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THE MILITARY VALUE OF TRAINING

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General, USA (Retired)

December 1990

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FOREWORD

I am an old soldier--an infantryman by trade--inured to the rhetoric of military training. I am prepared to stipulate that the Romans trained so that their drills were bloodless battles, and their battles bloody drills, and that the ancient Chinese correctly perceived that they could trade sweat evoked by arduous training for blood drawn by an enemy's edged weapon. But I have observed that aphorisms are hardly adequate ammunition for an engagement with a committee of legislators probing large expenditures for military training in a time of nominal peace. Maxims certainly offer slender guidance for solving the range of perplexing problems presented to military professionals by contemporary issues of training other than costs: effectiveness, environmental impact, strategic utility.

This paper is a reminiscence prepared to respond to an inquiry from a NATO group seeking to explicate with operational research the contribution of military training to the overall effectiveness of forces. That group defines the "military value of training" as "the contribution of training to the required availability of (potential) combat power."* I agreed that in a time of financial constraints it is indeed important to understand relationships between resources allocated for training and readiness for war. What follows is what I learned from my personal experience from 1970-1980--my understanding of certain operational analyses and field tests, and my experience as trainee, trainer, combatant, training developer, and student of military history.

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* Orlansky, Dr. Jesse, ed., *The Military Value and Cost Effectiveness of Training*, Defence Research Group, Panel 7 on the Defence Applications of Operational Research, RSG 15 on the Military Value and Cost-Effectiveness of Training, AC/243 (Panel 7/RSG. 15)D/4, December 28, 1989, p. 18. A related paper, an elaboration of certain of the materials in the foregoing, is Deitchman, S.J., "Further Explorations in Estimating the Military Value of Training," Institute for Defense Analyses, IDA Paper P-2317, January 1990.

ABSTRACT

An account of how operations research influenced one U.S. Army officer as he confronted issues of training cost and effectiveness during the period 1970-1980. Favorably impressed by training developments in the U.S. Navy and the U.S. Air Force during the early years of that decade, when the author was the Deputy Chief of Staff for Training of the Army's Training and Doctrine Command, he backed the Army's adoption of Tactical Engagement Simulation. During the latter years of the decade, while commander of the 8th Infantry Division in Germany, he was required to train under "zero growth" budget guidance. To meet higher standards of readiness, he adopted unconventional training methods which included broad recourse to multi-echelon training, and to various forms of simulation, including subcaliber firing, and battle simulation for training command groups. He concludes that contemporary Army training technique, observed at the National Training Center, is fundamentally sound, but that Tactical Engagement Simulation remains an immature training technology.

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GLOSSARY

ΔP	Improvement in proficiency of an individual or crew manning a weapon system
ΔT	Improvement in tactics or techniques by which one or more weapon systems are employed by a commander in battle
ΔW	Improvement in capability through the introduction of modernized or upgraded materiel
7A	Seventh Army, the U.S. field army, deployed in Europe for wartime command of V and VII Corps
ACMI	Air Combat Maneuvers Instrumentation
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARTEP	Army Training and Evaluation Plan, a TRADOC-prepared plan for training a specified unit, expressed in tasks, conditions, and standards
ATP	Army Training Program, a U.S. Army curriculum for training specific units, by subjects and hours for each
ATT	Army Training Test, administered to ascertain whether a unit had satisfactorily completed its ATP
Bradley	The infantry fighting vehicle of the U.S. Army, equipped with an automatic cannon and TOW
BRM	Basic Rifle Marksmanship, U.S. Army Training Program
Bundesbahn	The railroad system of the Federal Republic of Germany
C^3I	Command, Control, Communications, and Intelligence
CATB	U.S. Army Combat Arms Training Board, established in 1971 to catalyze improved training in U.S. Army units by better links with TRADOC schools. Amalgamated with the Logistics Training Board in 1977 to form the U.S. Army Training Board. Disestablished 1989.
CATTS	Combined Arms Tactical Training Simulator, a computerized simulation of battle in the Sinai Desert used for training commanders and staffs at Forts Benning and Leavenworth in the 1970s.

CDEC	Combat Development and Experimentation Center, Fort Hunter-Leggett, CA
CEP	Circular Error Probable, a measure of ordnance delivery accuracy
CPX	Command Post Exercise, usually a drill for one or more commanders and their battle staffs
CPII	Cardinal Point II, a field exercise conducted in Germany during the summer of 1978.
CS	A chemical agent, a non-lethal lachrymal and nasal irritant used for riot control and for troop training in gas warfare
CvT	Conventional Training
D Day	The day planned for inception of a major military operation.
D.O.C.	Unit Desired Operational Capability, an expression of mission essential tasks for training USAF squadrons
FTX	Field Training Exercise, usually involving the deployment of complete units with all their personnel and equipment, for the purposes of training for combat
kepi	The field cap worn by French forces, with a flat, round top, and a stiff visor.
Kriegspiel	War game, in particular that used by the Prussian Army to train commanders and staff officers, and to rehearse operational plans
M-1	The Abrams, main battle tank of the U.S. Army
M.E.	measure of effectiveness
MiG	Soviet designation for a fighter aircraft from its Mikoyan design bureau
MILES	Multiple Integrated Laser Engagement System, the U.S. Army laser-based TES system, the acronym for which alludes to "miles," Latin for soldier.
NATO	North Atlantic Treaty Organization
NTC	National Training Center, the U.S. Army's TES facility at Fort Irwin, CA
O.E.	Organizational Effectiveness, the program for enhancing the performance of U.S. Army units adopted in the mid 1970s
OP	Observation post

OPFOR	Opposing Force, typically equipped like a Soviet force, and trained to use Soviet tactics and techniques, for the purpose of training U.S. Army units
OR	Operational Readiness; for vehicles, expressed as a "rate," or percent of assigned vehicles capable of wartime mission performance
OT	Operational Test. OTIII was troop-user test, the final trial of a developing system before type-classification and fielding
Pickelhaube	The helmet worn by the Prussian Army that had a sharp point atop its crown
RAF	Royal Air Force
REALTRAIN	A TES-system for armored combat based on displaying numbers on the vehicles that were readable through tank and antiarmor weapon sights; REALTRAIN was compatible with SCOPES
RED FLAG	Exercises on the Multi-threat Range at Nellis AFB, Las Vegas, Nevada, that employ TES and ACMI
SCOPES	Squad Combat Operations Evaluation System, a TES-system for individual combatants based on telescopic sights for rifles and machine guns, and numbers on helmets; compatible with REALTRAIN
TAC	Tactical Air Command
TACATA	TRADOC Combat Analysis and Test Agency, Fort Hood, TX
TES	Tactical Engagement Simulation
TOP GUN	Training employing TES and ACMI at the U.S. Navy Fighter Weapons School, Naval Air Station Miramar, San Diego, CA
TOW	Tracked, Optical, Wire-guided Missile, the 3000-meter range Heavy Antitank Weapon introduced into U.S. forces in the early 1970s
TRADOC	U.S. Army Training and Doctrine Command
TRAINFIRE	THE U.S. Army's standard rifle marksmanship range and an associated marksmanship training program, in which firers shoot at pop-up targets at unknown ranges
USA	U.S. Army
USAC&GSC	U.S. Army Command and General Staff College, Fort Leavenworth, KS
USAF	U.S. Air Force
USAREUR	U.S. Army Europe, the Army component of the U.S. European Command, and in peacetime, a headquarters collocated with that of Seventh Army

USMC	U.S. Marine Corps
USN	U.S. Navy
Wehrmacht	The German Armed Forces before World War II.

SUMMARY

During the period 1970-1980, the U.S. Army adopted two novel forms of training: Tactical Engagement Simulation (TES), and Battle Simulation, both of which were demonstrated to be extraordinarily effective compared with conventional methods.

The Army's version of Tactical Engagement Simulation had its origins in aviation training for air-to-air combat: the U.S. Navy's TOP GUN school, and the U.S. Tactical Air Command's RED FLAG exercises, both of which employed a form of free-play force-on-force mock combat. The Navy's TOP GUN program is a rare instance in which the payoff for a superior training technique appears to be evident in wartime loss ratios. The TAC training expressly sought to provide each participating fighter pilot experiences which could serve as a surrogate for his first several combat missions, when operational research had revealed he would be at extraordinary hazard. Over several years the Army evolved comparable training techniques. TES, based on experiential learning, produces better performances in training by small armor and infantry units than traditional didactic methods.

High-payoff training technique is especially relevant when armed forces face constrained budgets. Training policy at the national level has to foster active pursuit of more efficient means of gaining and maintaining combat readiness, especially in unit training, which tends to conservative adherence to accustomed methods and means. Readiness entails attention not only to providing superior materiel to the force, but assuring the proficiency of those who man that materiel, and the competence of those who provide tactical direction for employment of materiel and crews.

The author cites his experience with the U.S. Army's 8th Infantry Division in Germany, during years in which the division's requirements for readiness were rising, as were its training costs, but its resources were mandated as essentially level. To meet these circumstances, the division adopted measures to conserve vehicular fuel, to increase return on expenditures of tank ammunition, to husband artillery ammunition, and to broaden the competence of its infantry and its other component. Of particular note, the division made use of battle simulation to train and evaluate its line battalion command groups.

Over the past decade, TES has figured ever more prominently in U.S. Army training, and is today the principal method employed at the National Training Center, Fort Irwin, California. The author holds, nonetheless, that TES remains an immature training technology which can and should be improved.

I. TRAINING FOR DECISIVE COMBAT

A. COMBAT ALOFT

Some twenty five years ago, Herbert Weiss, an American operations analyst who pursued as an avocation what he termed "bellometrics," wrote a seminal paper in which he observed that in the Battle of Britain each side lost aircraft in proportion to the number of aircraft it committed to battle, relatively independent of the number of enemy aircraft present. In this respect, Weiss was describing a characteristic of any large organization in which output from individuals or groups can be measured precisely. Another keen observer of air warfare is Norman Augustine, who heads up the industrial firm of Martin-Marietta in the United States, and who was Under Secretary of the Army in my era. He has written a tongue-in-cheek book of theorems pertaining to acquisition policy, among them "Law XIX":[1]

> One-tenth of the people involved in a given endeavor produce at least one third of the output, and increasing the number of participants merely serves to reduce the average performance.

Among the empirical data cited by Augustine to illustrate this postulate on the concentration of excellence were staff actions in the Office of the Joint Chiefs of Staff, touchdowns by rushing in the National Football League, arrests by Washington, D.C. police, and air-to-air victories by RAF pilots in World War II.

Herbert Weiss also went beyond the RAF to examine air-to-air combat on both sides of the World Wars and the Korean War. He noted that winning a deadly clash between fighter aircraft required extraordinary pilot proficiency, and that a surprizing number of victories were accounted for by a very small fraction of combatants--the aces.[2]

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1 Augustine, Norman R., *Augustine's Laws*, American Institute of Aeronautics and Astronautics, New York, 1982, pp. 99-101.

2 Weiss, Herbert K, "System Analysis Problems of Limited War," *Annals of Reliability and Maintainability*, Volume 5, *Achieving System Effectiveness*, American Institute of Acronautics and Astronautics, New York, 18 July 1966. The author also has an informal paper of Weiss, entitled "Preliminary Notes on Modelling of Air Combat," 11 January 1966. Cf., Herndon, R.L., "The Army's National Training Center: A Case Study in Management of a Large Defense Project," thesis for the Sloan School of Management, Massachusetts Institute of Technology, May, 1983, Chapter II.

For example, during World War II thirty pilots, the top ten aces of the United States, England, and Germany, shot down a total of 3176 aircraft. Weiss' analyses led him to the very edge of some important truths about the value of military training. Citing data from both World War I and World War II, Weiss demonstrated that tyro pilots, in engagements that ended in one opponent being shot down, were distinctly disadvantaged. At best, inexperienced pilots had four chances out of ten of being shot down, and "fewer than 15 percent of all pilots had a better than 50 percent chance of surviving their first combat." But with each successive victory, a pilot's survivability increased dramatically. By his fifth victory (and his achieving the status of "ace"), his chances of being downed had *decreased* to about 5 percent--in short, his survivability *improved* by a factor of at least eight. If he survived thirty fatal engagements, his probability of loss declined to one chance in a hundred. Weiss charted from his data a curve something like this to illustrate the steep decline in vulnerability in the first ten decisive battles, and stable invulnerability thereafter:

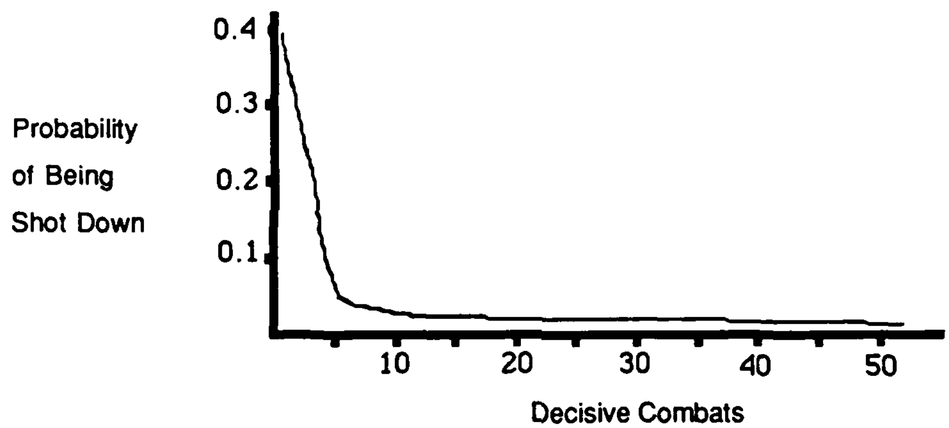

Figure 1. Probability of Loss in Air Combat

Weiss found his curve proved valid when compared with records of those U.S. aces in World War II and Korea with 10 to 30 victories. Aviation records of several wars, in several air forces, show that aces who kept flying combat missions register 50 to 100 kills before being shot down. Weiss pondered whether these data depicted a form of learning under way, a sort of deadly tutorial, but concluded that the phenomena could only be accounted for by "survival of the fittest"--less *training during battle than being endowed with an aptitude for combat*--and he dismissed battle-occasioned learning as "insignificant" in his subsequent bellometric musings about air warfare.

Weiss did, however, offer these useful conclusions:

> ...the increasing complexity of equipment, and the incredibly demanding environment of air combat, will only reduce to even smaller numbers those individuals who can master their equipment and the combat environment, and whose presence as dozens, within a force of hundreds, or thousands, will be decisive.
>
> It seems clear...that any realistic assessment of the capabilities of equipment must properly account for the variability of human performance, and allow for the selection and maximum exploitation of the rare capabilities of the best operators, while raising to a maximum the performance of the less skilled...
>
> The methodology now exists for producing analytical tools of convincing verisimilitude--but both the analyst and military user must continue to remain aware of the fact that this appearance of truth may be false, that the validity of an analysis is subject to proof in the "moment of truth" on the battlefield, that verification is of such importance that all possible avenues of test from field exercises to combat records must be utilized.

B. COMBAT UNDERSEA

What is true of pilots in air-to-air combat, seems to hold for submarine skippers. In the mid 1970s. there was a NATO-sponsored review of the performances of World War II German submarine commanders which found that 10 percent accounted for 45 percent of recorded sinkings, with one outstanding captain engaging 118 times, with 39 kills. Still, 33 percent failed to engage ever, and another 13 percent failed to sink any of the targets they engaged. Thus, nearly half, 46 percent, were ineffective.[3] In 1968 Herbert Weiss wrote a paper about U.S. submarine commanders based on records of 373 instances of decisive engagement during World War II, in which Weiss noted a strong correlation between early combat effectiveness and subsequent invulnerability, similar to that he had described in dogfighting. "Once a [submarine] commander had scored a kill, his chances of further success as opposed to his chances of losing his submarine appear to improve by a factor of *three*. The records show cases where submarines with high kill scores under previous commanders were lost by new commanders without a score..."[4] Weiss' naval analyses imply that he had come to attach greater importance to experiential learning.

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[3] NATO/SACLANT Memorandum, 16 March 1977, quoted in "Report of the Defense Science Board Task Force on Computer Applications to Training and Wargaming," Office of the Under Secretary of Defense for Acquisition, May, 1988, pp. 6-7.

[4] Weiss, Herbert K., "Submarine Losses as Related to Experience of the Submarine Commander," unpublished paper in the possession of the author.

In any event, in 1972 Weiss' writings came to the attention of a member of the staff of the United States National Security Council, then-Colonel Jack Merritt.[5] Merritt wrote a memorandum to Henry Kissinger urging that the Department of Defense reexamine both selection and training of individual combatants, arguing that improving such personnel policies might be more cost-effective than developing better materiel.

C. U.S. NAVAL AVIATORS OVER NORTH VIETNAM

Merritt was aware that air combat in Southeast Asia demonstrated the acuity of Weiss' conclusions about the criticality of pilot skill. The U.S. experience in air combat over North Vietnam indicated, however, that training is much more important than Weiss' data had led him to believe--a reflection, no doubt, of much higher investments in pre-combat training among U.S. pilots in Vietnam than among those of earlier wars. The campaign conducted from U.S. air bases in Thailand and the Republic of Vietnam, and from Pacific Fleet aircraft carriers, proceeded in two periods of air-to-air fighting during nine years, with an intervening lull in 1969 in which neither side shot down an adversary. During the first four years, the battles proved costly for both U.S. Air Force and U.S. Navy aviators: about one U.S. fighter was lost for every two North Vietnamese MiGs downed. During the second four years, the Navy altered its outcomes dramatically, improving its kill-loss ratio by a factor of *five* to better than 12:1. Naval officers attributed the difference to the TOP GUN Fighter Weapons School, formed in late 1968, to train selected fighter pilots of the fleet how to shoot MiG-17s and MiG-21s out of the sky. The training method was engagement simulation, air combat maneuvering pitting pilots in training against instructors flying aircraft resembling the enemy's in speed and performance, with mechanisms to simulate weaponry, followed by a detailed after action review of each engagement. Said the School's commander, "We take the best fighter pilots in the world and make instructors of them to teach other fighter pilots how to fly and fight. But our job is...to win. Basically, we teach dogfighting, a graduate course in dogfighting."[6] TOP GUN graduates began to reach the fleet in Southeast Asia in the late

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5 General Jack Merritt, U.S. Army (Retired), who last served as U.S. Representative to the Military Committee of NATO, and presently heads the Association of the United States Army. Merritt developed his ideas with the assistance of Pierre Sprey, then also on the NSC staff. He reports that he had tested his thesis in an oral presentation at a meeting at U.S. Air Force Academy early in 1972, during which he had interacted, *inter alia*, with Col. John Seigle, President, U.S. Army Combat Arms Training Board, then proponent for the Army thrust toward tactical engagement simulation.

6 "You Fight Like You Train," *Armed Forces Journal*, May, 1974, pp. 25-26, 34.

spring of 1969. When the air battles over North Vietnam resumed, Navy pilots turned in much better scores (Fig. 2).

4-Year Period	Killed	MiGs Losses	U.S. Kill Ratio	Overall Ratio	USAF USN Ratio
1965-1968	110	48	2.29	2.25	2.42
1970-1973	74	27	2.74	2.00	12.50

Figure 2. How the Vietnam Air War Changed

Over the second four years U.S. Navy pilots were both much more lethal and much more survivable than those of the U.S. Air Force. No difference in materiel seems to explain the Navy advantage; in many instances the USAF flew the same aircraft, the F4, as did their naval counterparts, except that USAF F4s were armed with both missiles and cannon, whereas the USN version had only missiles. Convinced that its training was valuable, the Navy retained TOPGUN training after the war. In fact, it has extended its use of engagement simulation to collective training: at its "Strike University" in Nevada, a squadron preparing for carrier deployment can conduct an "attack" on a defended in-shore "target," their maneuvers and ordnance expenditures carefully instrumented for after action review.

D. THE USAF OVER NEVADA

The evident superiority of Navy training was a factor in the U.S. Tactical Air Command's (TAC) forming, in 1974, "Aggressor Squadrons," to augment training for fighter pilots with engagement simulation against aircraft of dissimilar characteristics, flown expertly with realistic threat tactics. TAC also extended its test instrumentation at Nellis Air Force Base in Nevada, and applied it and the Aggressor Squadrons in RED FLAG, a rotational training exercise for TAC squadrons. In explaining these decisions to me, TAC officers at RED FLAG cited Weiss' analyses, pointing out that USAF exhausted every recourse open to it in selecting fighter pilots, but that the U.S. Air Force could ill afford not to provide for its pilots-to-be, however well selected, training aimed at optimum effectiveness in those early, vulnerable battle encounters. RED FLAG's stated objective was to enable each pilot to experience his first ten "decisive combats," and thereby make available to air commanders, on D Day of any future war, the differential between

40 percent and 5 percent probability of pilot loss on sortie one, and the significant increase in pilots and aircraft that would be available for sorties two, or three or n.[7] RED FLAG's training method included not only flying experience difficult to duplicate outside of war, but also a vivid after-action review for each pilot by an expert instructor, who could selectively summon from a computer minute details of each engagement, and drive home his teaching points with three-dimensional graphic aids, thereby overcoming the disadvantages for training of simulated engagements which occurred in seconds, or fractions of a second. Thus the whole simulation focused on impressing upon the learner-pilot the hard lessons of early combat missions.

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7 Gorman, Maj. Gen. P.F., "Toward a Combined Arms Training Center," transcript of remarks at the PM,ARTADS-TRADOC Conference, Fort Monmouth, NJ, November 1976. Author was then serving as Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command.

II. THE U.S. ARMY'S ANABASIS

A. THE NEED FOR BATTLE SEASONING

I knew that pre-combat lessons which led to higher effectiveness and survivability in battle, if they could taught, were crucial for the U.S. Army. While the Army had probably always sought to select its junior leaders carefully, there was ample evidence that it had found no reliable method of picking effective combatants out of the crowd. In most of the Army's many wars, its early battles had been disastrous; infantry units, in particular, were regarded as unreliable until they had been "bloodied," or seasoned in a battle or two. Common among these failures were forward fighting elements composed of green troops led by poorly prepared officers, incapable of realizing potential combat power. For example, contrary to American self-images of a nation of shooters (e.g., the RAMBO-syndrome), it has often been the case that the U.S. soldier simply did not fire in battle. My own combat experience had taught me that the American infantryman could engage effectively with his weapon, but that he was not likely to do so absent persistent training and leadership. I knew, from listening to seniors, that failure to engage was scarcely a new problem in our Army, and I have been led to believe, through conversations with German veterans of World War II, and Israeli veterans of more recent wars, that the problem may be universal. One of my mentors in such matters was (and still is) General William E. DePuy, then the commander of the Army's newly-formed Training and Doctrine Command (TRADOC), who taught me that battle is a powerful, but expensive teacher for young leaders, particularly platoon leaders. Recently he wrote down what I had heard him state on many occasions:[8]

> In prolonged combat there are two reciprocal forces always at work. Sadly, the more casualties, the less seasoning--and happily, the more seasoning, the fewer casualties. And casualties are not solely, often not even primarily the responsibility of lieutenants. It is the job of leaders at battalion and above to tip the scales toward seasoning and away from casualties by skillful and imaginative tactical concepts--in short, to fight battles in ways conducive to keeping lieutenants alive and learning.

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8 DePuy, W.E., "Battle Participation and Leadership," remarks to the TRADOC Commanders' Conference, USAC&GSC, Fort Leavenworth, KS, March, 1989.

When a lieutenant is lost to a platoon, he takes with him a large fraction of the cohesion, teamwork, trust and confidence that are associated with his time on the job and his leadership--not to mention his painfully acquired battlefield skills.

And then, of course, a new man arrives. He is an unknown quantity without credentials and he may not have time to learn them.

Let's look at some hard evidence on that score.

Per infantry regiment of the 90th Division during seven weeks of fighting in Normandy, the average loss in officers was 123. About 95 percent of these were infantry platoon leaders. Weekly losses averaged 48 percent of the lieutenants commanding rifle and weapons platoons. Thus the average longevity of the lieutenant was just over two weeks. The casualty curve was steep, and the seasoning curve was flat.

Five months later after the dash across France--fighting at Metz, crossing the Mosel and Saar--the division fought in the Battle of the Bulge. During this equal period of seven weeks the average loss of infantry lieutenants was ten percent a week.

During the five intervening months, the 90th Division had learned how to fight. Partly this was because the seasoning curve was steeper while casualties diminished. And it was because battalion and higher commanders found that there were ways to win battles at reduced costs.

Success is a function of tactical skill and relative force strength. It is not simply the product of some character inventory of the opposing soldiers.

The professional leader is, of course, concerned about the motivation of his soldiers and their morale. But he is preoccupied (or should be) with achieving the highest possible level of individual participation by his concept and control of fire, by assignment of sectors and targets, and by active positive command.

What the Army needed was battle seasoning for its cutting-edge formations, a way to teach them how to fight and win at reduced costs, avoiding the payment exacted of the 90th Division.

B. THE 3 × 5 TEST

In 1973 I was appointed General DePuy's Deputy Chief of Staff for Training in TRADOC, and among the first papers I was asked to read was Col. Merritt's. Thus attuned to possibilities, I examined training in the U.S. Navy and the Air Force. I noted for Army commanders that our concepts for macro-management of training had been developing in a pattern which paralleled those of the Air Force, but lagged behind them. In the aftermath of World War II, both the Army and the Air Force managed training by time.

The Air Force prescribed the number of hours pilots had to spend in the air annually for given purposes to maintain qualification. Standards then evolved to setting as well performance criteria for specified events, e.g., "drop three bombs; CEP[9] 50 meters." In its next step, TAC recognized that modern air combat involves critical teamwork among pilots with very different tasks: for example, a squadron's combat mission might require some of its planes to deliver ordnance on a bridge, but others to suppress air defenses, to conduct electronic warfare, or to defend the whole formation from attack by enemy fighters. Hence, TAC adopted collective training objectives based on expected combat missions, referred to as a "Unit Desired Operational Capability", or D.O.C. I used the following comparisons (Figure 3)[10] to explain myself:

U.S. Air Force	U.S. Army
Flying Hour Program	Army Training Program
Specified Events	Army Training Tests
Unit D.O.C.	ARTEP
Aggressor Squadrons	OPFOR Units
Multi-threat Ranges (RED FLAG)	Engagement Simulation

Figure 3. Evolution of Training Management, U.S. Army and U.S. Air Force

The Army Training Program (ATP) for each type unit stipulated x hours of training for Subject A, y for B, etc. Army Training Tests (ATT) listed, in check-list format, ways a unit could demonstrate mastery of ATP subjects. The Army Training and Evaluation Program (ARTEP) went beyond the ATT to describe mission-essential tasks, conditions, and standards to guide both training and evaluation of training. And in the early 1970s, the Army Combat Arms Training Board (CATB) began to urge force-on-force engagements for collective training and evaluation, not on a scale commensurate with the Navy or Air Force engagement simulation it emulated, but nonetheless significant as a departure from what had gone before.

I became convinced that the Tactical Air Command and Naval Aviation had found a valuable approach to training, and that CATB was on the right track. Data I was fond of citing to prove my point were collected in field trials by the TRADOC Combat Analysis and

9 Circular Error Probable.

10 Gorman, "Toward A Combined Arms Training Center," op. cit.

Test Agency (TCATA) at Fort Hood, Texas. TCATA had been tasked to compare the effectiveness of two different tank platoon configurations: the traditional U.S. 5-tank platoon, and a novel 3-tank platoon proposed for adoption in a reorganization of U.S. armored and mechanized divisions.[11] All troops and tanks that participated in what came to be known as the"3 × 5 Test" were drawn from one of the two line divisions at Fort Hood. TCATA used an elaborately instrumented range for its trials, and was able to collect convincingly complete data on a series of realistic combat exercises extending over two weeks, involving both laser-aided engagement simulation, and live-fire platoon battle runs. In those subtests which attracted my attention, platoons undergoing evaluation were assigned a mission of defending against an attacking force outnumbering them 4:1--the 5-tank platoon opposed 20 attacking tanks, and the 3-tank platoon, 12 attacking tanks. To minimize differences in leadership or experience, and to compensate for the lack of doctrine for the 3-tank version, the test design provided that at the end of the first week, the tankers of the 5-tank platoon of Week One sent two of their crews and vehicles back to their parent organization, and assumed the 3-tank role for Week Two, while the 3-tank platoon of Week One was reinforced with two new crews to assume the 5-tank platoon role for Week Two. Test results were reported, *inter alia*, in ratios of hits per shot, and of "enemy" kills to own losses (both mobility "M" and "K" kills counted), charted as follows :

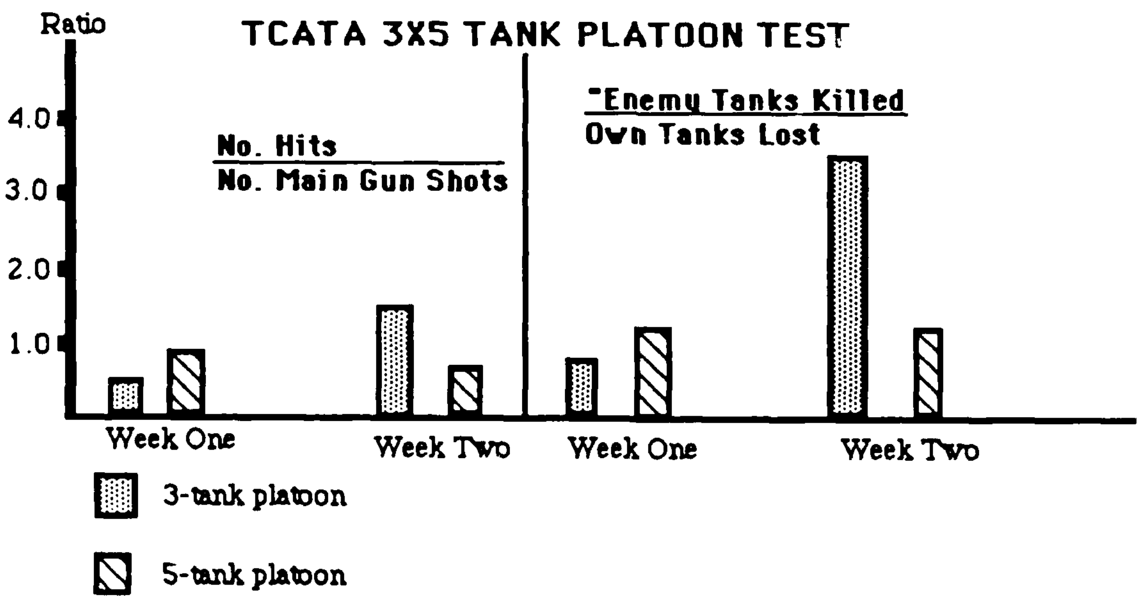

Figure 4. Experiential Learning in Operational Test

[11] *Ibid.* Also, "Trends in the Army's Training System," transcript of remarks to the Army War College, 21 January 1977.

These portions of TCATA's 3 × 5 Test were not very instructive for General DePuy in deciding platoon configuration precisely because the TCATA observers concluded that test outcomes were dominated by experiential learning. The 5-tank platoon of Week Two was demonstrably encumbered by its two neophyte crews: their two tanks were reported as among the first lost for all missions, and their shooting was markedly inferior to that of the better experienced crews. The 3-tank platoon of Week Two, on the other hand, had become quite expert, manifesting not only cohesion, confidence and tactical agility, but innovative technique, such as dismounting an observer, husbanding their tanks in defilade until he signaled, and then cresting to open fire in volley, before backing down and moving to another position. The seasoned tankers of that platoon progressed in both killing prowess and survivability: in their initial defensive mission in Week One, all their vehicles were "destroyed," but in their final defense in Week Two, they "killed" all the attackers without losing a single tank. An Israeli observer of the test, an armor officer well familiar with fighting 3-tank platoons in the 1973 War, stated that by Week Two the leaders had evolved tactics and techniques he deemed just about right. TCATA recommended to the Commander, TRADOC, that laser-aided engagement simulation, supplemented by live fire battle runs, be incorporated into armor training Army-wide.

C. TACTICAL ENGAGEMENT SIMULATION

Fortunately, several parallel actions were under way which made it possible ultimately to act affirmatively on TCATA's recommendation. What TCATA had replicated in its 3 × 5 Test was a high-technology version (lasers and computers) of the collective training technique the U.S. Army Combat Arms Training Board (CATB) had been investigating, labeled *Tactical Engagement Simulation*, or TES. Inexpensive training aids and pamphlets which facilitated TES--training based on simulating in real time what happens when one weapon system fires upon another in battle--were already being fielded under the auspices of CATB to be used in unit collective training, materiel referred to as SCOPES (for dismounted combat) or REALTRAIN (for both mounted and dismounted training).[12] Careful evaluations of these low-technology versions of TES by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) were producing data

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[12] U.S. Army Infantry School, "SCOPES: Squad Combat Operations Exercise (Simulation)," Special Text 7-2-172, 1973. Department of the Army, "REALTRAIN: Tactical Training for Combined Arms Elements," Training Circular 71-5, January 1975.

on training effectiveness which strongly supported the thesis that TES could train small units of the ground combat arms how to win in battle, and teach that lesson powerfully.

Typically, an ARI evaluation of TES consisted of a pretest in which small units were evaluated using TRADOC criteria for tactical proficiency to establish their baseline proficiency. These units would then receive a week or so of intensive training, half being trained conventionally, the other half being trained using TES. Assignments to a particular type of training were designed to produce two groups of units with comparable proficiency as determined in the pretests.

The term "conventional training" was construed to mean that training methodology which the U.S.Army then used in institutional training, and which was usually employed in unit training--explanation, demonstration, application, evaluation, feedback. Conventional tactical training tended to emphasize doctrine, principles, terminology, and procedures, and conventional evaluation methods tended toward verifying observance of what had been taught. The unit was allowed to use its best-reputed instructors for the training; afterwards, soldier-participants rated the conventional training higher than TES training--it was, after all, what they were conditioned to expect of "training," and it was much less demanding of each individual.

TES training (properly conducted, as it was for the trials) is less didactic, and more experiential, than conventional tactical training--essentially learning by doing, with a casualty assessment system as the reward for tactical soundness, and the punishment for tactical vacuity. Participants are allowed free maneuver, and are encouraged to be innovative. Much of the actual learning--internalization--in TES training occurs in a dialectic after-action review, in which participants are guided through an examination of each action in minute detail--e.g., exploring the cause of each casualty--being encouraged to be brutally frank, so that good tactics could be recognized and adopted by all, and dubious tactics thereafter shunned. TES matches well with doctrine: what units learn via TES is what conventional training assays to teach, and demonstrably teaches less effectively.

In both sets of ARI trials, following the training period each unit underwent posttests. First were evaluations in which they were assigned a tactical mission to be accomplished opposed by an expert opposing force (OPFOR). Then pairs of units were drawn from each of the two training groups; each unit in each pair received a tactical mission which precipitated a "shoot-out" meeting engagement with its counterpart.

Performance in engagements was carefully evaluated by a team of controllers, guided by ARI technicians, who collected extensive quantitative data on fire and movement, communications, timing, command and control, casualties on both sides, and recorded judgements on mission accomplishment from expert observers.

Following are results from two series of such evaluations, the first involving infantry rifle squads, and the second Armor/Anti-Armor teams that consisted of one tank platoon, one Heavy Antitank Weapon Section (TOW), and one artillery forward observer party.[13] In Figure 5 is an analysis of the change in the effectiveness of 18 infantry rifle squads from pretests to posttests:

Effectiveness Measure	TES Δ	Conventional Δ
Mutual Support	1.66	1.15
Protection and Observation	2.24	1.00
Control and Communications	1.92	0.79
Firepower and Tactics	2.58	0.74
Overall	2.10	0.90

Figure 5. Factor of Improvement (Δ) on Measures of Infantry Squad Tactical Performance

"Mutual Support" refers to arrangements among members of the squad for fire to cover movement. "Protection and Observation" refers to provisions for security of the squad. "Control and Communications" and "Firepower and Tactics" are self-explanatory. Note that the TES-trained units *doubled* in effectiveness from Pretests to Posttests, while effectiveness of the conventionally-trained squads showed a slight decline. Among TES-trained infantry squads, both improvements in individual or crew proficiency (ΔP) and in unit tactics (ΔT) were recorded. In defense, compared with conventionally-trained (CvT) squads, TES-trained squads accomplished their mission more often, inflicted more casualties, sustained fewer losses, better provided for security to their front and flanks, employed mines to better effect, and were more likely early to detect and open fire upon the OPFOR. In the attack, they accomplished their mission more often, and were both more

[13] Scott, Thomas D.,"Tactical Training for Ground Combat Forces," *Armed Forces and Society*, University of North Carolina Press, Volume 6, Number 2, Winter, 1980, pp. 215-231. Cf., Research Reports of the U.S. Army Research Institute for the Behavioral and Social Sciences: concerning REALTRAIN Validation for Rifle Squads, Number 1192 of October 1977, 1203 of March 1979, and 1213 of July 1979; concerning REALTRAIN Validation for Armor/Anti-Armor Teams, Number 1191 of October, 1976, 1204 of March 1979, and 1218 of July 1979. Cf., Hart, R.J., and Sulzen, R.H., "Comparing Success Rates in Simulated Combat: Intelligent Tactics versus Force," *Armed Forces and Society*, Volume 14, Number 2, Winter 1988, pp. 273-285.

lethal and more survivable; they were more likely to use cover and concealment, to employ overwatch, to suppress with their machine gun, to maneuver in close to the OPFOR and to "kill" with grenades (the broad infantry mission is to close with the enemy and destroy him), and to remain the while a cohesive team, responsive to control of a leader. The TES-trained squads had patently learned how to avoid casualties: in the first event in the Posttest, CvT units lost on the average at least 70 percent of their numbers within the first fifteen minutes, demonstrating no improvement over the Pretest; in contrast, the TES-trained squads showed losses in the same period of only 30 percent. Controllers rated TES-trained squads much more cautious than CvT squads, but after the first seven minutes of the engagement, CvT losses outnumbered TES-trained losses 2:1, and TES-trained squads inflicted on OPFOR more than four times the losses from CvT squads.

In the Armor/Anti-Armor trials, similar results were obtained with quite different weapon systems being simulated--"kills" at 3000 meters were feasible. TES-trained units again proved more lethal, more survivable, and more cohesive. In all Pretests, more than half of all platoon leaders and platoon sergeants became early casualties. In the Posttests of TES-trained squads, losses of leaders were down to 13 percent, while in CvT units, the leader-loss rate was 63 percent. "Battle" seasoning did indeed seem to be occurring.

Overall results of both the dismounted and mounted evaluations are presented in Figure 6.

	Missions Accomplished				Casualty Exchange Ratios			
	TES		CvT		TES		CvT	
	Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)	Pretest (%)	Posttest (%)
Infantry Squads (n = 16)								
Attack	0	50	0	0	0.04	0.39	0.03	0.08
Defense	0	75	0	13	0.55	1.62	0.54	0.52
Shoot-out	74		26		1.54		0.64	
Armor/Anti-Armor (n = 8)								
Attack	25	75	25	0	0.04	0.41	0.08	0.05
Defense	25	50	0	25	0.28	0.90	0.16	0.60
Shoot-out	86		14		2.50		0.40	

Figure 6. Tactical Test Mission Outcomes

Two generalizations from Figures 5 and 6 are immediately evident : (1) TES-trained units proved markedly more effective than CvT units--in the "shoot-out," TES-trained units were *two to six times* better; (2) the *entry proficiency* of all units was deplorably low--most units were simply wiped out in the pretest exercises. Hence, the Army badly needed the training leverage of TES. Thomas D. Scott of ARI, who participated himself in TES evaluations, wrote that:

> If the tactical proficiency of most small combat units is as poor as that of the test units, the degree of unpreparedness for combat has serious implications. Squads and platoons are the heart of the Army's conventional fighting capability, and without at least moderately proficient small units, larger units cannot be effective, regardless of how well equipped they are with modern weapon systems. Ill-prepared tactical units can only weaken the deterrent effect of U.S. ground combat forces. As the data presented earlier have shown, engagement simulation methods can provide one means for making much needed improvements in the proficiency of small combat units.

SCOPES and REALTRAIN, the TES devices used in these trials, were optical: weapon effect was simulated by requiring a firer to read, through an optical weapons sight, a number worn by his target, whether individual or vehicle. The power of the optics and the size of the number were chosen so that earliest readability approximated the weapon's effective range. On reading, the firer would call out target number to a controller, who radioed a fellow controller on the opposing side to inflict the "kill." Though cumbersome, these practices proved much faster and more realistic than any previous control system for direct fires in field exercises, and while they required a substantial overhead of controllers and communications, controllers were being trained as effectively as the unit participants. SCOPES and REALTRAIN had been demonstrated to be effective for training; however, in recognition of their manpower costs, and of the inherent limitations on numbers of targets they could accurately process per unit of time, the CATB had also launched in the early 1970s development of an automated family of laser-based TES devices, labeled the "Multiple Integrated Laser Engagement System," or MILES.[14]

D. MILES

In MILES-instrumented TES, all participants wear laser detectors, and all direct fire weapons are equipped with a small, bore-aligned, eye-safe gallium arsenide laser, the

[14] The acronym was chosen by CATB both because of the Latin *miles* (soldier, infantryman), and because the Army Materiel Command's Program Manager for the development bore "Miles" as his given name.

power of which roughly matches the range of the weapon to which it is affixed. When the firer "shoots," a weapon-signature blank cartridge fires, acoustically triggering emission of a burst of laser-energy. The laser beam is modulated, or coded, to convey to a detector on the target the type of round it represents, and logic built into chips embedded in the detector array for each type target then can determine whether the "hit" was a "kill" or a "near-miss." If the former, the detector disables the target's weapon, and provides audible or visible indication of "kill"; if the latter, the detector warns the target that it is under fire, enabling both suppression for the firer, and evasive action for the target. If the hit could not affect the target--e.g., a rifle shot hitting a tank--the detector logic simply ignores the event. MILES enables substantial automation of TES, eliminating many controllers and radios, and expediting exercise control. MILES equipment costs more to acquire and to maintain than optical TES aids, but is more reliable, works at night, and accommodates much more complex engagements, involving many more weapons of different types, than the optical systems could ever support.

From 1977 to spring 1979, I commanded the U.S. 8th Infantry Division (Mechanized) in Germany. Beginning early in 1978, the Division adopted REALTRAIN for its small unit tactical training and evaluation, and in the fall of 1979, after my departure, the Division was selected to conduct the Operational Test III for MILES (the troop wring-out for the materiel, largely focused on collecting data concerning mean-time-between-failure). OTIII involved about 100 days of field exercises for some two hundred participants, who were afterwards polled to ascertain their judgments concerning MILES merit or demerits. When soldiers of that relatively well-informed "electorate" were asked whether they regarded MILES better than conventional tactical training, or better than REALTRAIN TES, results (Figure 7) were a clear endorsement for MILES:[15]

Is MILES better than:	Infantry			Armor			Total
	EN	NCO	OFF	EN	NCO	OFF	
Conventional Tactical Training?	76.8	95.7	100	64.7	88.1	100	78.9
REALTRAIN?	73.0	91.7	100	75.4	88.4	100	79.5

Figure 7. Percent of Respondents Selecting MILES as "Better"

[15] Gorman, LT. Gen. P.F., "Training Technology for Modernization," paper of OJCS, J-5, 9 June 1980.

The 8th Division's report concluded that the test had demonstrated three primary advantages for MILES: enhanced troop esprit and competitiveness, the systems' utility in night training, and its adaptability for training outside normal ranges and maneuver areas, unfettered by safety concerns for the firing of actual weapons, or the inadequacies of conventional targets--many of the Division's ranges had been installed by the *Wehrmacht* before World War II , and were not particularly useful for training units in employment of thermal sights and other modern target acquisition or fire control gear.

E. THE NATIONAL TRAINING CENTER

In any event, following the 8th Division test, MILES was adopted by the Army as a standard training device, and the decision to do so converged with the establishment of the National Training Center at Fort Irwin, California, in 1981, located about 100 miles west of Las Vegas, Nevada. Fort Irwin is a military reservation in the high desert, near Death Valley, comprising over 600,000 acres of mountains and open, arid valleys with contiguous air space, useable for fire and maneuver. One attraction of Fort Irwin--then under control of California National Guard--was its proximity to similarly large U.S. Air Force, Navy, and Marine Corps reservations: within 200 miles or so of Las Vegas lie the western world's largest expanse of militarily controlled air and land reservations. All the other U.S. armed services had been conducting extensive training exercises in this region, and the Navy and the Air Force both had invested in Air Combat Maneuvers Instrumentation (ACMI) which could be used interoperably for engagement simulation. By reactivating Fort Irwin as an Active Army post, the Army put itself in a position to participate in joint training in three dimensions, with its own troops participating in large scale--brigade level--TES using MILES, with headquarters of other brigades and the parent division coupled by a computer-aided command post exercise. Or such was the concept in 1976 when we initiated action to reacquire Fort Irwin and put it to those purposes.

Land and air space set aside for military training, I scarcely need remind, has increasingly constrained the effectiveness of training for modern war. Since the introduction of the ogival projectile in the period of the American Civil War, there has been a discernible trend toward dispersion to cope with increased firepower;[16] the fragmentation

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[16] Dupuy, Col. T.N., *Numbers, Predictions, and War*, MacDonald and Jane's, London, 1979, p. 7, in which the author plots lethality (killing capacity per hour) increasing from 400 B.C. to the present by six orders of magnitude, while dispersion (square meters per man in combat) increases by four orders of magnitude. Dupuy notes that the technological change which had the greatest influence (cont'd)

munitions of World Wars I and II accelerated this tendency.[17] Nonetheless, improvements in C^3I, mobility, and armor protection have also increased mission requirements for units training for close combat. Presented in Figure 8 is a chart compiled in part from data I used in the 1970s to argue for establishment of the National Training Center.[18]

One implication of force modernization over the past century is growth, by orders of magnitude, in the area that a battalion-sized force (some 600-800 men) can influence. At the front, more and more has been expected of fewer and fewer soldiers. Armies exist fundamentally to control land and people; hence, training a battalion to do its job in war implies its practicing the physical feats that wartime missions will require of it: dealing in space and time with vast expanses of complex terrain and the works of man thereon, and using weapons of increasing puissance with deft timing and discrimination against a numerous enemy equipped with comparable materiel. Firepower trends that are not well illustrated by Figure 8 are (1) a growing proportion of indirect lethal ordnance, delivered by elements other than battalions in contact at the front, and (2) the proliferation of precision guided munitions, or other "brilliant" munitions, the efficacy of which cannot adequately be expressed as throw-weight, or "pounds per man per hour." But the diagram helps underscore the fact that modern battle spreads a battalion across a dauntingly large area, and therefore that large amounts of land are required to ready it for war.

At Fort Irwin, California, the United States Army had enough land to train well at least two battalions of a mounted brigade in modern mobile warfare--1000 square miles of uninhabited land, the nearest town 35 miles to its south, with Death Valley National Monument to its north, and the China Lake Naval Weapons Center to the west and northwest. The National Training Center established there provides an intense experience in moving, shooting, and communicating lasting some three weeks, during which participants fight eight to ten "battles." The training methodology is centered on

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(cont'd) on modern ground warfare occurred between 1850 and 1860, when the introduction of conoidal bullets enabled infantry to deliver accurate, lethal fire for hundreds of meters, vice tens.

17 Ellis, John, *The Sharp End*, New York, 1980, pp. 176-177. British medical records trace the transformation from domination of direct-fire weapons to supremacy of indirect fire: in the first two years of World War I, bullets caused more than three out of four wounds, but as the war continued, fragmentation wounds became more common. In World War II, three out of four wounds among British forces were caused by explosive munitions: grenades, mines, mortar and artillery projectiles, and aerial bombs.

18 Cf., Department of the Army, Training Circular 25-1, *Training Land*, 4 August 1978, pp. 4-11.

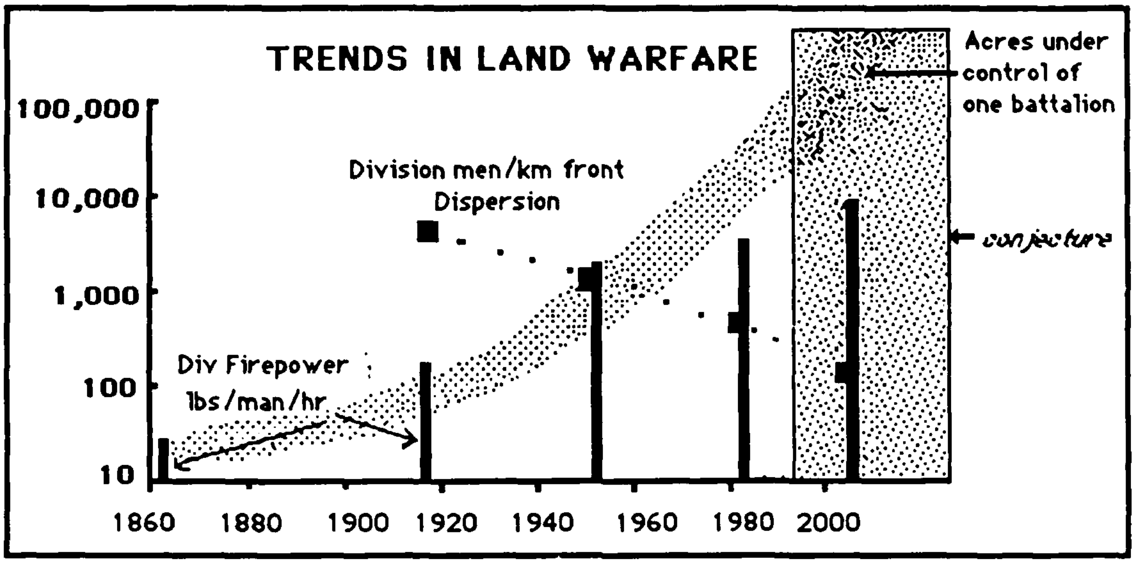

Figure 8. Trends in Land Warfare

experiential learning, with emphasis on after-action reviews of each battle, and detailed records of each battle for use by the unit in its subsequent training at home station. The enabling techniques include both TES and live firing, instrumentation of participants which permits recording maneuvers and firing events (real or simulated), and use of a resident Opposing Force (OPFOR), modeled upon a Soviet Motorized Rifle Regiment. Both sides are allowed, within the limits of safety, free maneuver in their operations, and neither is provided any information of the other it does not earn through reconnaissance. But OPFOR has the advantage of knowing the hostile, complex terrain very well, and it employs Red Army doctrine with ruthless efficiency to expose dependably the slightest tactical ineptitude on the part of a unit in training. Since its opening, over one hundred rotations of the latter have arrived at Fort Irwin to give battle to OPFOR, and only a few would describe their experience as "victorious." Yet in a larger sense, the whole Army has been a winner, for the small defeats in the Mojave Desert have spurred officers, noncommissioned officers, and soldiers to new professional heights.

The records of the battles at the NTC have been archived by ARI, and used to support the Army's Center for Lessons Learned, at the U.S. Army Combined Arms Center, Fort Leavenworth, Kansas, and for other studies and analyses. The NTC performance data can be analyzed to detect possible lacunae or misapprehensions concerning specific weapon systems, tactical doctrine, organizational structure, training, battlefield leadership, unit cohesion, and personnel management. For example, NTC data have been used to quantify relationships between funds allocated to support home-station field training (referred to as operating tempo, or OPTEMPO), and recorded tactical performance at the NTC.[19]

I am not in a position to cite figures on cost and effectiveness of the National Training Center. The Army is chary about data which, misconstrued by the media, might embarrass commanders thumped upon by OPFOR, and in any event, NTC's training effectiveness is manifestly as much a function of the training it stimulates at home station before and after the "battles" at Fort Irwin.

One measure of the NTC's effectiveness is that the Soviets have flattered it by imitation. During the 1980s the Soviets experimented first with a tank-mounted laser engagement system they called *ZORKEY* (sharp-eyed, vigilant), and then with a small-arms simulator for dismounted troops named *BESSTRASHNIYE* (fearless). These appear to be laser transmitter-receiver units functioning at 34.6 microns that, through laser reflectors at both ends of any firing event, and aided by embedded microprocessors, establish closed-loop communications and insert weapon-effect filtering; two pulses from an eligible firer are necessary to lodge a "kill" message with the target. Unlike the U.S. MILES equipment, these lasers are not eye-safe, and require wear of protective goggles by all involved with them. In 1988 tests were conducted with both motorized rifle and tank units in field exercises in the Carpathian and Baltic Military Districts. In 1989, the Soviet Ground Forces Combat Training Directorate began referring to a training center, to be established in the Western USSR, at which realistic force-on-force exercises would be conducted using the engagement simulation equipment: a battalion from one regiment would travel to the site to contend against a battalion from another regiment in both offensive and defensive operations. (There have been no references to instrumentation for after action reviews such as at the U.S. National Training Center, and no hint that there will be a U.S.-style OPFOR).

The major element in the the U.S. Army's budget for the National Training Center is transportation of units to and from Fort Irwin, but one might also include in any estimate of its marginal cost the entire operating budget for the post and the OPFOR brigade stationed there. Is it worth what has been expended? Senior serving officers are quite sure that it has been, and assert that the NTC has had a demonstrably pervasive, beneficial

19 Hiller, Lehowicz, and McFann, "Does Level of OPTEMPO Relate to Unit Performance Capability: An Objective Answer," paper prepared for the Army Science Conference, Durham, North Carolina, 1990.

impact on the combat capabilities of the Army. The present Chief of Staff of the Army, General Carl Vuono, told me that so long as he is in office, the NTC will be funded to continue its mission, because he regards it as the principal "driver"--motivating influence--on U.S. Army training today, and insurance that, in the first battles of the next war, the U.S. Army will not repeat the military disasters which have been its openers in past conflicts.

I do not believe that the NTC's cost-effectiveness can be quantified. Instead, let me quote the concluding paragraph of my foreword to Captain Daniel Bolger's fine book describing his battalion's experience--the Dragons of the 34th Infantry--at Fort Irwin:[20]

> I think it is fair to conclude that training at the NTC is stressful. Most participants agree with Captain Bolger on that score. The reader may judge from his account of the Dragon's experience whether this stress serves useful purposes. It is also evident that NTC exercises are expensive. How effective they are, and whether they thereby justify such difficulties and expense, is again a matter for the reader to weigh. I personally believe, on the evidence of Bolger's account, that soldiers of Task Force 2-34 Infantry (the Dragons) individually and collectively learned more at Fort Irwin than they might have learned in two weeks at war. And all emerged alive. Those Dragons may no longer serve together, but infantry and armored units in which they will train or fight in years to come will profit from what they learned. The NTC breeds battle-wise soldiers bloodlessly.

That says it all.

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[20] Bolger, Daniel P., *Dragons at War*, Presidio Press, Novato, CA, 1986, p. viii. I compared Bolger's work to Ernest D. Swinton's *The Defense of Duffer's Drift*. For an account of training at the NTC written explicitly to the Swinton model, see McDonough, James R., *The Defense of Hill 781*, Presidio Press, 1988.

III. THEOREMS FOR HIGH-VALUE TRAINING METHODS

A. A TAXONOMY OF MILITARY TRAINING[21]

In general, training conducted by an armed force to prepare its members for war occurs in four regimes differentiated by the target (object) of the training--whether individuals or collectives--or its environment (venue)--whether in institutions or in units; in short, defined by who is being trained and where the training is taking place.[22] Figure 9 provides a useful framework for training policy.

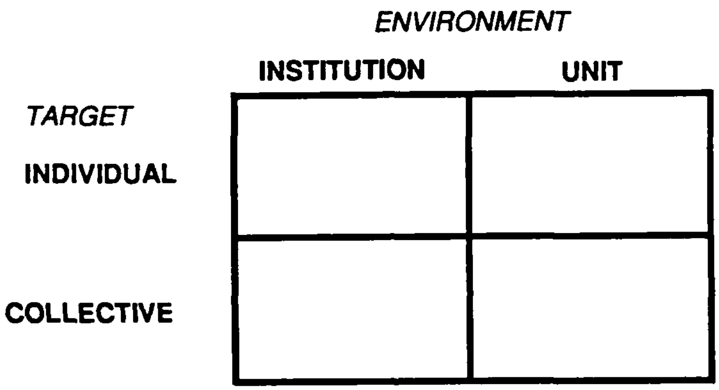

Figure 9. Framework for Training Policy

B. INSTITUTIONAL TRAINING

The term "institution" refers to the fixed facilities, faculty, and curricula which are characteristic of military schools and training centers, administrative procedures and forms of instruction which resemble those of civil school systems established to meet the needs of modern industrialized society. In institutional training, military student groups or classes progress through a curriculum, a faculty-defined and directed set of learning experiences, usually in accordance with an established schedule. Trainers on the faculty are advantaged

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21 The following section is drawn from the author's draft manuscript on "Training Technology" for the *International Military and Defense Encyclopedia*, to be published by Pergamon-Brassey.

22 Cf., Department of the Army, "Army Training," Army Regulation No. 350-1, 25 April 1975, para. 1-3.

by controlling with some precision the timing and pace of instruction, and by repetitive experience with different classes, which enables practice toward teaching perfection.

Individual training or education aimed at developing the cognitive or psychomotor skills of one military member is generally regarded as central to the professionalism of an armed force, its principal method of converting recruits to its outlook and ways, and of imparting to them job-essential skills and knowledge. For this reason, most forces establish institutions devoted to such training: facilities dedicated wholly or primarily to the task of training. Trainers therein are usually carefully chosen, and often constitute a professional élite, charged with establishing standards that will prevail throughout the force. A number of armed forces also use institutional faculties as authors for training manuals and other media that are conducive to building doctrinal consensus, and thus guiding unit training as well.

Military training for individuals differs from comparable civil training and education both in the social context within which the training is conducted, and the dire, possibly fatal consequences of failure to learn. But non-military pedagogical method is accepted as being highly relevant, and over the years there have been significant transfers of experience and technique between civil education and military institutions. Military trainers charged with individual training can draw upon a relatively rich literature, founded upon extensive research both in military service and in civilian schools and universities. For example, in higher institutions of learning, both civil and military, experiential learning through "case study," or through role-playing within simulations, is being used as a technique for training students how to cope with complex adversary proceedings.

In most military training institutions, the faculty, a relatively stable group of instructors or subject-matter experts, train classes, or groups of individuals, seriatim. However, institutions can also be used for collective training, such as forming provisional weapon crews or small tactical units to condition individuals for roles within teams when they are sent to the forces. And institutional training is also useful for units from the forces, such as for the leaders of a newly forming or reorganizing unit, and even for entire units. The U.S. experience over the past twenty years is to point: the Navy's Strike University, the Air Force's RED FLAG, and the Army's National Training Center all provide institutional training for units aimed at heightened motivation and combat readiness.

C. UNIT TRAINING

Individual or collective training which takes place within a military unit--a land formation, an air squadron, or a ship's company--is intrinsically different from that in institutions, in that the unit's leaders must manage (and often must design) the training, using a faculty drawn from among the unit's own personnel, who are frequently neither as well versed in the subject matter of the training, nor as well coached in instructional technique as an institutional faculty. In a unit, the student body is largely fixed, but the curriculum changes constantly. Unit trainers must be prepared to manage and present both individual and collective training. A significant amount of individual training in units is conducted on the job by first line supervisors or peers, and beyond basic entry training, unit training is all most soldiers receive as individuals. Individual training in units is largely unstructured and unevaluated, and records of skill advancement are rarely maintained.

Because of exogenous influences on a unit's schedule, neither individual nor collective training time and student attendance can be well controlled. Often a unit finds structured learning sequences, even those central to its readiness, difficult to pursue. Moreover, because of wide variations in experience and skill among personnel in most units, training managed as in an institutional setting by prescribing hours of instruction within a set curriculum is prone to be too advanced for some members, boringly repetitive for others, and plagued by spotty attendance by all.

Collective training, that directed toward developing teamwork among several individuals performing stressful tasks in common, has not been explored by non-military educators much beyond athletic teams, medical staffs, or commercial airline cockpit crews. The varieties among mature individuals, and the permutations and combinations of experience within casual groupings have led training researchers, civil or military, to focus mainly on institutional training, and on provisional collectives consisting of entry-level trainees, where homogeneity of background, experience, or age enables comparison of different training approaches. Largely unexplored in a scholarly sense is unit training of teams of teams, each consisting of a medley of experience-levels and skills, although this is exactly that training central to readiness for battle. As far as I know, the Army Research Institute has under way only one small project to develop models for predicting the acquisition and retention of collective tasks, in which the observed variables are the task or skill, the training standard to be met, personnel turnover or turbulence, enabling tasks or skills, and time in training.

Collective training in units tends to be precedent encrusted; unit trainers understandably emphasize practical exercises with actual equipment. Even after the U.S. Army issued TES equipment, trainers adhered to conventional instructional method, employing the TES equipment, if at all, merely as an adjunct to conventional field training exercises (FTX).[23] "Realistic" as usual FTX may be regarded, they have distinct limitations as simulations of modern battle, their effectiveness increasingly limited not only by infrequency because of expense, but also by available land and air space, and by concerns over environmental pollution, maneuver damage, and safety.

D. TRAINING COSTS

1. For Institutional Training

When it comes to formulating national policies for raising and training armed forces, the foregoing distinctions are not trivial, especially if austere defense budgets are in prospect, and some or all of the forces must be maintained in a state of readiness for war. Generally speaking, in most countries individual training is better conducted than collective training, and institutional training is more efficient than unit training. Yet, efforts directed at designing more effective training, especially at applying technology to improve it, tend to be focused on individual training in institutions, for military trainers can approach that undertaking with the greatest confidence of pedagogical soundness, of reliable cost figures, and of credible measures of effectiveness. Too, resources allocated for modernizing institutional training in a time of nominal peace are often justified as "seed-corn" investments which will ultimately benefit an entire force in a future war--a specific instance of the difference between setting preparedness for mobilization as the training objective, as opposed to readiness for war. Fixed costs for institutional training proceed from operation and maintenance of buildings and other facilities to support training. Moreover, up until the recent past, advanced training equipment, such as aviation simulators, has been very expensive, and institutions could assure full utilization of costly training devices far better than could a unit, with its conflicting demands on its time and personnel. Since variable costs in institutional training are mainly a function of course length, Curricular Time is a central to cost management. Curricular designers prefer that training proceeds until further

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23 Scott, op. cit.; Roberts-Gray, C., Nichols, J.J., Gray, T., "MILES Integration Support Analysis Phase II," Final Contract Report for the Army Research Institute, Alexandria, VA, 1984, p. 16.

time spent produces disproportionately little advance in learning. Two different curricular approaches might yield, as in Figure 10, quite different curricula, and time-related costs.

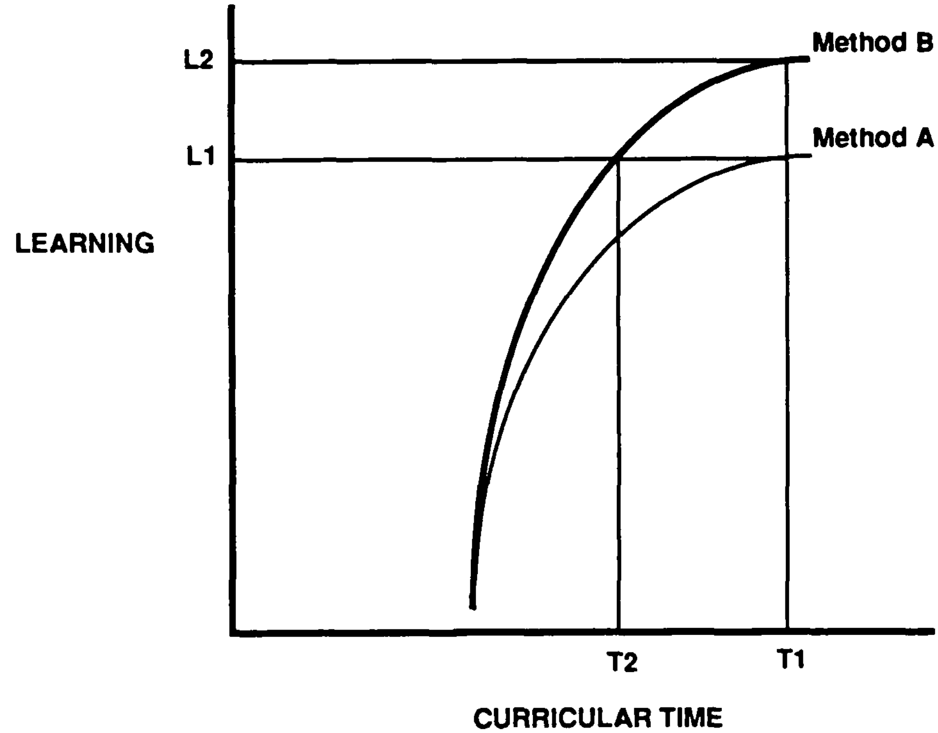

Figure 10. Efficiency in Institutional Training

The construct portrays two training methods. B is demonstrably more efficient than A, but offers a choice between saving time and money--accepting the T2-L1 solution--or opting for the T1-L2 solution, that would provide higher learning per funds invested. Note that there are few incentives for institutional trainers to seek, or to adopt Method B--especially when funds are short, the mere existence of a T2-L1 solution risks a loss of faculty positions and facilities. Often more efficient methods have to be researched outside the faculty, and imposed on the institution.

2. For Unit Training

Most funds allocated for unit training are used for fuel, ammunition, and other consumables to support practical exercises with actual materiel. In the past there were few effective alternatives. While sound procurement policy for weapon systems might have prescribed fielding robust training-subsystems to support individual and collective training in units, pressures on system program managers to keep per-unit costs as low as possible, and on service planners to buy as many weapons as the budget would bear, have usually eventuated in economizing on training subsystems, relying instead on unit trainers somehow to develop proficient users and maintainers of the weapon. Some "non-system" training devices have been developed to upgrade unit training in certain countries, but most recent expenditures for training technology have benefited unit training only indirectly.

Unit training poses choices not unlike those in institutional training, as shown in Figure 11.

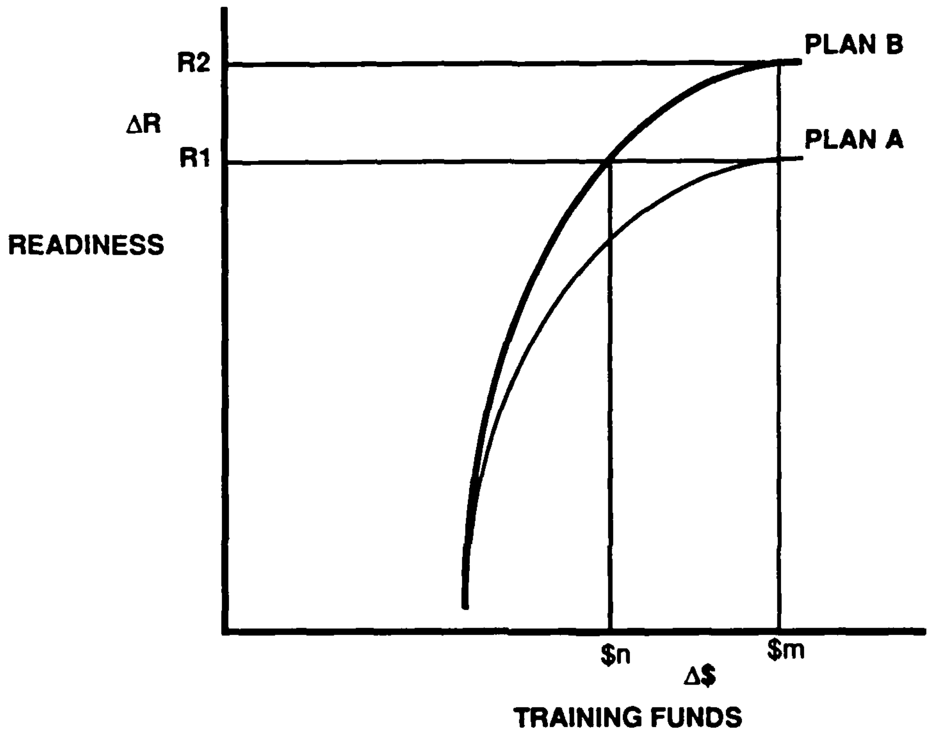

Figure 11. Efficiency in Unit Training

Depicted is a situation in which two different training plans, involving quite different training methods, open prospects for an increase in readiness (ΔR), or a decrease in costs (Δ$). Choice between Plan A and Plan B ought to be made in light of objectives for the training.

E. TRAINING OBJECTIVES

Most U.S. military trainers see their purpose as inculcating readiness for battle. They ought to start, then, from an operationally useful definition of such readiness, and proceed to practicable concepts for achieving same. I hold that battle readiness is a function of three factors: materiel, manpower, and technique. I refer to these as **W** for the in-built effectiveness of weapon systems, **P** for the proficiency of the crews that man and maintain those systems, and **T** for the finesse with which those manned systems are employed in battle--including the tactics, or the weapon system employment techniques of commanders. Readiness for war, R, then is a function of these variables:

$$\mathbf{R} = f(\mathbf{W},\mathbf{P},\mathbf{T}) \quad .$$

Most armed forces devote a very significant amount of resources and command emphasis to **W** variables--that is what "modernization" is all about. It is relatively simple to quantify **W**, and, given funds, to provide for incremental **W** improvements of demonstrated effectiveness: $\Delta\mathbf{W}$. Nonetheless, **W** is but one readiness variable, and there is strong evidence to suggest that often the others dominate.

The **P** factor also has a sizable, if less influential and well-resourced proponency in most forces: the personnel management community, schools and centers, technical documenters, and unit commanders. Most of what is generally understood to be "training," and certainly the mainstay of most evaluations of "training" for readiness, is related to the **P** factor: selecting, training, and manning competently weapon systems within a given unit. Costs for **P** can be fairly well defined, but **P** effectiveness tends to elude sound quantification, being driven by a large number of variables, including time, some of which can not be observed, let alone measured. Most of the furor over the use of simulation vice practical exercises with actual equipment has revolved around use of simulation to improve **P**, and around attempts by zealous accountants to mandate that funds used to purchase simulators for $\Delta\mathbf{P}$ be withdrawn from accounts that support practical exercises, usually by reducing allocations for ammunition or other expendables. In the usual case, trainers face readiness objectives such that they need both the simulators and the practical exercises, and the latter may be the sole provision for $\Delta\mathbf{T}$.

The **T** factor is least well understood, supported, or reported. Yet, any readiness advantage which may accrue from high **W** and/or high **P** can easily be offset by tactical ineptitude. For example, issuing a 3000-meter tank-killing missile system to infantrymen accustomed to thinking about the battlefield in 100-meter increments introduced major perturbations into U.S. Army training two decades ago which have still not been completely overcome. Let me quote from a TRADOC study of ten years ago:[24]

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24 USATRADOC, "Draft Battlefield Development Plan II for the 1986 Army," quoted in Gorman, op. cit., "Training Technology for Modernization," p. 26.

The introduction of new technology into the Army's inventory in the '80s and '90s will occur at a rate unparalleled since World War II. The U.S. Army's ability to achieve the benefits of its modernization will be limited by its ability to train up the force to the potential of fielded systems and to assimilate rapidly changing doctrine and tactics.

Experience derived from fielding the TOW weapon system provides a simplified indication of the complexity and danger of introducing rapidly changing doctrine and technology...The performance capabilities of the TOW were not immediately achieved. The doctrine, tactics, maintenance, soldier and ARTEP manuals lagged years behind the introduction of the system. Our units were simply incapable of rapidly exploiting the advantage of a fielded system...

The challenge is to develop a means to integrate dynamic doctrine and technology rapidly into Army organizations effectively. The components of this challenge include systems, doctrine and tactics, command control and communications, and training of commanders, staffs, crews and organizations...More highly cost-effective training systems are required if the Army is to modernize and maintain a high state of readiness in an era of declining manpower resources and increasingly sophisticated weapon systems...

General J.F.C. Fuller recognized that modernization counts for little, absent cerebral inputs from the commander, when he wrote that "tactics are based on weapon-power and not on the experiences of military history...that commander who first grasps the true trend of any new, or improved weapon will be in a position to surprise the adversary who has not."[25] However, Δ**T** often proves elusive, for military subordination and discipline--societal or cultural imperatives of the profession--militate against recognition of **T** shortfalls, let alone their correction. Effective methods for improving **T** include both costly institutions like the National Training Center, and relatively inexpensive "battle simulations" or "war games," some of which are described below.

Obviously, constrained defense budgets and mandated end-strength ceilings will necessitate downward adjustments of recruitment; force structure; active-reserve component mix; research, development and acquisition; training; procurement of spare parts and munitions; and military construction--any of which could adversely affect readiness. It seems virtually certain that, for most forces in the foreseeable future, incremental improvements via Δ**W** will come slowly and expensively indeed. High **P** might be maintained, but provisions for same will have to contend with severe downward pressures on funds for both institutional and unit training. Institutional cadres and costs per graduate

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[25] Quoted in Department of the Army, Final Draft Training Circular 21-5-7, *Training Management in Battalions*, 31 January 1977, p. 6.

will no doubt be targeted for economies and efficiencies, and unit commanders face reduced allocations for consumables, such as ammunition, replacement parts for vehicles, and fuels, and constraints on flying hours, steaming days, field exercises, and other forms of training which rely on exercising units as they would fight.

Ultimately, training policy must be consistent with national strategy. For the United States, a sensible training policy would provide cost-effectively for ΔP and ΔT, while seeking to find efficiencies which will support at least robust research toward ΔW. Is it reasonable to expect that such a policy can be formulated? I believe that it is, and to show you why, I want to cite certain of my experiences as a division commander, serving in Germany, 1977-1979, a time of severely constrained resources, much like the circumstance I have just described.[26]

[26] The section which follows is drawn largely from the author's paper, op. cit., "Training Technology for Modernization."

IV. THE PATHFINDER EXPERIENCE

In 1977, the U.S. 8th Infantry Division (Mechanized)--the "Pathfinder Division"--had an annual budget of perhaps $20 million dollars or so for operations and maintenance of units sprawled along the Rhein and Nahe Valleys, comprised of over 20,000 soldiers armed with 400 tanks, hundreds of other major weapon systems, and thousands of other vehicles. Budgetary guidance for the years ahead from superior headquarters--V Corps and U.S. Army Europe (USAREUR)--was "zero growth," despite expectations that there would be increased training costs attendant to introduction of modernized weapons, that the dollar would fall relative to the deutsche mark, and that the costs of training expendables would increase steeply. Training the division involved three large annual outlays: (1) railroad transportation to the Seventh Army Training Center near the Czech border--payable in deutsche marks, and therefore vulnerable to exchange fluctuations, (2) diesel fuel for tracked and wheeled vehicles, and (3) training ammunition, of which that for tanks and artillery were the principal elements. Ammunition was not paid for directly by the division out of its own operating funds, but the division managed ammunition expenditures by dollar value to meet explicit "zero growth" strictures from corps and army headquarters. If the Pathfinders were to increase readiness, and insure ΔP and the ΔT commensurate with the full potential of their weapons, those three major outlays would have to be operated upon. The Division would have to devise a Plan B, as depicted above, based on training methods markedly different from those previously pursed, Plan A. But a Plan B entailed obtaining discretionary funds for enabling capital equipment and expendables.

A. THE *BUNDESBAHN* BILL-PAYER

Payments to the *Bundesbahn* for unit movements to the Seventh Army Training Center, Grafenwöhr, were the first, most lucrative target. In fiscal year 1977, the division had paid over $4,400,000 to the railroad to move the equipment of its battalions twice, an average 1600 kilometers per battalion. To generate savings in FY 1978, the number of vehicles moved was cut back, and divisionally supervised pooling at Grafenwöhr of heavy equipment--notably tanks and self-propelled howitzers--was employed. As soon as it could during that year, the division eliminated all but a few shipments to Grafenwöhr, and substituted travel three times each year to a much smaller, but much closer German training area. Rail travel per battalion was reduced to 400 kilometers per battalion on the average, and divisional rail bills for FY 1978 dropped to $1,800,000 (divisional savings were actually larger than $2,600,000 because the division received a compensatory lump sum in dollars, sized to its previous-year foreign currency transactions). The differential was reprogrammed as capitalization of training, that is, for upgrading ways and means of training both at home station, and at the training area.

B. VEHICULAR FUEL

The cost of diesel fuel was also problematic for the Pathfinders. Between fiscal year 1970 and fiscal year 1978, cost of diesel had risen from 12¢ per gallon to 51¢ per gallon, and auguries were for even more dramatic rises. Nonetheless, during FY 1978 many of the rail moves to the German training area were eliminated in favor of marching battalions to the training area over the public highways because diesel costs, though higher per gallon as anticipated, proved somewhat lower than the escalating rail costs. Moreover, since the division's wartime mission entailed deployment over the same roads, the marches contributed to readiness. The training at the smaller training area was carefully managed to control consumption of diesel fuel. At Grafenwöhr, much diesel was consumed in traveling around its dirt perimeter road, moving from one range or maneuver area to another. The division's smaller training area cut back on these portal-to-portal costs, and the training techniques chosen avoided using tracked vehicles as training aids for battalion commanders and senior officers.

C. AMMUNITION FOR TRAINING TANKERS

As the division began revision of its training plan in 1977, it was aware that between fiscal year 1970 and fiscal year 1978, costs of a round of training ammunition for the 105mm. tank gun rose by a factor of 3.3. The division had been advised that the per round cost of tank ammunition would increase further over the following three years by a factor of 2.5, but that its plan could provide for no increase in some $13,000,000 allocated to underwrite its ammunition for armor training (TP-T, TPDS-T). The implication of that guidance was to decrease rounds per tank crew from 180 per annum to 71 per annum. This fiscal guidance ignored both a growing armor threat in the Group of Soviet Forces Germany, and higher standards for tank P established by the same headquarters that prescribed less ammunition to support training. During period FY 1975-1977, USAREUR had substantially increased the standards on its tank gunnery qualification ranges. From fixed targets and single exposures, the standard progressed to engaging moving targets and to multiple targets, to be hit with main gun rounds within twenty seconds. But I knew that the USAREUR standard, demanding though it was, was inadequate for readiness. TRADOC analysts had demonstrated, using a digital model of combat in the Fulda Gap region, that in the usual defensive sector of a U.S. tank company team facing a Soviet breakthrough attack, there would be 60 armored vehicles advancing at 10 kilometers per hour across an average field of fire of 1200 meters, so that the proper criterion for **P** should be that a Company Team engage and defeat 60 advancing targets within 7.3 minutes. TRADOC pointed out to USAREUR that at peak proficiency its tankers were probably capable of gunning down such an attack, but that its evaluations showed that three months after a tank gunnery "season", **P** had degraded, due to transfers from crews and decaying skills, some 25 percent. At that level of proficiency, winning was unlikely. Beginning in FY 1978, USAREUR required annual qualification on a new range for platoon gunnery, Tank Table IX[27] at Grafenwöhr, to emphasize the requirement for fire control and mutual support among tanks, and enjoined frequent practices throughout the year. It happened that the 8th Division was the first of USAREUR to use Table IX in the autumn of 1977, and our tankers were patently not up to it: only 7 percent of our platoons met the new standard. Both to cope with off-season readiness, and with the higher "mark on the wall," Pathfinder tankers needed a new training approach.

Among tank crews, **P** usually proceeds from repetitive firing practice, and is sensitive, *inter alia*, to both *frequency*, the number of firing repetitions per training session, and *periodicity*, the time lapse between sessions, during which **P** tends to decay.[28] But how could the division maintain **P** in the face of drastic cuts in its ammunition allowances? For FY 1978, the Pathfinders negotiated a tradeoff of artillery ammunition for tank rounds, keeping the rounds per tank crew at 100 per year. But this stratagem was coupled with a commitment to invest heavily in subcaliber firing. For tanks, this meant the division's

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27 Tables I-VIII progressively trained a single tank crew. Table IX required teamwork within a platoon of five tanks.

28 General Creighton Abrams once remarked to me that when he commanded the 34th Tank Battalion, 4th Armored Division in 1944 and 1945, he insisted on gunnery practice every two weeks because he found that, even in combat, crew timing and precision dropped off sharply in a matter of days; his practice sessions required his crews to recalibrate sights, refurbish intracrew gunnery procedures, and demonstrate ability to put steel on target within two rounds. For training techniques relevant to the USAREUR environment, see Brown, Maj. Gen, F.J., "The Use of Simulation in Armor Unit Tactical Training," presentation at the NATO Armor School Commanders' Conference, Samur, France, September, 1983. General Brown was one of my Assistant Division Commanders in the 8th Division.

funding manufacture of .50 caliber devices. The division also purchased $300,000 worth of portable, radio-controlled targets to align its tank training ranges with the challenges of Table IX. With these, frequent firing became practical; the devices leveraged upward the utility of available training areas. On the division's next tank shoot on Table IX at Grafenwöhr, 95 percent of its platoons qualified. Pooling of tanks at Grafenwöhr, rather than detracting from crew proficiency, aided standardization of loading plans within the division, and reduced rounds expended for calibration of the sight with the gun tube.

D. TRAINING AMMUNITION FOR ARTILLERYMEN

There was, of course, a substantial amount of thunder and lightening in the division artillery, and rumbles and flashes on the horizon in the direction of corps artillery, over what was perceived as an example of blatant racism, favoring tankers over redlegs. Yet artillery system **P**, like that of the tank, improves as a function of frequency and periodicity of practice. Artillery ammunition costs were also up, a round of 155mm having increased in cost by a factor of 2.8 from FY 1970 to FY 1978, but the per round cost was still only about a quarter the cost of a tank round. The division weathered the storm by offering its artillerymen a Plan A/Plan B shoot-off. Two battalions, both armed with the same 155 mm self-propelled howitzer, would participate in a 12-month test. Battalion A, billeted adjacent to the training area, so that it could fire almost literally from its motor pool, was to follow Plan A_{ARTY}, in which it was to be issued, on demand, all the 155 mm rounds it wanted for service practice. Battalion B, located furthest from the training area, with no opportunity to shoot full caliber except when it traveled to the training area, was to follow Plan B_{ARTY}: it would be allocated 70 percent the number of 155 mm rounds Battalion A received, but would also receive, again on demand, unlimited 14.5 mm subcaliber ammunition, which the division could purchase locally. The subcaliber munition was fired on a 1/10th scale range, so that using it, in effect, converted an unused airfield into an artillery range. At the end of twelve months, both Battalions A and B would be sent to Grafenwöhr, and there undergo shooting trials judged by impartial evaluators, using only 155mm ammunition. Well, of course, serving units can seldom sustain a pristine experiment of that sort, and training proficiencies early demonstrated by Battalion B prompted the Division Artillery Commander to prescribe 14.5mm subcaliber practice for all his units. Nonetheless, the test was carried to completion. Over the 12-month test period, the two competing battalions shot for training the ammunition shown in Figure 12.

In the end-of-year shooting trials at Grafenwöhr, evaluators concluded that both battalions met the readiness standards established by the Army Training and Evaluation Program, noting no significant differences among them in ability to deliver fire on target. They did comment that A handled its ammunition better, and that B's fire direction centers were faster. From the divisional perspective, this experience validated its Plan B_{ARTY}, in that *Battalion B's demonstrated readiness had been achieved with 72 percent of the 155mm ammunition cost for Battalion A*. The Pathfinder's redlegs were converted, and thereafter subcaliber firing became central to their training.

Battalion	155 mm Rounds	14.5 mm Rounds	Total Rounds
A (Full Firing)	4080	2720	6800
B (Constrained)	2880	4320	7200

Figure 12. Competing Battalions--Training Ammunition

E. INFANTRY TRAINING

The 8th Division was nominally an infantry outfit, and because of my upbringing, I interested myself in the effectiveness of infantry training even though it was not so weighty an item in Division budgets as artillery or tank training. I was disinclined to accept prevalent standards. USAREUR rifle ranges provided for the qualification firing prescribed by the U.S. Army in its Basic Rifle Marksmanship (BRM) training program. You may know that in 25 years, 1950 through 1975, the Army went from the M-1 Garand rifle of World War II and Korea, to the M-14 rifle, to the M-16 rifle. I sat on the Army Board which recommended adoption of the M-16, and I can report that one of the reasons we supported that weapon was its putative ease of training, occasioned by its low recoil, and its flat trajectory. Yet, the number of rounds prescribed for training and qualification with the M-16 was eventually raised to more than double the number the Army found adequate for M-1 BRM during the Korean War. Figure 13 presents pertinent data.

I have inferred that the reason that the number of rounds per soldier rose over time was the laudable desire of trainers to assure high P infantrymen for the force. But I knew from experiments TRADOC had conducted that number of rounds fired for qualification has little to do with combat effectiveness. Nor, it turns out, does number of hours of training. Figure 14 summarizes the results of four experimental training programs for 4400 soldiers, all conducted by expert instructors, or varying length, and varying number of rounds.

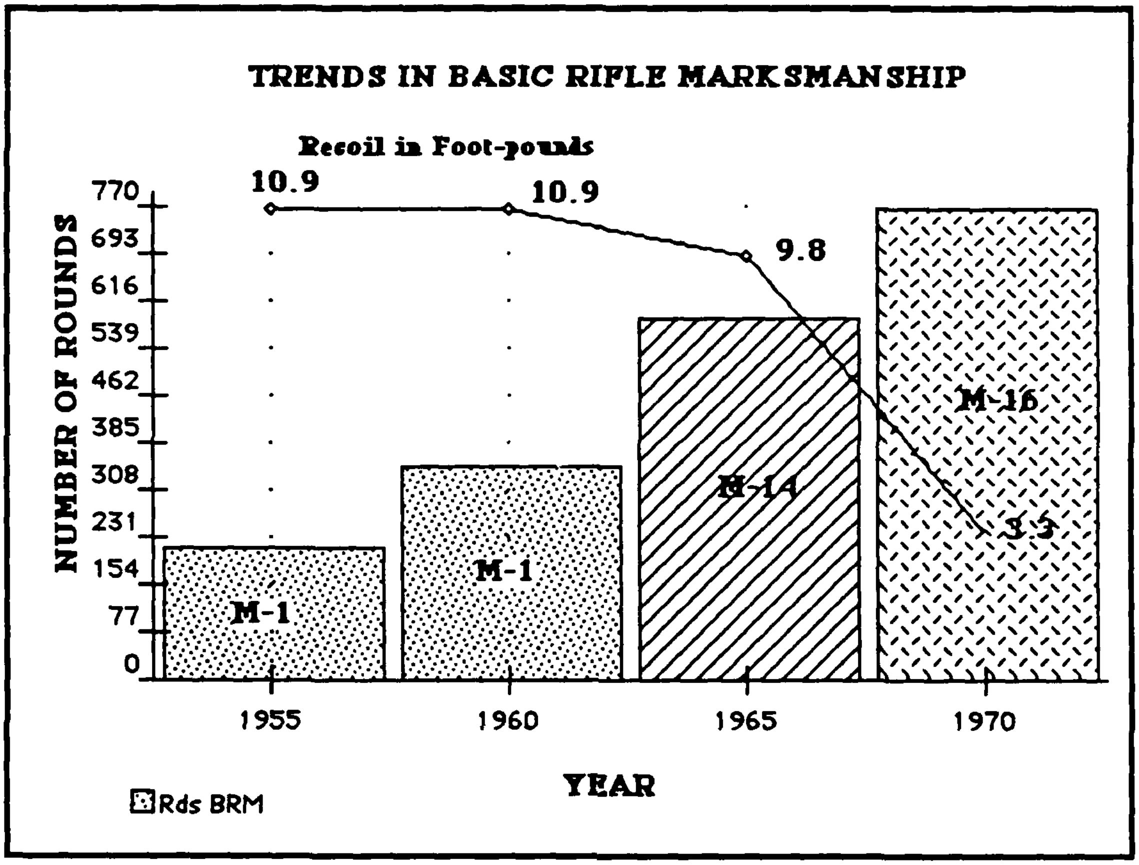

Figure 13. Trends In Basic Rifle Markmanship

Program	Hours	Rounds
Army Standard	72	778
Alternative 1	35	334
Alternative 2	49	262
Alternative 3	62	560

Figure 14. 1976 TRADOC Test of Basic Rifle Markmanship Programs

The difference in annual ammunition costs to TRADOC betv.een the Army Standard Program and the least expensive of the alternatives was $6,000,000 (in then-year dollars). Firing posttests were conducted with soldiers who had successfully qualified under one of the four programs to establish probability of hit on standard pop-up targets at ranges between 50 and 300 meters. The posttests showed *no significant differences* among the four training methods.

As a division commander, my dissatisfaction with the Army Standard Program was not its *costs*, either in money or time, but its *effectiveness*. The evaluation method prescribed was the so-called TRAINFIRE range, in which soldiers as individuals rotated among firing positions at the head of defined lanes. At various distances in each lane a target would be raised by electric levers, exposing a flat, head-shoulder silhouette, the plane of which was presented normal to the firer. The target would remain up for 10-12 seconds, unless hit earlier, and then fall back, but was otherwise static. I knew from tests at the Combat Development Experiment Center (CDEC) that TRAINFIRE provided quite unrealistic training for infantry expected to be in a high state of readiness for combat, in that 90 percent of all targets detected by infantrymen on the battlefield move angularly with respect to the observer. CDEC demonstrated that even soldiers in foxholes typically see and engage targets at angles of 20 degrees or more, that usual target-exposure times were no more than six seconds, and that nonetheless, with modest training, infantry could be trained to improve significantly probability of hit on such moving targets.

I therefore directed that under **Plan B**, Pathfinder infantry would use neither the Army Standard Program, nor TRAINFIRE tasks, conditions and standards, but would instead be trained to criteria which required them with live fire to engage fleeting, moving targets, and to do so as tactical teams. Requisite targets were capitalized, and necessary ammunition was provided via tradeoffs. My purpose went well beyond Marksmanship Badges to the fundamental question of infantry contributions to Pathfinder combat power.

F. IMPROVED READINESS

Regrettably for the purpose of this paper, while the Pathfinders collected some numbers to describe other differences between Plan A and Plan B, divisional records can provide reliable, comparable quantitative data only for the abscissa of the following construct (Figure 15); for the ordinate, usually only qualitative information is available.

The **Plan B** adopted by the division involved a significant departure from its previous training methods, capitalized in large measure by shifting training from a distant training area to a more proximate one, and using the differential in rail costs to capitalize new training techniques; capital investments in **Plan B** totaled more than $2,000,000. Figure 15 identifies costs labeled "Ownership" which represent funds expended on day-to-day maintenance and routine training at home station, constant in both Plans. The "Other Training" bars represent undertakings which cost about the same as what the division had done in previous years, but were qualitatively different. It is not possible to assign numerical values to the Readiness ordinate because readiness is compounded of disparate

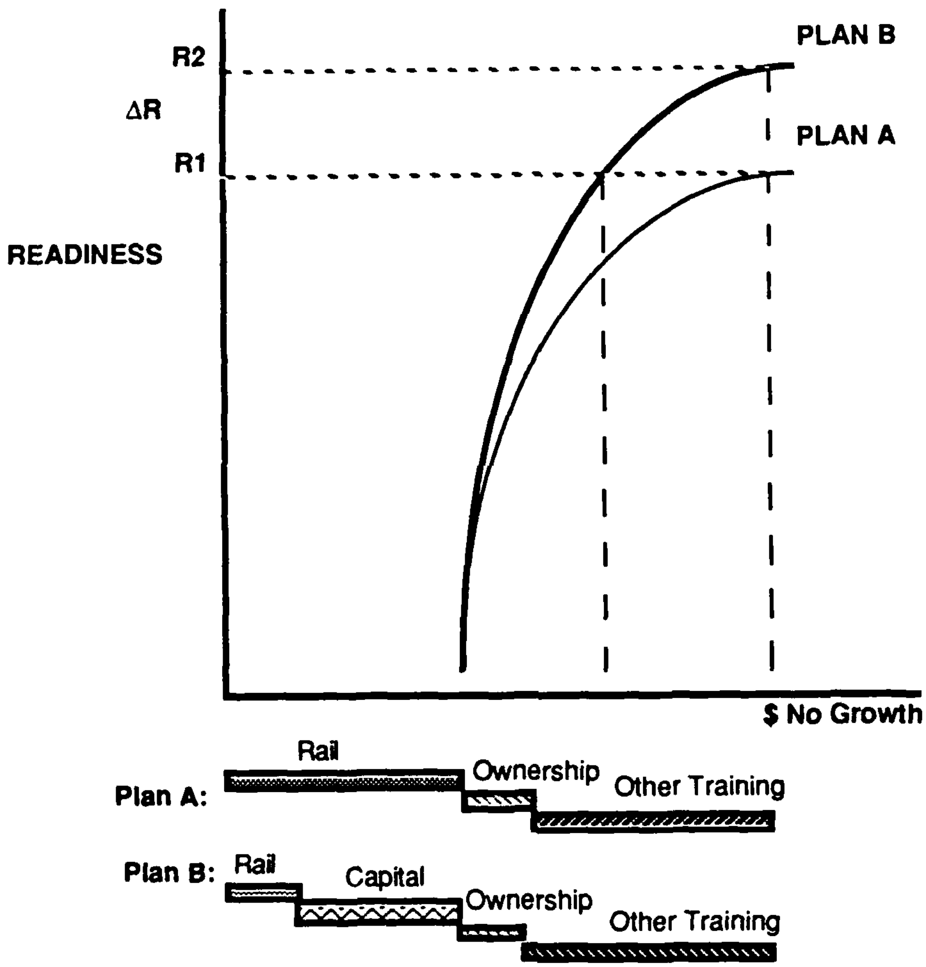

Figure 15. Efficiency in 8th Infantry Division Training

attainments among which no common measures exist. To carry the mathematical analog one step further, a postulated relationship between **R** and Training Funds, **F**, which might be expressed as a multiple regression equation of **R** on **F**:

$$R = a + b_1F_1 + b_iF_i + ... + b_kF_k$$

where a = cost of ownership

b_1 to b_k = regression coefficients, each expressing $\Delta Ri/\Delta Fi$, the marginal change in readiness for each increment of funding, for each task trained or evaluated, distinct from others by reason of locus, training technique, training equipment, or combination of frequency and periodicity. Each such coefficient expresses cost-effectiveness.

The aggregated readiness curves start to rise from a point to the right of the origin in the diagram because rail trips and a warehouse full of training equipment are unavailing for training. The two curves have slopes reflecting $\Delta R/\Delta F$. The upper curve reflects the relative cost-effectiveness of the division's **Plan B.** In the following table, Figure 16, are examples of $\Delta R/\Delta F$ tasks, and "measures of effectiveness" it achieved:

Training Task	Effectiveness
Infantry live-fire exercises.	Marked increase in numbers and difficulty
Adjustment of artillery on moving targets.	Regularly practiced from ground and air
Upload ammunition for war.	Time per battalion reduced 50%
Improve river crossing techniques.	Much better for both Rhein and Main
Increase efficiency road movements.	Accidents down; deployment time 15% less
Increase equipment availability.	OR rates up and climbing
Reduce, expedite tank zero.	Number of rounds down, speed up
Practice tank, artillery gunnery.	Subcaliber firing widely applied frequently
Improve qualification tank crews.	95% platoons qualified per 7th A standards
Improve C^3I at battalion task force/brigade.	Battalion command/staff trained/evaluated
Construction of defensive positions.	Actual strongpoint built; divisional manual
Employ antitank mines effectively.	Repetitive exercises in emplacing mines
Communicate surely, securely.	Directional antennas fabricated, employed

Figure 16. Examples of $\Delta R/\Delta F$ Tasks and Measures of Effectiveness

Note that effectiveness for only three tasks is described by a numerical value, and even these are dubiously useful numbers. The division had three models of tanks, each with a different fire control system, and boresighting/zero was different among them. The division used many portable, radio-controlled targets, so that often firing conditions varied from range to range, day to day; sub-caliber ranges reflected wide differences among local training facilities. Each river crossing tended to be unique, a task performance on which varied widely depending on conditions (e.g., location, bank status, state of the river, weather, available crossing means) so that standards were difficult to articulate, and comparisons largely meaningless; nonetheless, the division and supporting German units felt significantly more confident of their combined abilities after the exercises than before, and interoperability increased throughout them. Uploading ammunition for war was a task the division could time, and repeat task performance under comparable conditions, but the timing improvement reported represents the differential between what the first battalions uploaded achieved and what the last battalions did, there having been between each iteration a substantial amount of training based on lessons learned from earlier evaluations. In the road movement case, accidents reported were compared with vehicular miles on German roads; the latter rose sharply per **Plan B**, so the proportionate decrease in accidents must be interpreted in that light. Moreover, some readiness training tasks were more important than others, but often the more important were those most difficult to measure: ΔP for tank crews and artillery units was relatively easy to measure and to quantify, but how does a commander train for, let alone measure ΔT? To train how to win battles at low cost?

G. ΔT THROUGH BATTLE SIMULATION

The first battle of most wars fought by the Army of the United States was a disaster: a costly defeat or a Pyrrhic victory. One American historian, in a study of ten of these misfortunes, concluded that a fundamental weakness of American arms has been ill-prepared command groups:[29]

> ...More glaring than poorly trained troops as a first-battle problem is the weakness of command and control. Virtually every case study emphasizes the lack of realistic large-scale operational exercises before the first battle, exercises that might have taught commanders and staffs the hard, practical side of their wartime business as even the most basic training introduces it to the soldier at the small-unit level. Virtually every case study indicates that the results of confusion, demoralization, and exhaustion at the command and staff level are at best bloody, at worst irremediable--a more crippling defect even than combat units falling apart, because units can often be relieved and replaced in time, headquarters almost never...
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> ...At least through the First World War, the professional response to the chronic American weakness in command and control was to plan more thoroughly, leaving as little to chance as possible. But thorough planning,

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[29] Shy, J., "First Battles in Retrospect," in Stofft, W., *America's First Battles 1776-1965*, Lawrence, Kansas University Press, 1986, pp. 329-331.

> with its natural de-emphasis on unexpected situations (beyond the scope of contingency plans), led to rigidity and often heavy losses. In other words, the command-and-control weakness and its chosen professional remedy were but two aspects of a single larger problem: inadequate preparation of commanders and staffs for the real world of combat...
>
> ...It is likely that this problem is more acute in America's first battles because the size and structure of the prewar Army, and thus the prewar experience of senior commanders and staff officers are--even today--dictated largely by peacetime needs, not by wartime probabilities. Headquarters in the U.S. Army habitually expend their time and energies on routine administration, seldom pushing training and testing themselves as they push, train, and test their troops. The result too often seems to be that the troops, even when inadequately trained and armed, are readier for war than the men who lead them. The implied lesson is that senior commanders and their staffs might do well to free themselves from the routine busywork of peacetime military life and to plan and carry out frequent, more realistic training exercises for themselves, involving several command levels and arms, that will hone skills that otherwise must be bought with blood and, possibly, defeat...

One exception to this training lacuna occurred after the stunning Prussian victories over the French in 1870. The U.S. Army promptly traded its *kepi* for the *Pickelhaube*, and *Kriegspiel*, or wargaming, gained recognition as a method for training officers for decisionmaking in battle. In 1879, Livermore's *The American Kriegspiel*, an elaborate, map-board, two-sided, manual war game, based on the weapons and tactics of the Civil War, came into use.[30] This game, and its contemporaries, was onerously clumsy. Moreover, as weapons advanced--for instance, the introduction of the breech loading rifle and the machine gun--the Livermore model of war and similar models lost credibility. But the latter nineteenth century seems to have been the only period in which two-sided war games enriched the peacetime training of U.S. Army command groups for battle, at least until the recent past.

In the early 1970s, the U.S. Army Combat Arms Training Board (CATB) launched a revival of battle simulation for training battle staffs, fielding both manual, or map-board simulations, and computer-driven simulations. "Battle simulation" is a term which describes procedures which depict in real time the results of two-sided, free-play encounters of opposing armed forces. Typically, actual forces are not employed, and the simulation is focused on decision-prompting events, inducing combat-like circumstance for command groups. The term sometimes fits the rubric of "command post exercises"

[30] Cf., Perla, Peter P., *The Art of Wargaming*, United States Naval Institute, Annapolis, MD, 1990, pp. 54-59.

(CPX), yet it is important to note that the terms are not necessarily synonymous, in that the conventional CPX is neither two-sided, nor free-play. Battle simulation can involve exercises on terrain, perhaps using just leaders, command groups, or skeletal forces.

By 1976, CATB's prototype board games were in use in institutional and unit training, and its prototype computer game, the Combined Arms Tactical Training Simulator (CATTS), was being used for training evaluations of line battalion command groups at USAC&GSC. In 1977, a USAC&GSC-developed board simulation, FIRST BATTLE, supported the V Corps portion of the annual REFORGER exercise in Europe. The following summer, as part of its **Plan B**, the 8th Infantry Division incorporated another USAC&GSC battle simulation, PEGASUS, into field exercise CARDINAL POINT II, to support a brigade-level, hybrid battle simulation, conducted in part on terrain, and in part on a map-board. The design of the battle simulation portion of the FTX was an outgrowth of Project FORGE, conducted at the United States Army Infantry School from 1968-1971,[31] and FORGE's lineal descendant, CATTS, which was used first at the Infantry School and later at USAC&GSC. Moreover, CARDINAL POINT II employed multi-echelon training, seeking to challenge simultaneously both the officers responsible for battalion-level tactical performance through battle simulation, and leaders and soldiers in platoons through small-unit practical exercises which required them to move, shoot, and communicate.

General "Ace" Collins, one of the modern Army's noted trainers, held that

> ...in a maneuver, or field-training exercise (FTX), which is the normal form of large-unit training, the higher the level of the participating units, the poorer the performance of the small units. Exceptions to this generalization are rare. Research indicates that this has been a consistent criticism of large-unit training since the Louisiana Maneuvers in 1941...Over the years, observing exercises has led me to the following rule of thumb: the benefits of a field-training exercise extend to units two levels below the highest headquarters participating.[32]

Collins believed that a brigade-level field exercise could provide meaningful training only for battalion and company commanders, and urged that the "real key to successful training" was emphasis on individual and small-unit performance. He noted that the training of the

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31 Olmstead, J.A., Christensen, H.E., and Lackey, L.L., *Components of Organizational Competence: Test of a Conceptual Framework*, Alexandria, VA, Human Resources Research Organization, Technical Report 73-19, August 1973. The author became Assistant Commandant at the Infantry School shortly after Project FORGE concluded, and was instrumental in launching its successor, CATTS.

32 Collins, Lt. Gen. Arthur S., Jr., *Common Sense Training*, Presidio Press, San Rafael, CA, 1978, pp. 146-147.

World War II German Army had "emphasized small-unit training and was done for the most part near home *Kaserne* (barracks)." But the Germans did not neglect the training of commanders and battle staffs either, and Collins also advocated command-post exercises (CPX) and what he termed "reduced-distance exercises" for battalion and brigade commanders, remarking that "these forms of training can be done without the cost and loss of troop time involved in large-unit field training exercises."[33]

CARDINAL POINT II (CPII) encompassed the 8th Division's FY 1978 **Plan B** training evaluations, and took place during the summer of 1978, largely on "maneuver rights" land surrounding a German training area within the division's garrison region, but using the ranges of the latter. (General Collins did not observe Cardinal Point II, but he probably would have endorsed its structure.) Seven sequential evaluated Field Training Exercises (FTX) took place, each extending day and night over ten days, each for a brigade of two battalion Task Forces--one tank battalion and one infantry battalion, cross-reinforced. To exercise the division's organizational flexibility, the brigade headquarters deployed was usually one other than that to which the battalions were attached in garrison. Division controller teams aided the brigade in portraying the tactical situation, assuring safety, and conducting evaluations. The sequence of key events for CPII is shown in Fig. 17.

On Day 1, the unit was required to upload a wartime issue of ammunition, represented by boxes of appropriate cube and weight. Then followed three operational phases: rehearsal of wartime deployment and exercises in tactical troop leading, evaluations of combat proficiency, and further exercises in movement. Ordered "forward," the battalions had to cross a major river, and march by road to an assembly area, cross reinforce, and then move into position on unfamiliar terrain for two days of occupying successive positions for defense and delay. Figure 18 portrays the second phase, a four-day period in which the two Task Forces were divided among three different activities: (1) a battle simulation for the two Task Force command groups and their company team commanders, conducted under control of a brigade commander; (2) an extensive evaluation of small-unit training, a series of platoon exercises at 20 different locations using both live fire and TES; and (3) a FTX for a company team actually constructing a strong point. In the third phase, units returned to garrison under orders which stressed cohesion and teamwork.

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33 Ibid.

Day	Tasks
1	Alert Upload as for war Precombat Inspection* Movement (by road) to forward assembly area Form combined arms task forces Receive order; troop leading procedures*
2 and 3	Conduct two-day field exercise in defense* Occupy successive positions* Plan fires and maneuver* Maintain security* One Company Team selected to construct strongpoint*
4 through 7	For Task Force Commanders, staffs, and Company Team Commanders: Hybrid battle simulation, 4 battles* For platoons, sections, and TF support elements: FTX, live fire and TES* Company Team at strongpoint continues construction*
8	Reassemble battalions; maintenance Leaders critique strongpoint*
9	Officers conduct cross-country navigation exercise* NCOs march battalions to home station After-operation maintenance
10	Post-exercise inspection*

* Divisional evaluation

Figure 17. Sequence of Key Events for Cardinal Point II

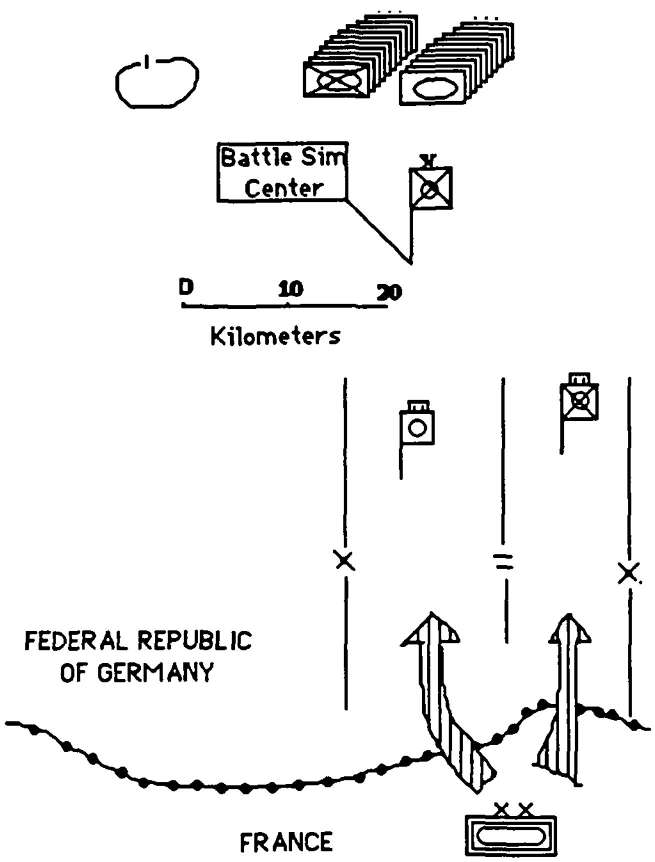

Figure 18. Battle Simulation Phase of CARDINAL POINT II

The battle simulation phase extended continuously for 96 hours, based on a scenario in which an OPFOR division drives north out of France toward the brigade, that has taken up position as covering force for the division. Four battles then ensue, a defense against a hasty OPFOR attack, then a defense against a deliberate OPFOR attack, followed by U.S. reinforcement, a counterattack, and pursuit. The exercise combined use of actual terrain with notional forces on a congruent map board, represented down to individual armor-antiarmor and indirect fire weapons, headquarters, and logistic elements. OPFOR were controlled by a team of officers from division intelligence, and friendly elements were handled by the Company team commanders, according to the orders they received from their Task Force commanding group. Combat outcomes were determined using a division-modified version of PEGASUS. Task Force command posts deployed within their assigned zone and displaced realistically, fully camouflaged as they would be in wartime, all radio nets operational. Within each command post there was one specially trained officer-observer, whose task it was to note intra-staff transactions.[34]

Pre-battle troop leading, including reconnaissance, took place on the ground, but when the company team commanders had received their orders and completed their reconnaissance, they, together with personnel representing the Combat Trains for logistical inputs, were flown to the Battle Simulation Center where they arrayed elements of their commands, weapon system by weapon system, on a 1:10,000 game board. Thereafter, they "fought" a free-play battle against OPFOR. The team commanders were linked to their Task Force command post by radio, reported developments in the situation to the command group, and reacted to its orders. Some Task Force commanders went forward to confer face to face with one or more of their Team commanders during battle, in which case the latter left the board, and flew to rendezvous on the ground.

The timing of battles was left to the Brigade Commander in his role as Exercise Director. Clock time usually equaled exercise time, but the Exercise Director (Brigade Commander) could at will advance the situation rapidly. He was allowed to halt action, and even direct a restart if he chose to do so in the interests of more effective training. Moreover, the battles were designed to be of unequal intensity and difficulty for the participants. The controllers themselves rated the first battle the least demanding of the Task Forces, and the third battle the hardest; following are indices of controller-assigned difficulty:

Battle 1: 1.00 **Battle 2**: 1.44 **Battle 3:** 1.73 **Battle 4:** 1.29

Incorporated in the exercise were a number of U.S. weapons which the division expected to receive in the year ahead, but with which none of the command groups had previous experience: e.g., artillery-delivered mines, and thermal sights for tanks, for anti-armor weapons, and for artillery forward observers. In some instances, command groups had to school themselves on the characteristics and employment possibilities of these novelties, just as they might were the unit to receive a newly-fielded system amid an actual battle. (We considered, but rejected in the interests of other training goals, injecting into

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34 Olmstead, J.A., Elder, B.L., and Forsyth, J.M., *Organizational Process and Combat Readiness: Feasibility of Training Organizational Effectiveness Staff officers to Assess Command Group Performance*, Human Resources Research Organization, Alexandria, VA, IR-ED-78-13, 1978. Cf., Barber, H.F., and Kaplan, I.T., *Battalion Command Group Performance in Simulated Combat*, ARI Technical Paper 353, March, 1979; Barber & Kaplan, *Training Battalion Command Groups in Simulated Combat: Identification and Measurement of Critical Performances*, ARI Technical Paper 376, June 1979.

the simulation an OPFOR Weapon X, unknown equipment like a new armor suite for their main battle tanks, to probe whether the U.S. forces could detect and counter the new materiel.)

After each battle, play was suspended and an after action review was conducted. The Brigade Commander led a discussion for all participants, including the board controllers, asking what went operationally right or wrong in the course of the action. Then the officer-observer who had been in the Task Force command post privately briefed his Task Force commander on his observations of the functioning of the command group. Time was also made available to the Task Force to concert plans for improving their performance on the next battle.

Improve they did. A fairly elaborate evaluation organization was in place to record changes in the performance of each participating command group, supervised by a team of scientists from the US Army Research Institute for the Behavioral and Social Sciences (ARI), and the Human Resources Research Organization (HumRRO). These adopted two independent measures of effectiveness (M.E.): one was a military scale (Military M.E.) which rated effectiveness in terms of mission accomplishment, ground area controlled, resources remaining at battle end, and force exchange ratios; the second was an "*organizational effectiveness*" scale (OE M.E.) which rated the process, or interpersonal relations, within the command group in terms of reality testing (sensing, communicating information, and ability to learn from success/failure to modify the process), adaptability (decision-making, coping with changes in the situation, and transmitting decisions, orders, and other implementing directions), and integration (actions to compensate for disruptions in the process, or to stabilize it). By both M.E., and according to recorded judgments of interviewed participants, effectiveness advanced significantly throughout the four days, from battle to battle. The data were internally consistent: the scores using Military M.E. correlated well with scores using OE M.E., and both moved upwards as the exercise progressed. "Learning curves" were recognizable, and these had evidently not yet reached the point of diminishing return: a fifth battle would probably have produced further improvements. In reporting on outcomes, the battalion command groups, not otherwise identified, were divided into six upper-half performers, and six lower-half performers, using the OE M.E. Figure 19 shows these results.

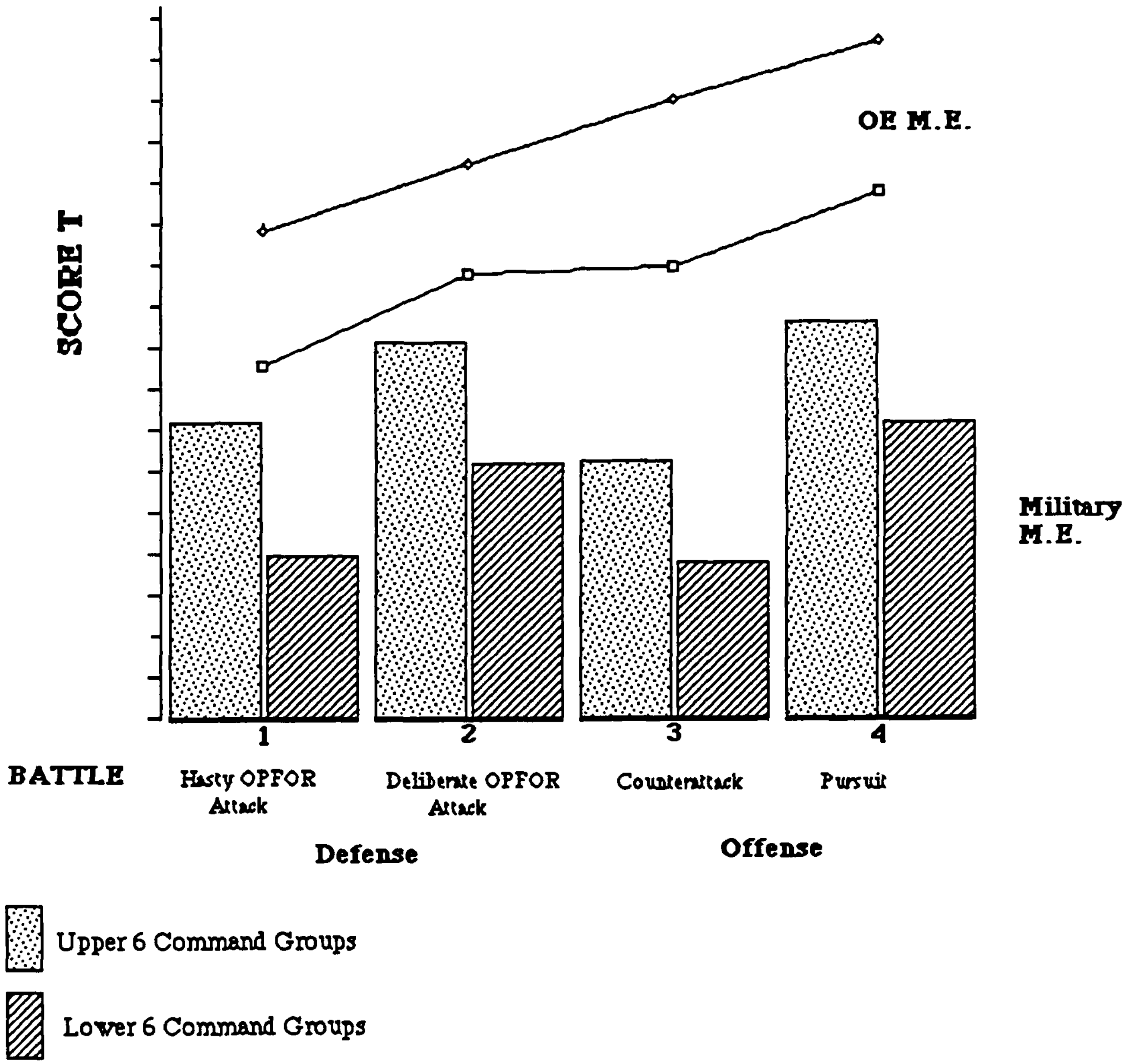

Figure 19. Cardinal Point II Battle Simulation Evaluations

These outcomes occasioned some surprise among the command groups at brigade and division. In the first place, all the participating battalions had known for at least six months what tasks, conditions, and standards would figure in CARDINAL POINT II.[35] While there were differences among them in organization and equipment, they were all

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35 Letter, Headquarters, 8th Infantry Division, 9 January 1978, "78 Divisional Evaluations per ARTEP 71-2--CARDINAL POINT II." The name derives from this notion: "...will serve to orient our professional compasses both over the next six months as we prepare for it, and afterwards, when we can address diagnosed weaknesses in our FY79 training."

well-practiced in cross-reinforcing, in training and operating as Task Forces, and in exploiting the potential of each weapon system in the division. Brigade and division both reported them all as having the same high rating in readiness reports. Moreover, all twelve battalion commanders had been selected for their assignment by a Department of the Army Command Selection Board, and their records showed them to be remarkably alike in age, experience, schooling, and previous efficiency ratings. But during the CARDINAL POINT II Battle Simulation, marked differences became evident among those commanders in their ability to lead in battle, and in the effectiveness of their command groups, differences which can fairly be said to reflect T.

The scores of battalion command groups for Battle 1, before the first after action review, and before opportunity to rectify egregious error and omission, probably fairly depicts their state of readiness as they entered the exercise. The OE M.E. improved fairly steadily from Battle 1 through Battle 4, but the Military M.E. regressed between Battle 2 and Battle 3 as the mission shifted from defense to offense--understandably, since offense had theretofore received little emphasis in divisional training overall. The change in scores from Battle 1 through Battle 4, reflecting experiential learning, cumulative feedback and rectification, measures the overall ΔT from the four days of battle simulation. Figure 20 summarizes these results by dividing scores for Battle 4 by those for Battle 1.

Military M.E.	Upper Half	1.35
	Lower Half	1.82
OE M.E.	Upper Half	1.94
	Lower Half	3.68

Figure 20. ΔT as Factor Battle 4 ÷ Battle 1

Except for the command groups rated by the Military M.E. in the upper half, all ratings show an approximate *doubling of effectiveness*. Gains in effectiveness, whether measured by the Military or the OE M.E., were much more pronounced for the less effective performers. Nonetheless, the spread among the participants remained significant; as Figure 21 shows, "lower half" command groups finished Battle 4 about where "upper half" command groups finished Battle 1.

The largest measured differences among command groups were Military M.E. ratings on Mission Accomplishment, Area Controlled, and Force Exchange Ratio, all performances central to successful implementation of U.S. Army doctrine for winning in battle against foes superior in numbers. Command Groups that were rated high by organizational effectiveness measures (OE M.E.), performed well by operational measures (Military M.E.). Being enabled thus to perceive differences in effectiveness among these command groups was, in itself, a signal contribution to the readiness of the division, informing its commanders where and how to act to ameliorate T in subsequent training.

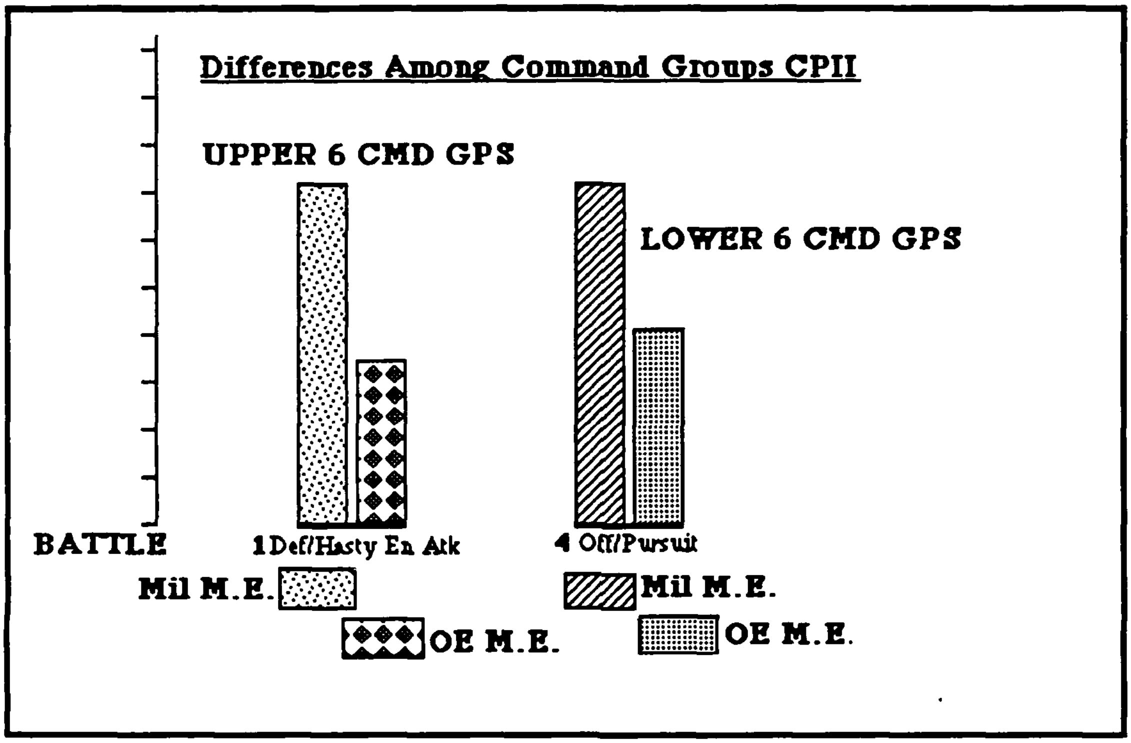

Figure 21. Differences Among Command Groups CPII

I personally had expected the battle simulation to show significant differences in effectiveness among my battalion commanders and their staffs. At TRADOC, I had seen reports from over forty battalion command groups of battalions stationed in the United States evaluated by the Combined Arms Tactical Training Simulator (CATTS) at at the U.S. Army Command and General Staff College (USAC&GSC), among whom there had been a substantial spread in effectiveness. One of the statistics I used to cite from that era compared a "qualified command group" with an "unqualified command group" (those labels were my own, not used by the CATTS controllers or USAC&GSC), both of whom chanced to encounter the same size enemy force on identical terrain. In both instances, the OPFOR had a 4:1 advantage in numbers. The "qualified command group" led its unit to victory in the ensuing battle, emerging with 22 tanks after cutting the OPFOR down to 12;

the "unqualified command group" in very similar circumstances found itself withdrawing with just 5 remaining tanks, pressed hard by 35 OPFOR tanks.[36] In CARDINAL POINT II, I was the only officer in the Division privy to all unit identifications and ratings. I must confess that I was surprised to find among the lower six command groups one commander I had theretofore regarded highly, and one other commander in the upper six whom I had expected to manifest grave difficulties. In the first instance I had been misled by the commander's personal brilliance and persuasiveness; he had simply not formed a team within his command group, and found that he could not carry prolonged action on his own shoulders. In the second, a competent staff carried along a plodder, and his team performed along with the very best. Again, the evaluation of effectiveness was of utility to me as I modified plans for training their respective brigades thereafter.

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[36] Gorman, op.cit., "Trends in the Army Training System," pp. 28-29.

V. A LAST BATTLE

A. BREAKTHROUGH AT DAWN

Fort Irwin, California, mid-August, 1990. I had been driven in greying darkness over miles of rocky trails, across a pool of CS[37] gas, up onto a barren promontory centered in a broad valley. To the flanks and front, scores of flickering lights marked vehicles destroyed, OPFOR and U.S., in reconnaissance/counter-reconnaissance skirmishing which presaged a major OPFOR attack. As the rising orange-red sun grazed the escarpments to the east, OPFOR vehicles drove hard out of the shadows toward the left flank of the U.S. position, laying smoke. I could just discern behind the lead smokers two columns of OPFOR armor--surely more than fifty tracked vehicles--advancing at top speed, but as the desert warmed, the smoke clouds rose, became back-lighted, and hid the formation behind a roseate screen.

The U.S. plan had anchored the defense of an infantry-heavy battalion Task Force on the hill on which I stood. OPFOR was storming past most of the Task Force, to fall in force on its left flank company team, somewhat less than a third of its combat power. But anticipating this move, brigade had concentrated to the left flank Team's front all available Copperhead[38] fires, and had positioned both a laser-designator team in a ground OP, and an airborne laser-designator to cover a "fire sack" there. On came the enemy, directly into the fire sack--the plan had worked!

But wait. The Task Force commander hustled by afoot, his vehicle shot out from under him, looking for another from which to command. No Copperheads were fired--not at the plainly visible lead smokers, nor at the columns behind them. There were no fires at all in the fire sack. The full weight of the OPFOR assault fell on the M-1s and Bradleys of the left flank Team. The Team commander there called frantically for reinforcement. On the radio nets, easily discernible over OPFOR jamming, there arose the shrill cacophony of impending tactical disaster. At last word came from higher to unstring the reserve. Out

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37 A riot-control chemical used at the NTC to simulate lethal agents.

38 Copperhead is an artillery-launched, tank-killing, guided projectile which homes on laser reflections from a target, typically from the beam of a laser designator in the hands of a forward observer.

from cover behind the hill, boiling dust at high-speed, charged a platoon of M-1 tanks, a gesture as colorful as it was futile. Too late to help defend, too vulnerable, exposed and moving, too few, the tanks were hit almost all at once by the concentrated fires of the OPFOR assault echelon. In less time than it took me to drink half a cup of coffee, the OPFOR mass had ground through the last U.S. position, and follow-on columns were streaking onward up the valley toward the brigade's artillery and trains. Breakthrough!

Afterwards I was told by controllers that the ground laser-designator team, exhausted by the effort to position and conceal itself, had fallen asleep, and that the airborne designator had failed accurately to initialize his equipment, so that the Copperhead system could not function at all. The battalion commander was temporarily off the radio nets while he sought another vehicle, and there was in any event much confusion thereon. But whatever the reason, the order directing movement of armor to bolster the left flank was issued too late, and eventuated in the desperate headlong dash into a frontal meeting engagement at 10:1 odds.[39]

Almost at once the after action reviews got under way. On the battleground there started, under polite and respectful questioning of the controllers, from platoon level on up, inquiry into what went wrong and why, and how to put together a less brittle defense that could have held. I was driven down to listen to the sergeant-controller who had been with the reserve tank platoon in its futile headlong charge from behind the hill.

B. A MOMENT OF TRUTH

> ...It is interesting to know: the disposition taken to meet the enemy or the order to march toward them. What becomes of this disposition or this march order under the isolated or combined incidents of terrain and the approach of danger? Is this order changed or is it continued in force when approaching the enemy? What becomes of it upon arriving within the range of the guns...? At what distance is a voluntary or an ordered disposition taken before starting operations for commencing fire, for charging or both? How did the fight start? How about the firing? How did the men adapt themselves? (This may be learned from the results: so many bullets fired, so many men shot down--when such data are available.) How was the charge made?..At that moment, if the control is escaping from the leader's hands, has it no longer been possible to exercise it? At what instant has this

[39] Seymour Deitchman of IDA, in commenting on a draft of this paper, observed that "there is a lesson here about a high-tech army having to provide back-ups and cross-checks to make sure that the high tech works as planned. Isn't this a crucial part of ΔT? The battalion commander should have prepared for the contingencies on which his battalion's life depended."

control escaped from the battalion commander? When from the captain, the section leader, the squad leader? ...[40]

I have quoted, of course, not the NTC sergeant-controller--although I heard him ask the assembled platoon virtually the same questions--but Colonel Ardant du Picq, killed in action against the Prussians leading the 10th Regiment of the Line near Metz in mid-August 1870. I strongly suspect that du Picq would endorse TES, the training methods of the NTC, and other training which emphasizes after action reviews. That military thinker wrote that:

> The smallest detail, taken from an actual incident in war, is more instructive for me, a soldier, than all the Thiers and Jominis in the world. They speak, no doubt for the heads of states and armies, but they never show me what I wish to know--a battalion, a company, a squad in action...All these details in a word, enlighten either the material or the moral side of the action, and enable it to be visualized. Certainly one cannot obtain all the details of the same incident. But from a series of true accounts there should emanate an ensemble of characteristic details which in themselves are very apt to show in a striking, irrefutable way what was necessarily and forcibly taking place at such and such a moment of an action in war. Take the estimate of the soldier obtained in this manner to serve at the base for what might possibly be a rational method of fighting. It will put us on guard against *a priori* and pedantic school methods. Whoever has seen, turns to a method based on his knowledge, his personal experience as a soldier....

Brigadier General S.L.A. Marshall believed, like du Picq, that the ground-truths of war were to be found down where the fight is joined. Of effectiveness in military training, SLAM wrote this:[41]

> ...Kant has said: "What one learns the most fixedly and remembers the best is what one learns more or less by oneself." To square training with the reality of war it becomes a necessary part of the young officer's mental equipment for training to instill in him the full realization that in combat many things can and will go wrong without its being anyone's fault in particular. The problem of command in battle is ever to establish a safe margin that will allow for such misadventures. But this much is certain--that there is no system of safeguards known to man that can fully eliminate the consequences of accident or mischance in battle. Hence the only final protection is the resiliency and courage of the commander and his subordinates. It therefore follows that the far object of a training system is to prepare the combat officer mentally so that he can cope with the unusual and the unexpected as if it were the altogether normal and give him poise in a situation where all else is in disequilibrium. But how to do it? I would say that the beginning lies in a system of schooling which puts the emphasis

40 du Picq, Col. Ardant, *Battle Studies*, Military Service Publishing Company, 1958, pp. 5-8.

41 Marshall, S.L.A., *Men Against Fire*, Morrow, New York, 1964, pp. 116-117.

> on teaching soldiers *how* to think rather than *what* to think...The test of fitness of command is the ability to think clearly in the face of unexpected contingency or opportunity. Improvisation is the essence of initiative in all combat just as initiative is the outward showing of the power of decision....

The small defeat I witnessed in the desert was designed to ready participants for other fields, other days, to season them, to teach them how to foil enemies of the Republic, and to husband American combat strength in materiel and soldiers. Will it?

C. WORTHWHILE FRICTION?

Confronting a question such as the foregoing, a militarily educated person, such as the author, is inclined to reach for his volume of Clausewitz. Of course, one can find a relevant passage:[42]

> ...We have identified danger, physical exertion, intelligence, and friction as the elements that coalesce to form the atmosphere of war, and turn it into an activity that impedes activity. In their restrictive efforts they can be grouped into a single concept of general friction. Is there any lubricant that will reduce this abrasion? Only one, and a commander and his army will not always have it available: combat experience.
>
> ...In war the experienced soldier reacts in the same way as the human eye does in the dark: the pupil expands to admit what little light there is, discerning objects by degrees, and finally seeing them indistinctly. By contrast, the novice is plunged into the deepest night.
>
> No general can accustom an army to war. Peacetime maneuvers are a feeble substitute for the real thing; but even they can give an army an advantage over others whose training is confined to routine, mechanical drill. To plan maneuvers so that some of the elements of friction are involved, which will train officers' judgment, common sense and resolution is far more worthwhile than inexperienced people might think. It is immensely important that no soldier, whatever his rank, should wait for war to expose him to those aspects of active service that amaze and confuse him when he first comes across them. This is true even of physical effort. Exertions must be practiced, and the mind must be made even more familiar with them than the body. When exceptional efforts are required of him in war, the recruit is apt to think that they result from mistakes, miscalculations, and confusion at the top. In consequence his morale is doubly depressed. If maneuvers prepare him for exertions, this will not occur...

For the United States Army, the analytical question comes down to just how good are TES, our battle simulations, our instrumented ranges, and our other simulations of war, as surrogates for actual battle? Note that the data I have presented thus far on training

[42] von Clausewitz, Carl, *On War*, Howard, M., and Paret, P., ed. & trans., Princeton, 1976, p. 122.

effectiveness is comparative, that is, it states effectiveness as a differential between one state of training and another. Some anecdotal connections have been made between the training methods described and actual war. Naval aviators have attributed their success in Vietnam to TOP GUN, and both generals and Congressmen have told me that JUST CAUSE, the recent operation in Panama, fully justified whatever the National Training Center had cost the Army. TRADOC in my era often used models of war, or simulations of war, to prescribe training standards, but TRADOC knew, perhaps better than most, that its models and simulations were pale representations of war itself. There is no analysis that I know of which will resolve the central doubts about the validity of present simulations, or indeed of any training methods, other than actual battle.

Always I bear in mind du Picq's warning:[43]

> It often happens that those who discuss war, taking the weapon for the starting point, assume unhesitatingly that the man called to serve it will always use it as contemplated and ordered by the regulations. But such a being, throwing off his variable nature to become an impassive pawn, an abstract unit in the combinations of battle is a creature born of the musings of the library, and not a real man...the human heart, to quote Marshal de Saxe, is then the starting point for all matters pertaining to war. We shall learn...to distrust mathematics and material dynamics as applied to battle principles. We shall learn to beware of the illusions drawn from the range *and the maneuver field. There, experience is with the calm,* settled, unfatigued, attentive, obedient soldier, with an intelligent and tractable man-instrument, and not with the nervous, easily-swayed, troubled, distrait, excited restless being, not even under self-control, who is the fighting man from general to private...(1868)

Still, military professionals must do what they can in time of peace to prepare for war--if for no other reason, *"Si vis pacem, bellum parate."* I believe that in the latter part of the 20th century, the U.S. Army began to restore to its military training some of the battle realism and belligerent pertinency which dwindled with the advent of modern weaponry. The training methods central to this progress, such as TES, were not welcomed by many traditional trainers in my Army; I think it is fair to say that those methods are still on trial, still unproven in the eyes of some. Tests, analyses, and my own experience convinced me. I came to believe firmly in training which efficiently produces both ΔP and ΔT.

I have no doubt that it is possible, with appropriate training method, to *double* the combat effectiveness of land combat units. Capitalization of improved training methods will usually be necessary, but funding better unit training deserves to be considered with all

[43] du Picq, op.cit., pp. 39-41, quoted in Training Circular 21-5-7, op.cit., p. 8.

other budgetary goals, not addressed exclusively through trade-offs within training accounts, precisely because it can produce significantly higher readiness for combat, which ought to be the ultimate objective of all expenditures. In some instances, higher readiness can be achieved without significant added costs. But I hasten to note that high-gain training, where a doubling would occur, is more likely in a relatively untrained unit than one already at high readiness. I entertain some skepticism toward analyses predicated on optimization of one, or even several $\Delta \mathbf{P_n}$, for land forces ought to train to fight as combined arms, and the records of recent wars underscore the hazards of reliance on one weapon system, or one arm. Robustness and redundancy should surely figure in training policy no less than in battle. And I would be quite hesitant to infer high $\Delta \mathbf{P}$, crew proficiency with a given weapon, from data, such as emerges from TES, which is probably largely reflective of ΔT--tactics, technique, and leadership.

Much more scholarly, and persuasive, observations have been presented on the matters upon which I have touched.[44] There are surely analyses patently more germane to decisions on allocation of national resources, particularly decisions on capital investments for training--whether or not to buy certain aids to training. Yet, were I still in a position to influence such decisions, I would reinforce the success of the methods I have described, and capitalize improvements upon them. For example, Tactical Engagement Simulation, even as it is practiced at the National Training Center, is not a mature training technology; I believe it to be superior to other methods, but it can and should be significantly improved.

[44] e.g., Orlansky, Dr. Jesse, ed., op. cit.