Crews need to practice shooting moving targets and engaging targets from a moving tank. Units are limited to an average of 3-5 hours of UCOFT training per month for each of the 58 tank crews in the battalion, and must make the best use of their training time. Bachman's 1985 report gives a breakout of possible unit training time schedules.

An optimum training strategy needs to be developed using training and gunnery data from TO&E units who have the UCOFT. This strategy should indicate different prescriptions depending on whether or not a unit is preparing for gunnery. No strategy currently exists. A potential training strategy for units preparing for gunnery might have crews spend half of their time firing the computer-recommended exercises and half of their time firing more advanced non-degraded exercises which match tank Table VIII tasks.

The structure of the training matrices might also be rearranged to better match unit needs. As the training stands, the crew must complete half of the matrix before firing from a moving tank and three-fourths of the matrix before firing at moving targets from a moving tank. Given that these engagements are required on the tank Table VIII, the advantages to training the moving tank non-degraded exercises earlier in the matrix are clear.

Rearranging the training matrix in such a manner does, however, have a downside. Pushing the more difficult degraded-mode tasks to the end of training reverts to the traditional Army approach of training easy tasks first. There is little, if any, evidence that this approach facilitates quicker development of the more difficult skills. In addition, this approach too often results in training only the easier tasks, or at least those tasks that will be tested. The current UCOFT matrix, while not without correctable flaws, introduces the degraded-mode gunnery training early in this matrix to ensure the training will take place.

Proponents of the UCOFT claim the device trains combat gunnery skills to a greater extent than does Tank Table VIII. If this is the case, formal acknowledgement of UCOFT performance would ensure command emphasis of the training which would result in the development of higher skill levels. The acknowledgement could be in the form of promotion points, or mention of crew, platoon, company, or battalion UCOFT certifications in enlisted and officer efficiency ratings. The UCOFT certification requirements could be defined by performance on standardized UCOFT tests or on UCOFT training matrix progress. Security procedures would have to be developed to ensure equity across units. The discussion on the development of a UCOFT data base later in the paper addresses some of these issues.

The UCOFT also holds potential for special applications including rapid train-up programs, training continuous operations, and modeling NBC environment effects. Of particular interest here is using the UCOFT to administer standardized gunnery tests. The current UCOFT software unfortunately is not flexible, which makes applications other than training with the matrices cumbersome. The software also includes features which are detrimental to reliable testing. For example, quasi-random error is added to each round to produce dispersion rounds. A soldier may, as a result, miss a target even though he has perfect reticle aim and has fired within the time limit. While this feature was added to mirror the "real world" where bad ammunition does exist, the addition of random error definitely reduces the reliability of UCOFT tests. Dispersion rounds, in addition, probably have a small negative effect on the training of gunnery skills, as they result in spurious feedback. Software updates should provide the capability of turning off the dispersion round feature when desired, such as when the UCOFT is used for testing or early in training.

A software update is tentatively scheduled for delivery in 1QTR FY88. The list of the proposed changes can be obtained from the Army Materiel Command Weapons Systems Manager, the new UCOFT proponent replacing Project Manager Training Devices (PM-TRADE). A partial list is provided below.

1. Raise the minimum proficiency levels, i.e., require the crew to complete more difficult target conditions before moving on in the matrix.

2. Improve the boresight exercise.

3. Eliminate the "Repeat" key used to cancel the computer-recommendation, i.e., once you start the exercise, you will have to finish.

4. Require more (10) coax rounds to kill a jeep.

5. Randomly require more than one main gun round to kill some tanks.

6. Make SABOT the correct ammo for choppers, eliminating the effectiveness of Cal.50 rounds.

7. Change the stabilization function on the UCOFT to better reflect the tank. Presently, the UCOFT is not smooth enough with stabilization and too smooth without stabilization.

8. Allow the Instructor/Operator (I/O) to print the crew records. This can now be unofficially accomplished by logging on at the line printer.

While the proposed changes are primarily small fixes, the impact of some of the changes may be great. Concerning the use of UCOFT as a gunnery testing device, the addition of a feature which randomly requires more than one round to kill certain tanks is horrendous. As with dispersion rounds, it is essential that this feature be turned off during testing applications. Other changes, especially that of raising the minimum proficiency levels, will likely result in slower progress through the matrices. Requiring crews to engage multiple targets is advisable from a training and readiness perspective. This proposed additional requirement will, however, exacerbate the problem commanders are having in getting crews through the UCOFT training quickly enough.

One issue of contention between UCOFT users has been whether the training guidelines should be based on time, e.g., 10 hours, or level of proficiency defined by a position in the matrix. In particular this has concerned the amount of training new crews need to receive in an initial block. Regardless of the debate, most crews need some concentrated period of time at the beginning of their UCOFT training to become minimally proficient or comfortable with the machine and procedures, even though requiring extra training time for new crews places an additional burden on the training schedule. Continuing UCOFT research will help clarify these training guidelines.

A similar issue concerns the reconstitution of TC/G pairs who have had separate UCOFT experience. It is likely a waste of valuable training resources to enter a TC and gunner with independent UCOFT experience at the beginning of the training matrix. Where they should enter is not, however, clear. ARI and the Armor Center (USAARMC) have been discussing research which would serve as the basis for developing guidelines for optimum training matrix placement for reconstituted crews.

Skill decay is another area of interest. How quickly does a crew lose proficiency without training, or similarly, how quickly can a crew retrain to its previous level of proficiency? It has been hypothesized that crewmen trained to higher levels in the UCOFT matrix would show less decay than those trained to lower levels. It has likewise been proposed that reconstituting crews with higher matrix proficiency should result in less of a negative effect than putting together crews with lesser experience. This hypothesis suggests that if you put together a crew who had independently certified in Group 6 of the matrix, they should quickly be able to certify together. By contrast, if you constituted a crew who independently were in Group 3, the new TC/gunner pair would take longer to get back to Group 3 than it would to take the certified TC/gunner pair to recertify. If these hypotheses are verified, UCOFT training will considerably reduce the negative effects of crew turbulence on gunnery performance. The Armor goal will then become to get all crewman as far into the UCOFT matrix as quickly as possible. This could partly be accomplished by giving additional UCOFT training in the schoolhouse.

Some of the UCOFT problems, such as not being able to get crews through the matrix quickly enough, are resulting from the newness of the simulator and the fact that all crews are starting at ground zero. In several years, the UCOFT will no longer be another scheduling hassle nor the highlight of the VIP tour, but an integrated part of gunnery training. In addition, continued UCOFT research will ensure more efficient training strategies.

No training medium, including UCOFT and live-fire exercises, is appropriate for training the gamut of tank gunnery skills. The assumption is too often made that if a device or exercise requires that a set of behaviors be performed, then those behaviors are being trained. This is not true. In particular, evidence is mounting which suggests UCOFT does not train target acquisition skills (Rapkoch & Robinson, 1986). Detection and identification of computer-generated images on UCOFT is much different than acquiring pop-up panel targets on live-fire ranges or tanks on the battlefield. Target acquisition training on devices other than UCOFT is required. What is needed are guidelines which specify an optimal device mix for training all armor gunnery skills. The ARI Fort Knox Field Unit is currently developing such guidelines.

UCOFT DATA COLLECTION

What types of performance data does UCOFT provide?

The UCOFT includes data collection capabilities which serve as training feedback and as training matrix movement rules. For each engagement (1-3 targets), a variety of performance measures are reported. These are shown in Table 4.

The latter three composite scores are the basis of the matrix movement rules. The scores are ordinal with values of 4, 3, 2, and 1 and are reported as letter grades A, B, C, and F, respectively. They correspond to matrix movement rules of Rapid Advance, Normal Advance, No Advance and Reduced movement.

Each of the composites are derived from two or more measures. Each measure also consists of an ordinal score (A, B, C, or F) based on time or number of errors. In each case the composite is simply the lowest of the various measures, e.g., a "B" and "C" results in a composite score of "C" -"No advance," for that engagement (UCOFT Utilization Handbook, 1985).

The Target Acquisition (TA) score is based on target acquisition time and identification and classification errors. The Reticle Aim composite is based on time to first round and Reticle Aim error. In a ARI report by Graham (March 1986), Reticle Aim scores for novice gunners were found to be predominately influenced by hit rates, i.e., reticle aim error. The implication of this finding is that opening time information normally does not influence the scoring composites and in effect is lost unless specifically recorded.

Table 4

Current UCOFT Variables

1. Target type
2. Type of ammo/weapon fired
3. Number of rounds fired
4. Azimuth and elevation reticle lay errors
5. Results:
   a. Hit/miss for main gun targets
   b. Area coverage for machine gun targets
6. Target identification times
7. Fire time (opening time)
8. Hit time
9. Kill time
10. Target acquisition and system management errors
11. Mean fire, hit, and kill times for an exercise
12. Composite scores
    a. Target Acquisition
    b. Reticle Aim
    c. System Management

The System Management (SM) score is derived from pre-firing and time of firing errors, e.g., whether the correct ammo and weapon are indexed. The system management dimension determines the number and range of the targets, going from single short-range, single long-range, multiple short-range, to multiple long-range targets. If, however, a crew gets a reduced recommendation (or two consecutive no advances) in the Reticle Aim dimension, e.g., level 4-stabilization failure, they do not go back to level 3, the NBC condition. Instead the System Management dimension is reduced, e.g., from multiple short-range to single long-range targets.

Minimum "proficiency levels" are, however, required for advancement in Reticle Aim. For example, a crew enrolled in sustainment training must successfully complete an exercise at SM Level 2 to move on in reticle aim. An exception exists for the NBC condition in each of the four groups, as it has been designated a "gate" condition. Progress over the gate must be at SM level 4 (multiple long-range targets) and at TA level 3 (Battlefield conditions-limited visibility, friendly targets, friendly and enemy fire).

UCOFT DATA COLLECTION PROBLEMS

How might UCOFT data recording be improved?

No capability currently exists for transferring UCOFT performance data directly to data processing equipment. This capability is essential for quality control and for establishing and maintaining large data bases over extended periods of time. Currently crew performance data must be taken from UCOFT printouts and keystroked into computers with statistical processing capabilities.

There is a need to take UCOFT performance data collected in USAREUR and CONUS units, and send it to a central data processing site for further analysis. The critical requirement is the development of software which will write the appropriate UCOFT performance data out to some peripheral storage device. Several alternatives being considered would require additional hardware be added to the UCOFT, e.g., a tape drive. It should be stressed, however, that the data transfer requirement is primarily a software problem. Several alternative solutions will be discussed.

The UCOFT's General Purpose Computer (VAX 11/780) presently contains an 8 inch floppy diskette drive which could be used to collect the data. This solution would probably not require any additional hardware, but most likely would hold the least amount of information of any of the alternatives. Software routines that dump the data from the UCOFT hard disk to the diskette would therefore have to run more frequently than with other solutions. Also, numerous diskettes would have to be handled at the data processing site. Specific estimates of how much information could be stored on each diskette should be required of potential software developers before any decision is made to adopt this solution. A tentative requirement for this type of data handling system might be that the data dumping routines need only be run once a week, and that the storage medium, be it a diskette or tape, need only be sent to the central data processing site once every two months.

An alternative software strategy might write the performance data to the diskette as soon as the crew finishes the training session. In this case, the software must indicate when the diskette or tape is full to prevent loss of data. When full, the diskette would be sent to the data processing site. This software strategy should require that a backup copy of the file be maintained on the system's hard disk.

A similar solution being considered by 7ATC would add tape drives to the UCOFT. The advantage is more data storage capacity, which would make it easier for both UCOFT trainers and the data processing site. The disadvantage is the cost of the additional hardware and maintenance contract costs.

The USAARMC COFT branch is considering a proposal that would create the capability of sending UCOFT student records to a central location. Generally speaking, student records could be sent via modem and phonelines or over a satellite link to a dedicated VAX computer. One advantage to this type of system is that student records can be sent back to other remote UCOFTs. Therefore if a crew changed units, their records could be transferred to a different machine. A similar application is where two battalion's UCOFTs are colocated. If student records could be transferred from one UCOFT to another, the units could easily and efficiently use each other's UCOFT when one unit has other requirements. This system is obviously more expensive than the other approaches discussed as it would require major software changes and a dedicated host computer. If, however, USAARMC were to develop such a system for CONUS units, less expensive copies of the system might be obtained by USAREUR.

While the UCOFT software currently reports most performance data of interest, the organization of the information is not appropriate for analysis. The current reports include ones designed for student feedback and others for crew and unit training summaries. After each exercise is completed, three records can be sequentially printed for the trainee debrief. These are the Situation Monitor, the Performance Analysis and the Shot Pattern, each of which breaks out the performance target by target. One problem with these reports is that if the I/O forgets, inadvertantly hits the wrong key, or mistimes his keystroke, the records are lost. This problem should be corrected in the software updates.

What is needed for statistical analyses across subjects and time are data which are summarized to the appropriate level. The data should neither be too detailed nor have critical data lost or lumped together. As it stands, none of the UCOFT reports are acceptable for what is needed in a longitudinal data base. Specialized software routines, as discussed earlier, must be written to copy data to other computers. This software must also create a file which satisfies the analysis needs.

Establishing and maintaining quality control of a large data base containing various types of information is difficult. Careful forethought concerning the amount and structure of the information is essential, if the data are to be useful. There is an oft used, if not trite, expression in data processing circles, "Garbage In, Garbage Out (GIGO)," which addresses these problems. What this means is that if the data being analyzed are not well-organized, well-defined, and without errors and huge omissions, the analysis of the data will be of little worth.

Several major problems currently exist in the UCOFT data collection and reporting procedures. First, there is no easy way to know how long a crew has trained on the UCOFT. The Crew Record contains information on the last 100 exercises fired, but does not discriminate between exercises which were selected by the I/O and those which were terminated while in the computer-recommended mode. It can reasonably be assumed that a completed exercise takes a fixed amount of time, for example, 12 minutes. One cannot assume how much training was received on the terminated exercises. This is not a trivial problem as half of the exercises in some student records fall into this category.

Another problem is that no information concerning Target Identification (ID) times, opening times, or percentage of hits (hit rate) is contained in the crew record. Most of this information is produced in the session summary, but this report is only printed for the last session fired. Again, it is mandatory that software be written which places only selected performance data into the data base. Copying the existing UCOFT records into an analysis data base is unacceptable.

Decisions must be made as to which variables are going into the data base. As discussed earlier, when similar performance is to be measured and compared in different situations, e.g., UCOFT and live-fire gunnery, the more similar the measures, the greater the likelihood of finding a strong relationship. The UCOFT data base should therefore include performance measures which are as similar as possible to tank Table VIII. UCOFT performance is, therefore, best measured in terms of variables such as hit rate, first round hit rate, number of rounds fired and opening time, as opposed to the UCOFT-specific composite scores.

Concerning the UCOFT training analysis, the variables should indicate how much training the crew and/or TC received, their progress through the matrix, and over what period of time. A list of recommended variables which should be stored in the data base for each exercise is in Table 5.

For the last three composite variables, the current system which uses words to represent computer-recommended exercises and letters to indicate that the I/O selected the exercise should be maintained. The UCOFT Session Summary is most similar to this proposed data file. The software routine must be able to merge consecutive files for each crew as the data periodically comes in from the units. The software must also check for overlapping records and prevent duplication.

DEVELOPMENT OF COMPREHENSIVE USAREUR DATA BASE

How can the value of UCOFT data be increased?

The value of the UCOFT data base will be greatly enhanced if it is paired with USAREUR gunnery data and other soldier data. Ideally, the comprehensive USAREUR data base would contain not only live-fire gunnery data routinely collected in tank Table VIII qualification runs and UCOFT data, but other predictor, training, and biographical information, e.g., contained in the soldiers' Enlisted Master Files. The comprehensive USAREUR data base should therefore include the information listed in Table 6.

Table 5

Recommended Variables for UCOFT Data Base

1. Date
2. Exercise number
3. Number of targets presented
4. Number of targets fired upon
5. Number of hits
6. Number of first round hits
7. Number of rounds fired
8. Mean azimuth error
9. Mean elevation error
10. Mean ID time
11. Mean opening time (fire time)
12. Number of TA errors
13. Number of SM errors
14. TA computer-recommendation
15. RA computer-recommendation
16. SM computer-recommendation

Table 6

Recommended Variables for Comprehensive USAREUR Data Base

1. SSN of crew members
2. Tank table gunnery data broken out by tasks
3. UCOFT training data
4. ASVAB scores
5. Project Alpha scores
6. Standardized UCOFT test scores (if developed)
7. Training data, e.g., time in crew
8. Medical data, e.g., blood pressure, visual acuity

The key to accessing these types of information hinges on having SSN in the data base. A considerable amount of coordination is required to maintain data bases containing names and SSN as result of the Privacy and Freedom of Information Acts. If the decision is made to go with the data base, this coordination should begin immediately.

The UCOFT data base, gunnery data, and other information need not reside in the same file, as long as the file structures are compatible. Instead statistical routines are needed which could compute variables of interest in both the UCOFT and live-fire data. The UCOFT training data might, for example, be recomputed into variables such as:

1. Current reticle aim position in matrix.

2. Number of computer-recommended exercises fired.

3. Number (or percentage) of Tank Table VIII-like exercises fired outside of computer-recommendation.

4. Mean number of exercises fired per difficulty level in each RA group.

5. Mean hit rate and opening times for various types of exercises, e.g., NBC vs. non-NBC conditions.

The live-fire gunnery data could similarly be collapsed across variables of interest, e.g., NBC tasks or tasks with multiple moving targets.

The proposed comprehensive USAREUR data base would contain the highest-quality live-fire gunnery performance data known, systematic training data from the UCOFT, and a variety of predictor information. This data base would indeed be a rich environment for analysis from which the Army could reap benefits for years to come. These benefits include:

1. The ability to understand the relationship between UCOFT performance and tank table gunnery performance.

2. The development of efficient UCOFT and unit training strategies.

3. The rapid establishment of concurrent validities of numerous predictors with live-fire gunnery and training performance.

4. A mechanism for establishing predictive validities of gunnery performance.

In general, the comprehensive USAREUR data base would result in faster turnaround and higher quality answers to the hosts of personnel, training, and readiness questions that regularly surface in the Armor community.

SUMMARY

To date, Armor performance prediction research has produced little in the way of useable products, and guidelines for tank crew assignment are not existent. Much of this failure is due to the lack of valid and reliable job performance measures. The Army has not, as yet, determined what to measure and how to measure it in reference to the performance of tank crews. This is linked to the ever present problem of attempting to train tasks which for safety reasons or resource constraints can not be performed within a job context short of war. The only answer to this problem lies in simulation for training and testing. The extent to which the simulation retains sufficient fidelity to provide the necessary job context, is the extent to which we will ultimately be able to predict soldier performance in war.

The issues addressed in this research product have the common theme or goal of maximizing combat effectiveness through personnel selection and training. It is clear that long research efforts, such as Project Alpha, are needed to adequately address the problems of personnel selection and assignment in Armor. The past piecemeal, small sample size efforts cannot hope to produce the desired results: valid performance prediction tests and assignment guidelines.

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APPENDIX A

STUDY PLAN: "NATURAL SHOOTERS" AND TANK GUNNERY QUALIFICATION

1. Purpose: To evaluate if a relationship exists between individual small arms and tank gunnery qualifications.

2. Background: Considerable research efforts have been exerted by the Army in the area of personnel selection. The majority of these efforts have investigated the relationship between some of intelligence (as measured by a written test) and job performances. Few investigations have explored the relationship between psycho-motor skills job transfer skills and job performance.

Recently the 7ATC Commander has raised several issues concerning tank gunnery training. One of the issues of interest is concerned with the identification of "natural shooters" and the relationship between "natural shooters" and their performance on Tank Table VIII. "Natural shooters" are defined as those individuals who have the innate ability to hit targets. Evidence of this ability can be demonstrated by many measures (personal weapons qualification, ability to shoot skeet, skill at video games, etc.).

If a motor skill (as contained in the "natural shooter") is shown to be related to the performance of job skill (Tank Table VIII), then the implications for crew-position selection are significant. Commanders would attempt to maximize their combat effectiveness by selecting the best qualified soldier to be the gunners, regardless of rank. New measures of job success (hands-on tests) would allow Army recruiters to identify, select and assign inductees to Career Management Fields that would maximize their potential. A literature search for previous study efforts is currently underway.

3. Terms of References:

a. Problem: Are "natural shooters" better tank gunners? 7ATC (Training Analysis Division) propose to determine if significant relationships exist between tank gunners small arms qualification scores and their tank gunnery scores. The results of this study are important due to implications of changing tank crew selection standards based on small arms qualifications.

b. Objectives:

(1) Define "natural shooter" in relation to individual weapons qualification score.

(2) Determine the relationships between tank gunnery qualification scores and the performance of the "natural shooter".

(3) Examine the relationships between physical fitness factors, "natural shooters" and tank gunnery qualification scores.

c. Methods:

(1) The sample will consist of 232 gunners (4 battalions, 2 battalions from each Corps).

(2) During a unit's density at Grafenwoehr, the 7ATC study team will collect the following data on tank gunners"

(a) SSN (released by Privacy Act)

(b) Vision measures (acuity, color blindness)

(c) Blood pressures

(d) Physical fitness scores

(e) The study team will observe and collect the results (number of hits, time to hit) of the conduct of the gunner's individual weapons qualification.

(f) The study team will observe and collect the results (number of hits, time to hit) of a skeet shoot for a subset of the battalion's gunners.

(3) Tank gunnery qualification scores will be collected during the battalion's density.

(4) Data will be analyzed for relationships.

(5) Expected products will include the following: interim brief, final brief, and a 7ATC technical report.

d. Limitations: This study is limited to determining if significant relationships do exist between small arms and tank gunnery scores. It is beyond the scope of this study to determine if small arms training could improve tank gunnery performance.

4. Resource Requirements:

a. Study requires use of Training Analysis Division computer facilities.

b. Units will be required to conduct small arms qualifications and submit physical fitness data at Grafenwoehr.

c. Study requires the lease/purchase of a 12/16 20 gauge shotgun, ammunition, skeet pigeons and skeet-throwing devices. Estimated cost for 100 persons shooting 10 rounds at 10 skeet ($5.50/25 rounds + 25 skeet) si $220.

d. Study requires temporary detail of a medical personnel (91A Medic) to assist in periodic data collections.

5. Milestones:

a. Aug 86 - Finalize study plan

b. Sep 86 - Complete USAREUR administration requirements

c. Dec 86 - Collect small arms qualification scores

d. Feb 87 - Conduct analysis

e. Apr 87 - Provide preliminary results

f. Apr 87 - Write report

6. Support Requirements:

a. Study requires USAREUR coordination with field units to perform small arms qualification scores of tank crews and allow a 7ATC study team to observe individual weapons qualifications at Grafenwoehr.

b. Study requires USAREUR coordination with field units for the collection of gunner's vision, blood pressure, and physical fitness measures at Grafenwoehr.

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