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File Folder NEW TECHNOLOGY FOR LAND WARFARE: SOME OBSERVATIONS ON SOVIET AND US APPLICATION OF PRECISION WEAPONS AND AUTOMATION, OCTOBER 1980 (3 of 4) **FOIA** F00-089

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6082 REPORT	PUBLISHED REPORT ("A RAND NOTE") OF A STUDY BY RAND CORPORATION FOR THE OFFICE OF THE SECRETARY OF DEFENSE, P. 69-109 PAR 12/29/2010 F2000-089/1	164	10/1/1980	B1

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1970s are given credit for a 50 percent hit probability against a standing tank at a range of 1500 meters by firing only one round, whereas a World War II tank required 13 rounds and a Korean War tank, 3 rounds.⁽²²⁾ While such claims of effectiveness are quite inflated over what would occur in actual combat, they do represent highly significant improvements in the potential firepower of missiles and tank guns, with intensely lethal combat such as occurred in periods of the 1973 Middle East War a real possibility.

Killing armored vehicles has become such a principal MOE for new equipment that each branch of the service has had to respond. Much of the justification for the development of the Copperhead antitank missile for artillery was the possibility that for the first time artillery fire could be accurate and lethal enough to kill armored vehicles with a reasonable probability (compared to the ineffectiveness of conventional high explosive rounds). The role of artillery in armored warfare has presented a dilemma, since its greatest effectiveness in the past has been in inflicting casualties on unprotected troops, whereas the Soviets operate primarily from vehicles. Although it has had a role in *suppressing* armored operations by restricting tank commanders from viewing the battle and disrupting tank movement, such effects have not been accounted for systematically and are viewed as being ineffective and weak compared to being able to destroy the tanks. In the 1973 Middle East War artillery was used extensively for suppression. Moreover, artillery fire stripped the external equipment from tanks, including searchlights and machine guns. Israeli tank commanders suffered high casualties because they needed to expose themselves to infantry and artillery fire in order to view the battle.

A pattern has emerged in which the United States has increasingly emphasized using highly accurate and lethal conventional weapons in relatively small numbers to counter the large number of Soviet tanks viewed as the primary threat. An unwillingness to match Soviet numbers, as discussed earlier, together with a propensity to take advantage of our seemingly superior technology, has led to depending on *superior* performance from *outnumbered* forces. "The U.S. Army must prepare its units to fight outnumbered, and to win. To win,

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our soldiers will need the best weapons that industry and technology can provide."⁽²²⁾ The enemy is now recognized to have weapons systems as effective as our own, so that the United States must seek to gain maximum advantage from its weapon systems.

The defender has many advantages: full use of cover and concealment, selection of the ground on which to fight, weapons sited for maximum effectiveness, reinforcement of terrain with mines and obstacles, and the choice of firing first. Because of these advantages, the defending forces should be able to defeat an attacker superior in combat power by a ratio of about 3:1. The attacker, on the other hand, must expose his force by moving to contact, must fight on ground selected by the defender, must clear mines and obstacles while under fire, and must destroy or suppress weapons which have taken full advantage of cover and concealment. Therefore, the weapons of the attacker are not as effective as the weapons of the defender, and his forces are more vulnerable. . . . Because the attacker will attempt to overwhelm the defense with a concentrated mass of tanks and armored vehicles supported by very heavy artillery fire, the success of the defense depends upon the destruction of enemy armor. The problem will be to destroy many targets in a short period of time. Thus the defense must be built around tanks and antitank guided missiles. These are the backbone of the defense. In order to cope with large numbers of targets the tanks and ATGMs must be sited so that they can engage at maximum effective range and begin the attrition of the enemy early. (22)

Several points emerge that illustrate U.S. dependence on undegraded high performance by the defending forces:

- o To counter the Soviet preference for meeting engagements in which defenses are hastily organized, U.S. defensive doctrine emphasizes the need to be concealed and in optimum defensive sites.
- o Destruction of attacking armor is the dominant concern.
- o Engagements should be at maximum effective ranges.
- o Undegraded high accuracy and lethality are emphasized.
- o The defender can win when outnumbered 3:1.

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The stress on accurate fire also includes providing for coordination between defenders to assure that they engage separate targets. "Multiple kills on one target resulting in the absence of coverage of all targets will spell defeat."

One of the obvious factors leading to the emphasis on accuracy has been the constraint on numbers, leading to a widespread feeling that each weapon on the battlefield should be the best (i.e., most accurate and lethal) that the technology can provide. In the case of tanks, this urge was initially a prescription for disaster, since the initial efforts to build a new main battle tank to follow the M60 series led to designs which were so expensive and complex that they failed to clear the budgetary hurdle.

Weapon effectiveness has been measured at the one-on-one level, with improved tank gun or missile accuracy leading to a higher kill probability at a greater range than in the past. With this as the primary MOE, the fact that ATGMs were developed for a decade without attention to the vulnerability of the operator on the modern armored battlefield can perhaps be understood. Similarly, equipping attack helicopters with a TOW missile, and then extending the range from 3000 to 3750 meters, offered an impressive potential for tank killing by helicopters. However, battlefield reality was submerged; the length of time the helicopter must spend acquiring a target and then keeping it in view during the missile time of flight left the helicopter vulnerable to lethal or suppressive counterfire.

The one-on-one emphasis has been used to demonstrate the virtues of improvements in tank gun fire control, enabling a tank with improved accuracy at ranges beyond 2000 meters to win duels against a more modestly equipped tank such as the Soviet T-62. Tank duels such as these are rarely realistic; many tanks and many additional weapon systems participate. Engagement ranges are shorter because of terrain and weather obscuration, battlefield smoke and dust, and confusion. A vivid example of the latter occurred in the 1973 Middle East War in the Battle of the Chinese Farm, where Israeli and Egyptian forces which stumbled across each other at night fought the greatest tank battle since World War II at point-blank range at night.

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In contrast with the Soviets, who believe that any new technological development is useful only if it is produced in large numbers, the United States has been willing to procure nominally highly effective, accurate, lethal weapon systems in relatively low numbers. With smaller numbers the anxiety over vulnerability increases, and the highly effective systems must be able to demonstrate a high degree of survivability as well.

The employment of highly accurate, capable, and precious assets is constrained by the fear of losing the system. It is easy to demonstrate how rapidly a 5 percent attrition rate per sortie could wipe out the A-10 antiarmor aircraft forces, if they were attempting to mount a high-sortie rate to stem an armored advance. Attempting to keep very low attrition rates for valuable assets restrains their effectiveness. Bold operations with the risk of high losses, but which might be crucially important in reversing the course of battle, are less likely to be considered. *The employment of small numbers of highly effective, valuable weapon systems restrains bold usage of these systems. In contrast, with large numbers, greater risks of high losses can be accepted.* Along with the need to use scarce assets carefully comes the requirement to achieve the high effectiveness assumed for such systems. Degradations that seriously reduce nominal effectiveness are devastating.

The United States and the Soviet Union differ significantly in their approach. The United States put a premium on high individual performance, with accurate fire out to long range and with survivability stemming from defensive concealment, armored protection for tanks and eventually for ATGM vehicles, and lesser Soviet long-range capability. The Soviets, although interested also in long-range, accurate fire, gain an advantage from close-in engagement where the accuracy, rate of fire, and lethality of gun systems would be expected to dominate, and where their superior numbers and multiple attack tactics would prevail. For the Soviets, measures taken to prevent the U.S. weapons from being so effective at longer range become of paramount importance. Smaller tank size is helpful in this regard. Degradation of effectiveness will be treated further below.

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Marksmanship

Although the U.S. focus on highly accurate weapons is explainable in part because of the views regarding the military burden, and the defensive strategy with respect to the Soviets in Central Europe, it also is compatible with the long-standing emphasis on individual proficiency in the use of weapons that is part of the American heritage.

The U.S. social structure includes powerful civilian institutions dedicated to keeping individual arms, not for defense or warmaking, but because they believe that they have the right to have weapons at hand. The very fact of having this weapon suggests some pride and joy in knowing how to use it and in competing with others. The same institutions that strive to maintain the legality of individual arms are the prime supporters of shooting accuracy, manifested by massive programs of marksmanship training culminating in annual contests. Around this "sport" has grown a rather significant arms and munitions manufacturing community.

All this is aimed specifically at target shooting--delivery of accurate fire by individual weapons. In addition there is the rather extensive corps of hunters. Here, as in target shooting, the emphasis is on competition, for accurate shooting brings home the full bag and a common conversational gauge of hunting prowess is number of rounds of ammunition fired per item of game returned to the larder. Thus it has been since the days of the Pilgrims and the woodsmen when powder was scarce: accuracy of shooting preserved resources, provided food, and often insured survival in the presence of human and animal enemies. The Tennessee long rifle employed by individual scouts is a sterling example of aimed firepower in the hands of a few selected marksmen; they knew little of suppressive firepower, only that creating gaps in the line of attacking troop formations would eventually break the discipline of the advancing troops and the attack would stall; if it did not, the modus operandi of the American troops permitted individual withdrawal to a rearward firing position from which the long range attrition could be continued.

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. . . the undisciplined woodsman with his seven-foot, fourteen pound mass of wood and steel would deliver a bulls'-eye hit in the face of a smashing kick [recoil]. The farmer was not so accurate at long range, the townsman very little better than the present generation as a whole. But as a rule the Revolutionary Army shot well. . . . A pole was set up and a marksman stepped off 250 paces. The farmer or townsman would scarcely have wasted powder at such a range. But the rifleman from the forest, firing singly, rarely missed the pole. (37)

In the purely military application of this notion, the U.S. Army has for many years fostered weapons marksmanship of all individual and crew-served weapons through requirements for annual qualification firing, bonuses for higher levels of accuracy, and an exclusive fraternity for Distinguished Marksmen. Sharpshooters and snipers with special qualifications and equipment have long been a part of combat units. The "top gun" of the old West is now the master gunner in each tank company. There is a 200-year legacy of the rifle in the home and the requirement to fire it accurately as a means of survival. The average American knows little or nothing about suppressive fire until he becomes a part of a military unit, and even then the term blends in with other descriptors such as base of fire, supporting fire, preparatory fires, final protective fires, and the like. In artillery parlance, fire for effect means fire at adjusted positions for the express purpose of hitting something or some specific point--accuracy is paramount, even if mass is also applied.

By contrast, in the Soviet Union ownership of an individual weapon is beyond the realm of possibility for an average farmer or would-be weekend hunter. This was true long before the 1917 revolution, for Russian monarchs shared the reluctance of current Soviet leaders to relinquish their power through armed revolt or to share the joys of hunting with serfdom. Other than in the military, there is no real drive for shooting accuracy within the USSR. Even within the military, mass of fire seems more important than individual accuracy. In the case of artillery fire, delivery of a designated norm is the means employed to reduce a particular target. Adjustment of fires prior to starting the preparation is unlikely; accuracy is not at issue, but a specific mass of fire is.

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There is another type of difference between the U.S. and the Soviet soldier that may have some bearing on the U.S. emphasis on accuracy compared with the Soviet reliance upon fire for massive suppression and area destruction. The United States teaches that survival on the battlefield is important and that the object of the exercise is to make the enemy soldier die for his country, somewhat more colorfully stated by General Patton in World War II. Conservation of manpower and achieving each objective with a minimum casualty rate are important command considerations for each U.S. officer. This local emphasis does not appear to be true in the Soviet army, either currently or historically, where locally heavy casualties are acceptable if the overall campaign objectives are furthered. The natural result of the U.S. emphasis is to attempt to substitute firepower for the risk of casualties,* using mass where available but emphasizing accuracy of delivery. The Soviets apply established norms to situations, with the norms based on experience factors generated from data accumulated in World War II, updated by continual testing and training, and factoring in military judgment. If the norm is met, the advance proceeds and the soldiers move forward assuming that the expected degree of suppression has in fact been achieved. The echelonment of reinforcements within all formations recognizes that high casualty levels are expected, even with the suppression norms, and that individual survival on the battlefield is not so much a factor in battle planning as for the United States.

Another aspect of aimed fire versus volume of fire is exemplified in tank gunnery. U.S. emphasis for 30 years has been on achieving a first round hit at maximum effective range in a tank-on-tank engagement. To this end, massive amounts of time and resources have been spent training tankers in range estimation, then providing them with a series of increasingly sophisticated range determination devices coupled with ballistic computers to solve the basic gunnery problem at all feasible ranges. As a result of all this, the probability of

*This was carried to an extreme in Vietnam where commanders habitually substituted artillery fire and tactical air strikes for small unit maneuvers in order to hold casualties within acceptable limits, limits that were established by the military response to political pressures. It seems unlikely that Soviet commanders will be required to observe such constraints.

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achieving a first round hit has been significantly improved at ranges far beyond those at which intervisibility can normally be expected in western Europe.

(U) Until the deployment of the T-64 and T-72 tanks, the Soviets relied on closing with their targets to within that range at which the flat trajectory of their high velocity guns would essentially eliminate the requirement for a ballistic solution to the gunnery problem. A simple battle sight would suffice for direct aiming.* A second device for improving kills is platoon (three tanks) firing under platoon commander's control--the number 2 and 3 tanks firing on the same target as designated by the commander. This puts three rounds on target, improving the probability of achieving a kill. A common tanker battle drill is shoot-shoot-look, meaning that each tank fires twice at each target, then looks to see if it is out of action. For this system, a U.S. M-60 tank would expend two of its 63 rounds, while three Soviet tanks each would expend two rounds of their basic load of 40--a significant difference in resource commitment and drawdown of residual capability.

(S) However, there are indications that both nations are changing, each in the direction of the other. The United States is leaning more closely toward platoon fire control and is testing platoons of three or four tanks as an optimum fire unit. At the same time, Soviet T-64 and T-72 tanks have more sophisticated fire control equipment including range finders and fire control computers, a step conducive to individual tank engagement. The Soviets may, however, retain the platoon fire technique and go to a shoot-look combat drill because of the increase probability of achieving a first round hit.

(U) Analysis of Firepower Accuracy Versus Volume

(U) Studies performed by and for the Defense Department on the utility of new technology for land warfare dwell heavily on the problem of dealing with the vast number of enemy tanks. There is an

* (U) Recent information indicates that the Soviets now have entered in some of their battle sights two sets of lines, one cueing on the M-60 tank and one cueing on the height of the Chinese tank. These are range reference lines designed to improve battle sight effectiveness without computation.

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implicit assumption at the present time that unless new technology can contribute directly to killing armored vehicles, it will be unsuccessful in the competition for funding.

(S) In the past, new technology in the antiarmor role was evaluated largely in simplistic, one-on-one engagements such as tank duels, or in static, force-on-force engagements. A study done by OSD⁽³⁸⁾ in 1975 on antiarmor weapons addressed the antiarmor munitions requirements for U.S. forces for a war in the NATO central region, in response to a request by Congress for a justification of the number and variety of Army and Air Force antiarmor munitions. Although the study is heavily caveated as to the inadequacy of the supporting calculations, it nonetheless employs simple unrealistic kill probabilities derived from test data to make some assessments on the relative contributions of such diverse systems as tanks, ATGMs, attack helicopters, and fixed-wing aircraft to the problem of killing armored vehicles. In the analysis, ATGMs rate much higher than tanks, because of their nominally greater effectiveness at long range.

(U) Several studies by the Institute for Defense Analyses have been performed to analyze tank and antiarmor weapon systems, using force-on-force engagements modeled with somewhat more complex and realistic characteristics. In calculations using the Tank Exchange Model⁽³⁾ ten tanks on the offense attacked five on the defense. Terrain data from Central Europe were used, and losses were calculated from data on gun system accuracy and lethality and tank vulnerability derived from Army tests. The methodology was incorporated into another model, used for a study of combined arms effectiveness in antiarmor operations.⁽³⁹⁾ The model was employed to illuminate the improvement in capability offered by various new antiarmor systems or technology modifications under consideration by the Army. Evaluations were performed of the ability of U.S. antiarmor defenders to kill Soviet offensive forces consisting of tanks, BMPs, air defense weapons, and artillery units.

(S) The model results have been used by the Army⁽⁴⁰⁾ and by NATO in weapon system evaluation and force design. Because the model does not

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consider an actual campaign, the only useful measures of effectiveness emerging from it are the losses of forces by each side in the engagements simulated. Several aspects of the model engagements, however, severely restrict the utility of the model for judging the worth of particular technology changes. The battlefield environment is quite unrealistic. Weapons are given very high, test condition kill probabilities. Most of the results are for conditions of unrestricted visibility because of weather, although terrain restrictions are partially accounted for. Soviet tactics for the employment of suppression and smoke to reduce the defender's effectiveness are not accounted for. The Army in its usage of model results suggests much greater force effectiveness from improvements such as the XM1 tank and the TOW with armor protection. Improvements in accuracy and survivability through armor protection appear significant in loss exchange ratios with the assumptions used, although in cases where the attacking force outnumbers the U.S. defenders by 6 to 1, the attackers are successful in overrunning the defensive position. Although it is not accounted for, the attackers presumably would then be able to eliminate the remaining defenders.

(S) Analyses of weapon systems are not typically performed in which Soviet, rather than U.S., criteria are used in assessing the outcome of engagements. For the Soviets it is likely to be worth sustaining higher losses if a key defensive position can be overrun more rapidly and time objectives can thereby be met. Analyses of the contribution of various technological improvements to defeating Soviet movement goals, in addition to enhancing vehicle kills, would present a more complete and useful picture of how new technology contributes to battlefield effectiveness. Moreover, unless such evaluations are performed under realistic conditions, using representative Soviet tactics and degraded environmental conditions and lower accuracy figures, the evaluations will be too far removed from reality to be justifiable in assessing anything. Although qualitative factors may appear to be more difficult to model than straightforward quantitative factors such as accuracy, lethality, and vulnerability, their very importance demands that they be accounted for nevertheless. As will be discussed below,

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the Soviets are able to account quantitatively for factors that U.S. engagement models typically omit as not being quantifiable.

(U) How Automation Fits

(U) In Chapter II the differences in the U.S. and Soviet approach to the utilization of automation technology in land warfare operations were noted. The differences in how each side evaluates effectiveness, as presented in this chapter, suggest that the Soviets can more naturally incorporate such new technology initially than can the United States.

(S) The Soviet measure of time required for offensive operations is directly related to one of the most straightforward benefits from automation: *reduction in the time to process information and make consequent decisions.*

Although no apparent time savings resulted in solving operational tactical problems, the goal is clear. Planning in the 1960s suggested goals for reducing commander decision times:

<u>Command Level</u>	<u>Manual Time</u>	<u>Automation Time</u>
Front	6 hours	< 1 hour
Army	4 hours	< 40 minutes
Division	100 minutes	< 20 minutes

(S) The value of automated aids in artillery operations, for example, can readily be evaluated by comparing the length of time required to begin firing at a target, once a firing request is made, using manual and automated aids for calculation, data transfer, and decision.

(U) Automation is considered a crucial means to alleviate Soviet concern over delay and indecision in command operations. Routine calculations that consume a great deal of a commander's time and attention lend themselves to automation, thereby freeing the commander's attention to those problems where greater creativity may be needed. Soviet analyses indicate that more rapid decisionmaking, abetted by automation, will speed up operations. Decision and positive action, even if not optimum,

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are preferable to indecision, delay, and inaction. Automation offers the potential for presenting and evaluating more options for the commander to consider, with quantitatively based decisions using more precise information and assisted by combat models inculcating factors validated from previous experience and common criteria agreed upon throughout the command system. It also presents the commander with a call for a *decision that must be made at a certain time, without delay.*

In contrast, the U.S. use of battlefield automation is not so clearly related to its battlefield MOE of armored vehicle kills. It is reasonable to assess that information systems and C³ are necessary and important aspects of overall battlefield performance, but they are separated from weapon system effectiveness to a much greater extent in U.S. battlefield thinking than in the Soviet case. It is not possible to establish an easily understood relationship between killing armored vehicles and the products of battlefield automation. The contributions are indirect, and calculations of increased vehicle kills resulting from automation would be highly suspect in their methodology, with the possible exception of artillery applications. Thus, improved information processing, whether measured in time saved or in increased bits of information processed, may appear important to those directly concerned with such needs, but do not appeal to those primarily interested in killing tanks. One of the greatest gaps in attempting to introduce automation to the battlefield has been an inability to demonstrate its value to the commanders of combat units; their trust in and reliance upon ADP, storage, processing, and display had been slow to develop. Automation has consequently received much less priority in the development and acquisition process compared to weapon systems--in marked contrast to the high-level support and relative priority accorded to battlefield automation by the Soviets.

BATTLEFIELD DEGRADATIONS

Assessments of the utility of new technology on the battlefield are made with some view of the battlefield environment and the nature of warfare. In previous discussion it has been suggested that this

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environment differs markedly from the conditions under which new equipment is tested and in which training is conducted. In late 1977 General Kerwin, then Vice Chief of Staff of the Army, issued a memorandum entitled *The Use of Realistic Battlefield Environment Conditions Throughout the Army*, in which he was critical of the lack of sufficient realism and suggested developing new standards.

Three categories of battlefield degradations impeding ideal performance of men and equipment are noted in Table 10.

Table 10

DEGRADATIONS IMPEDING IDEAL PERFORMANCE

<u>Type</u>	<u>Cause</u>	<u>Effects</u>
Natural	Environment Weather Night Terrain features	Restricted visibility Restricted mobility
Battle conditions	Environment Stress Equipment failure Interference	Restricted visibility Restricted mobility Fear, confusion Isolation, disorientation Fatigue Equipment malfunction and loss Multiple targeting Data and communications loss or delay
Enemy counter-measures	Artillery, infantry fire Smoke Chemical attack Electronic counter-measures Deception Camouflage Mine attack	Suppression Restricted visibility Loss or delay of communications, information Restricted mobility Stress of personnel

Natural. These degradations include environmental and weather effects, such as restricted visibility and darkness, and terrain effects, including obscurations impeding clear line of sight and mobility restrictions because of trees, mud, and steep grades.

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(U) Battle Conditions. Battle itself creates additional environmental restrictions, including dust and smoke from burning equipment and weapons firing, and noise and blinding flashes. Personnel in battle can undergo severe stress, potentially reducing or destroying their effectiveness. Factors contributing to stress and degraded performance include fear, confusion, isolation, disorientation, fatigue, and casualties. Equipment failures, such as the severe problems encountered by the Israelis in 1973, occur in battle, as the result of enemy action, while forces are moving, from abuse or usage exceeding the tolerance of the equipment, and from natural wear and tear. In battlefield engagements there are many diverse elements, resulting in multiplicity in targeting, and mutual interference in communications or electronic emissions.

(S) Enemy Countermeasures. Artillery and infantry fire cause suppression, as well as destruction, thereby temporarily reducing force effectiveness. The deliberate employment of smoke to restrict visibility for target acquisition or weapon delivery, to conceal movement, and to inflict stress on enemy soldiers is a heavily practiced Soviet tactic. Soviet doctrine for radioelectronic combat is well integrated with overall force employment doctrine, and a concerted attack on the C³ system would include various ECM techniques in coordination with other means to degrade communications and render command posts inoperative at specific times in order to press the offensive. Deception and camouflage have the obvious effects of confusing the opponent regarding movement, intentions, and location, thereby degrading his responsiveness and diluting the effectiveness of his weapons. The use of mines, even if they do not cause large numbers of vehicle or personnel losses, greatly inhibits mobility, disrupts coordination, and creates tremendous psychological stress on personnel.

(U) The Soviets appear to give greater attention to degradation effects than does the United States. As noted in the discussion of effectiveness measures, the Soviets more naturally account for the degradation of their own forces and specifically are oriented to cause and exploit degradations of the enemy. They have detailed, widely practiced employment doctrines for various measures that, in the

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U.S. case, have been accorded only minor attention. In contrast, the United States focuses more on the optimistic, undegraded potential of its forces. This lack of attention to degradation may stem in part from the long-term disconnection between developers and users of equipment. Developers are part of a scientific technical establishment in which performance criteria tend to be technical and quantitative rather than operational. Moreover, the battlefield environment, including a decidedly malevolent opponent, is unlike any other environment in which scientific equipment is operated. To the extent that developers are not completely attuned to the wartime environment because of their own personal experience, or because battlefield-compatible performance criteria are not constantly forced upon them by the military, they are unlikely to be able to factor battlefiled operability into their designs and developments. Because developers see only the isolated segment of the battlefield related to the narrow focus that they naturally have, integration, overall compatibility, and coherence of operations can only come from the military users themselves.

Attention, or the lack of it, to degradation factors is a major indicator of the extent to which the development of new technology is attuned to military doctrine and views of the nature of warfare. Several examples in the area of countermeasures are elaborated here; the implications of stress for personnel performance are taken up in the next chapter.

Suppression of Antiarmor Weapons

Karber, in his paper on the Soviet antitank debate⁽⁴¹⁾ notes the great concern expressed by the Soviets over the potential effectiveness of NATO ATGMs, which are viewed as a threat to their armored vehicles. Their vulnerability to NATO's ATGMs suggests to them a potential problem in maintaining an armored offensive, unless suitable means to degrade ATGM effectiveness are employed. In particular, if the BMP is vulnerable, and is heavily attacked, the infantry operating from within might have to dismount and attack on foot. Their tanks would either engage the enemy unescorted, or the offensive would have to *slow down*. Karber suggests that Soviet commentators ". . . generally agree that

the ground force component most threatened is the motorized infantry, which in turn raises serious problems for the tempo and coordination of the offensive. What is being debated . . . is how to overcome the challenge of antitank weapons and retain a high rate of advance against a strengthened NATO defensive capability." It is important to note that the ultimate measure of NATO's ATGM effectiveness is not the accuracy of the weapons or the number of armored vehicles lost, but rather the large *number* of ATGMs available to NATO defenders and the effect of *slowing down* the Soviet offensive.

One option discussed widely in handling NATO's ATGMs is the use of artillery for ATGM suppression. The usage of artillery for suppression has been a Soviet practice for decades and detailed, quantified relations have been established between units of fire of various artillery munitions and the suppressive effect on personnel in various situations.⁽³³⁾ Suppression of ATGMs per se has been an artillery role from the beginning of the ATGM era, but only in the 1970s has the widespread deployment of ATGMs in NATO occurred and elevated the importance of the problem. Sagger suppression in the 1973 Middle East War accentuated its importance.

Karber notes that the artillery branch has assumed an increased role in ATGM suppression with great relish. It creates a greater role for artillery to play, increasing the resources devoted to the branch and helping them regain influence lost during the Khrushchev era. Suppressive firepower from artillery clearly exceeds that possible from any other type of system. However, lower rates of advance and delays might occur while suppressive fire is delivered, unless it can be done quickly.

"The struggle with antitank means of the enemy becoming one of the most important tasks of artillery. Consequently, the methods of combat use of artillery subunits demand further development."⁽⁴²⁾ Indirect fire is not sufficiently effective and quick.

"After indirect preparation fire some weapons still remain undestroyed. They counteract the tank and motorized infantry subunits during their advance. . . . To destroy them, artillery guns conducting direct fire must be detailed."⁽⁴³⁾

(U) As Karber points out, effective direct fire by artillery requires decentralization and attachment to maneuver battalions. In fact, 122-mm self-propelled artillery battalions (upgraded from just a battery) have been deployed particularly with BMP regiments in the last several years. These new weapon systems have excellent direct fire capability and are exercised in the direct fire mode in meeting engagement situations. Furthermore, their responsiveness is being improved through the use of automation, enabling them to fire more rapidly at ATGM locations.

(U) The desired effect on the ATGM is suppression, not necessarily annihilation. The Soviets have done a great deal of testing and analysis of suppression effects. Neutralization, the level of suppression for which the Soviets plan, is dependent upon disrupting the cohesion of a unit.

(C) If a sufficient number of individuals are shocked or traumatized sufficiently to withdraw temporarily from participating as members of the unit, time is required to reestablish contact with the sufficient fraction of the unit to organize an effective military response. Individuals who have gone through the experience of the appropriate density of artillery fire typically refer to a feeling of hopelessness and a belief that the unit has suffered overwhelming casualties even though the unit may have had only 5 to 10 percent killed. (44)

Soviet neutralization criteria include an expected damage level of 20 to 25 percent to material, 12 percent fatalities, up to 18 percent wounded, and the remainder of the personnel in shock for up to 20 minutes. The effect is dependent on the density of fire, with time compression heightening the effect. Soviet norms for neutralization fire explicitly account for the temporary nature of such suppression, and offensive operations must fit into the time slot that has been opened, during which the defenders are off balance and unable to reorganize and resist effectively. The effect of suppression on single weapon crews has also been studied by the Soviets. Crews without armor protection require a considerably longer time to regain effectiveness, 30 to 100 seconds, than do armored crews, after suppressive fires cease. (45)

(S) The potential effects of suppression of ATGMs in an engagement have been analyzed by SPC.⁽⁴⁴⁾ TOW and DRAGON launchers, even when well deployed, suffer serious degradations in effectiveness from artillery fire supporting an armored attack, with suppression the principal cause of the degradation. During the attack these degradations involve interruptions in firing and controlling missiles, the "flinch factor," with long-range engagement opportunities the most seriously affected. For example, TOW launches were interrupted about 1.5 times per minute. Providing armor protection for TOW (e.g., the ITV), or providing for DRAGON to be launched from foxholes, not only reduces the lethal effects of artillery fire, as is well understood, but is an even greater factor in reducing the effects of suppression--usually ignored in analyses. For example, the number of DRAGON's remaining effective increased by about 40 percent.

(U) Only recently have suppression effects begun to be investigated systematically in the United States, and quantitative understanding of the effects considerably lags that of the Soviets. The SPC report recommends

that testing be conducted to better understand the suppression phenomena and to quantify its effects . . . [and] that operational and development tests consider the vulnerability of ground weapon systems to suppressive as well as lethal effects of artillery. As the suppression phenomena [sic] becomes better understood, it should become a major criterion for ground system vulnerability analyses and testing.

(U) Smoke

(U) Another serious cause of battlefield degradation is the deliberate use of smoke to hinder visibility. Smoke delivery is a simple countermeasure which the Soviets would use extensively in offensive operations.⁽⁴⁶⁾ Its effectiveness is widespread, not dependent on any particular property of a specific weapon system, and would be simultaneously effective against many systems. Smoke can defeat or degrade optical and infrared systems of all types, from visual to automatically guided systems, providing protection for armored operations against attacks from the air as well as the ground. Under cover of smoke, advancing Soviet armored units can close to short range (e.g., below 1000 meters) where

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their numerical advantage and short-range weapon system capabilities give them a greater assurance of success.

(S) The Soviets have already deployed a wide variety of systems for smoke generation that allow massive delivery with high density, wide area, persistent coverage. The present Soviet arsenal includes smoke grenades, barrels, drums, pots, and shells for guns, howitzers, and mortars. They are capable of delivering smoke screens which not only completely attenuate visual transmission, but also reduce infrared transmission significantly. While infrared wavelengths transmit much better through smoke than do visual wavelengths, they can be attenuated severely by large layers of small-particle smoke and by thinner layers of large-particle smoke which are coming into use. Among the smoke agents that seriously affect the long-wave infrared region (where imaging infrared sights operate) are white phosphorus, anthracene, naphthalene, and titanium tetrachloride. A very responsive small-particle smoke capability is with fog oil smoke generated by Soviet vehicles using a device that pumps fuel from the fuel tank and sprays it into the exhaust; this device has been mounted on the T-55 and T-62 medium tanks, the BMP, the PT-76 light tank, and other vehicles. It can be generated quickly upon detection by defenders. While a low-density fog oil smoke would not appreciably degrade the performance of imaging IR sights, which operate in the 8-13 micron wavelength region, the tracking beacon signal from the rear of current ATGMs (TOW, DRAGON, and SHILLELAGH), which operates in the one micron region, would be attenuated to the extent that the range at which the weapons remain effective could be greatly reduced.

(U) The Soviets have long advocated the usage of smoke to counter ATGMs, have exercised extensively with smoke in support of offensive operations,⁽⁴⁷⁾ and have quantified its effects by testing and measuring the degradation that smoke screens impose on visual acquisition and weapon guidance. A number of articles in Soviet journals treat the use of smoke in World War II operations and relate the experiences to the importance of smoke in present circumstances.^(48,49)

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The use of smoke to degrade the effectiveness of ATGMs was noted in 1966,^{*} after Soviet ATGMs had been deployed, but before any significant deployment by the United States or its NATO allies:

It should be noted that it is not always possible to suppress enemy weapons, especially such weapons as PTURS^{**}. . . Some of them will remain unsuppressed and some of them which were suppressed during the firing preparation phase will come to life at the beginning of an attack.

At the next instant of attack the enemy's fire reaches maximum intensity. Therefore, blinding observation posts and gun crews in front of an attacking force will reduce losses in personnel and combat equipment considerably. . . .Blinding a launch position with a curtain of smoke makes it possible to lower the effectiveness of PTURS inasmuch as their fire is no longer aimed. Under these conditions PTURS teams usually cease fire completely and go to alternate positions. (51)

The effects of smoke have been portrayed quantitatively, similar to that for suppression effects:

Practical experience shows that a smoke screen can reduce losses of attacking tanks and motorized infantry podrazdeleniyes by 60 to 80%, and blinding the enemy fire weapons by the smoke reduces the casualties of our attacking forces by at least 90%. Smoke ammunition is relatively safe in handling and its use does not require significant material expenses or a special training. Therefore a systematic training of podrazdeleniyes in actions under conditions of smoke screening makes possible a better preparation of the personnel for accomplishing complex combat missions with low casualties and low equipment losses. (52)

In 1975 an article described the operation of a smoke screen computation device,⁽⁵³⁾ a battlefield circular rule similar to a nuclear weapons effects calculator widely used in the United States. Such a device, tested in the field, greatly reduces the time required to determine the resources necessary to deliver smoke screens of various sizes, intensities, and durations under various topographic and meteorological conditions. Formerly such calculations required lengthy tables and formulas.

^{*} Its use was advocated as early as 1962 and 1963. (50)

^{**} Antitank guided missiles.

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(S) The Soviets, as has been noted, have advocated the use of smoke to counter ATGMs since the early 1960s, and have trained extensively. Until the middle 1970s, this effect was virtually ignored by both developers and users in the U.S. weapon system community, despite the devastating effect that smoke could have. The effects of smoke on the operations of TOW, DRAGON, and the GLLD (the laser designator for Copperhead) *were first tested in 1976*, with results indicating a severe degradation in performance, as would be expected. Until that time the effects had not been seriously evaluated quantitatively. The supporters of laser-designated weapons to alleviate the tank problem, as exemplified by the emphasis on Copperhead, ignored the degradation or total inutility of such systems from even modest amounts of smoke. A typical response had been that the Soviets would be unwilling to use smoke in attack situations, because their own vehicles would be unable to see through it. However, the extensive training and development of special equipment and tactics suggests that the Soviets are indeed serious. As an example, the Soviets have provided land navigation equipment with directional gyros for armored vehicles, command vehicles, and air defense units that permit continuous operation under restricted visibility in water crossing or smoke operations.

(U) In waking up to the problems with smoke, the Army established a DARCOM smoke project manager office in 1976 and began to test equipment and train forces in a smoke environment. The Army's smoke project manager, in commenting on how to deal with smoke, ⁽⁵⁴⁾ emphasized these training aspects:

Recognizing the impact of obscuration on the effectiveness of our antitank guided missiles does not decrease the importance of those weapons. It does, however, highlight the importance of tactical training in a prolonged smoke environment. Failure to train operational units under these circumstances puts the element of surprise clearly in the enemy's favor. ATGM operators must be trained to understand that the effectiveness of their systems can be significantly lessened by smoke and dust.

(U) He adds an important observation by an unidentified member of an armored division:

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At this time there is an insufficient level of training in the offensive and defensive employment of smoke and in the techniques to counteract the effects of large amounts of smoke on the battlefield. . . . In order for smoke training to be effective, smoke must be employed in sufficient quantities so that the training unit can neither circumvent it nor wait for it to dissipate. The amount of smoke employed must be large enough to compel units to operate within the smoke (to accustom personnel to being in a smoke cloud).

There must also be sufficient quantities available to provide realistic tactical employment so that commanders can obtain practical training in both the offensive and defensive uses of large-area smoke and in the probable employment of smoke by potential adversaries.

He went on to suggest that it quickly became apparent that the Army did not have the capability to generate Soviet-style smoke screens in conducting tests and training under expected battlefield conditions. Delivery capabilities for large quantities appear to be very expensive, adding seriously to training costs. Yet without such training, seriously degraded personnel and equipment performance in such a battlefield environment would be even worse than it has to be.

THE TESTING OF NEW TECHNOLOGY

U. S. Testing

The fielding of new systems employing new technology usually results in the discovery of various operational deficiencies or vulnerabilities. Despite the fact that systems undergo development and operational test and evaluation before procurement, somehow these deficiencies remain unrecognized until much later.

In an earlier section it was seen that during its development the TOW missile somehow escaped being tested operationally under conditions simulating those on the NATO-Warsaw Pact battlefield. Vulnerability to suppressive artillery and infantry fire and the serious degradation of the system from the deliberate use of smoke were ignored.

Testing is done for a number of purposes. Technical testing is performed to evaluate whether equipment meets the technical requirements that have been specified; operational testing should reveal

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something about how the equipment performs when used in ways comparable to its ultimate mode of employment. However, since the testing process, part of the overall system of evaluating military needs, is also affected by the perceptions of the battlefield and the pressures of developing advanced technology as a substitute for manpower, there are likely to be serious distortions of reality and undetected inadequacies and deficiencies in systems undergoing testing.

The assumption that advanced technology for the West can offset the superior numbers of the Warsaw Pact is based in large measure on performance data and model results that fail to account for the realities of war. Stockfish has noted

There is presently very little basis upon which to validate the assumption as it applies to many systems, combat elements, and operational procedures. Models based on firepower scores or engineering data, especially after several cycles of weapons developments, will usually tend to support the idea that the more costly weapons provide a qualitative edge.

Yet if weapons are designed with poor information on how their incremental technical performance provides better combat capability, the hypothesis that a superior technology provides qualitative improvement is contestable. Most recent and existing modeling, however, supports a contrary view. Operational testing is one way to evaluate the hypothesis critically.(55)

Stockfish goes on to advocate small-unit operational testing to evaluate effectiveness parameters for use in modeling and to aid in the development and acquisition of new equipment. In particular performance under conditions of stress should be encouraged, and degradations should be noted. "If measured performance is less sparkling in a field trial than might be suggested by an unverified mathematical model, then comparable performance in real war will generally be even more degraded. What this means with regard to actual productivity in war is worthy to ponder."

The deficiencies in testing are serious despite the enormous effort and resources invested in it by the military.

The need for more vigorous empirical work, including operational testing, is of such magnitude that a major reallocation of talent

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from model building to fundamental empirical work is called for. . . . The real payoff from operational testing, as well as from more careful empirical study of past wars, is that these can potentially provide a way to check the assertions that flow from models--including the models used to justify technical performance specifications for new weapons--whether these models be "analytical" or "judgmental." (55)

An interesting example of the failure to identify the degraded performance of precision weapons under operational conditions comes from the operational test and evaluation of the Maverick air-to-ground missile prior to the final acquisition decision. The technology for this missile was indeed impressive, and successful use of PGMs against North Vietnamese targets, albeit *large fixed targets*, created a highly favorable environment for the performance evaluation of Maverick.

The operational tests of Maverick were conducted to evaluate, among other things, the probability of successfully acquiring a tank-sized target and locking the TV seeker onto the target. Data on visual tank acquisitions were taken under idealized test conditions, with pilot familiarity with the area and an awareness of the target arrangement. Most test trials were conducted with little cloud cover and high visibility conditions. Tank targets were also visually acquired under the worst weather conditions of the test, a cloud ceiling of 500 meters and a visibility of 5 km. The data were then extrapolated to poor weather conditions, *which had not occurred in the test*, to suggest that Maverick could be usefully employed at conditions of a 150-meter cloud ceiling and a visibility of 1.6 km. Using weather from Central Europe, the evaluation team found that Maverick had a utility factor in Europe of 91 percent annually and 87 percent in the winter.*

The performance has since been evaluated as being much lower than this, since the capability to acquire targets visually requires considerably better visibility and cloud-free line-of-sight. Upon the initial deployment of F-4s with Mavericks to Europe, it was quickly learned that it was much harder to acquire targets under European weather conditions than some had previously thought. Opinions

*From Ref. 56, based on test report of Ref 57.

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varied on the system's utility, with some high-level thought to removing the weapon system from Europe because it was so ill-suited for the environment.

The lack of evaluation of the missile in a European environment is epitomized by the fact that, five years after the operational test took place, a live missile was fired for the first time in Europe by an A-10 aircraft. In the A-10 tests of 1977, A-10 crews found that target acquisition could not be done at as great a range as had been anticipated, based on experience from U.S. tests. "In U.S. tests, targets often were acquired at distances greater than 6,000 feet. In Germany, the maximum distance for target acquisition was 4,000 feet, and often it was less." (58) The cost of the A-10 aircraft was kept down in the development process in order to make its acquisition more palatable. The lack of an inertial navigation system, however, is a serious deficiency.

"We've got to have it if we're going to be effective in Europe," One pilot said. "If they schedule all their wars at Gila Bend [Arizona, where tactical development work with the A-10 has been done] they may be able to do without it, but not in Europe.

"It's not realistic to ask a pilot to fly low-level over any distance trying to navigate in haze and smoke and miss the telephone poles, with a cockpit full of maps and an air conditioner blowing them all over the place," another pilot said. (58)

Inadequate operational testing for the M60A2 tank was noted by Alexander. (14) The system was rushed into production in an attempt to counter Soviet armored superiority, but the complexity of the system and the major changes in the fire control, turret, and gun subsystems led to unreliable performance and system failures. Production was eventually curtailed and the missile-firing tank concept has been abandoned. Earlier, thorough testing could have revealed the serious system integration problems.

Several aspects of U.S. testing lead to these inadequacies:

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- o Testing is primarily technical, with quantitative evaluation and control of parameters.
- o Small numbers of equipment items are tested, for a relatively short period of time.
- o Testing is "best" carried out in a clear environment: clean, with good weather, in the desert, no clutter and no mud.
- o Interference and countermeasures, such as ECM and smoke, are typically absent.
- o Evaluations are typically one-on-one. Systems are not tested in the context of an overall, combined arms force, for instance, and the enemy is played quite unrealistically.

Many of these aspects relate to the unrealistic perceptions of the battlefield and the emphasis on accurate, undegraded performance noted earlier. Tests which revealed degraded, but realistic, performance parameters or failure of systems because of interference measures may be seized upon as justification to cancel a program. Thus in the desire to maintain officially high performance parameters in order to facilitate a program's march through the acquisition process gauntlet, the deception as to what can be expected under non-ideal conditions becomes so pervasive that the users and force planners are also deceived and the doctrine becomes increasingly based on unattainable goals for equipment performance.

There are very good reasons for testing in a clear environment. Performance characteristics can be measured under controlled conditions, in a relatively scientific way. Only small numbers of items such as tanks or other advanced weapon systems are tested, and testing is expensive; conditions are undesirable which impede good, clean technical evaluations. Limitations on test range operations, because of competing demands for land use, have also helped to drive the test ranges to desert locations.

(U) There are repeated recommendations that real users and operational troops play a role in the testing process in order to provide necessary feedback to the developers on how the equipment performs under

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realistic conditions and use. However, the budgetary implications of such testing are great, and the major adjustments in the perceptions of battlefield reality and the military burden that would be required seriously impede such a change.

(U) Soviet Testing

(U) Soviet testing appears to differ from U.S. testing in several ways:

- o Testing has a greater operational emphasis.
- o Large numbers of equipment are tested by real, operational units over an extended period of time.
- o New equipment is deliberately tested under more realistic conditions, including degradations.

(S) Whalen has noted⁽⁵⁹⁾ that the Soviets conduct field exercises in which simulated weapons or system capabilities beyond existing equipment are examined. These exercises are believed to be part of the need definition process that precedes development. Among other things such exercises quickly reveal the concurrent developments of different equipment items and capabilities that are required in order to achieve an overall coherent system capability.

(U) Soviet testing is carried out with larger numbers of test vehicles or items of equipment than U.S. testing. This may reflect the fact that, since Soviet production figures are large, pre-production runs for testing can be proportionally large as compared to U.S. quantities. Soviet testing of large numbers in operational units in a battlefield context is exemplified by the strenuous testing given to candidates for new tanks in the 1970 Dvina exercise.*

* (U) Large-scale testing of arms has been characteristic of the Soviets since the 1930s. (14)

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(U) In such early large-scale operational tests, overall system performance in a realistic context can be studied and such factors as excessive operational complexity, insufficient protection, or insufficient mobility can be identified. The performance of an operational unit's set of new equipment can be measured, rather than only the technical performance of a single, or small numbers, of vehicles in a more simplified environment.

(S) There is some difficulty in distinguishing between large-scale testing of new equipment while still in the development phase from early operational use and subsequent modification. Perhaps the distinction is unnecessary. The Soviets may field new equipment for units to test over an extended period of time, with the equipment fully operational and yet still being evaluated for subsequent modification. The deployment of T-72s and HIND helicopters to the Group of Soviet Forces, Germany (GSFG) is an example of such a case. The larger production run of these systems is for modified versions compared to those initially deployed. In the case of HIND, more advanced target acquisition and fire control equipment and new ATGMs were probably planned from the start. Another example is the artillery automation equipment being evaluated in GSFG. Although U.S. analysts may not consider the equipment operational, and although many changes and refinements can be expected, the system may be operationally useful if the Soviets suddenly were at war.

(U) The Soviets test new equipment in a variety of sites, and leave equipment in the hands of troops for an extended period of time (e.g., months). Although certain test ranges may offer the clean environment that typifies U.S. ranges, the Soviets probably achieve greater diversity in the environment and conditions under which equipment is operated and tested. For one thing, Soviet weather conditions are much more variable than in the desert, and testing in extreme cold, or on overcast days with poor visibility is almost inevitable. The extended time for testing is likely to reveal more operational problems.

(S) The preceding discussion suggests that the Soviets may gain more insights into the operational value of new technology from more realistic testing. However, the urge to make certain improvements

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and the compelling authority of Communist doctrine that dictates that problems can always be solved may impede the recognition that certain developments are simply not good enough. The Soviets have experienced a good deal of trouble with new tank engine designs, and they have reverted to their traditional engine in recently fielded tanks, despite the desire to upgrade.* Early models of the T-64 apparently had new engines that did not perform well. Similarly, although the U.S. tank designers abandoned an automatic loader as too complex to operate and as susceptible to mechanical breakdown, the Soviets planned for the T-64/T-72 series tank to include the automatic loader from the start. If the loader breaks down the main gun cannot be operated in a backup manual mode. There is some indication that the Soviets are experiencing mechanical failures at a greater rate than is acceptable. Such problems as those with the new engines and the automatic loader should have been revealed earlier in the testing process.

(U) BATTLEFIELD EFFECTIVENESS IN SUM

(U) For whatever reasons, the intensity and lethality of the battlefield in the Middle East War in 1973 came as more of a surprise to the U.S. than it did to the Soviets. We believe that this is a direct result of greater Soviet cognizance of the realities of war and the stressful nature of the battlefield environment. It also appears that the emphasis in the training of soldiers is on their adaptation to the rigors of combat and their acceptance of the risks and exposures for longer periods of time. Soviet military leadership pays great attention to the need to keep the troops mission oriented and under control, and to counter natural tendencies of subordinates to fail to perform in the face of grave danger, extreme uncertainty, and physical privation.

(U) As to effectiveness assessment, a striking difference exists in placement of emphasis when considering the relative balance of power: the USSR stresses political will whereas the United States

* (S) Fragmentary reports on the T-80 tank suggest an upgrade to a possible gas turbine engine of about 1,000 hp.

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stresses military capability. While the Soviet primary combat measure of effectiveness (MOE) is rate of advance of units, the U.S. primary MOE is ability to destroy armored vehicles. There is also a similar fundamental variation in view as to the role of firepower: the Soviets exploit it to support and enhance maneuver, the United States plans its use for vehicle kills and secondarily to delay the enemy advance. The Soviets plan an offensive *expecting* high losses initially, while the United States designs its operations in an attempt to substitute firepower for personnel at risk. The United States expects this firepower to produce attack-stopping casualties, but the Soviets anticipate this and are prepared to degrade defender performance and to reinforce with fresh units.

Soviet preoccupation with rapid rates of advance is closely associated with two other historically based concepts: large numbers and high mobility. These are all treated in a highly aggregated manner, with operations being examined from a campaign perspective rather than on the basis of small unit or weapons system effectiveness. The purpose appears to be to guarantee the cohesion of operations involving large, rapidly moving elements. A high level of destruction is expected, with degradation of individual and unit performance being considered natural--this with respect to both sides in the conflict. With the Soviet emphasis on the offensive and on cohesiveness of major operations, emphasis at the small-unit level is on executing simple operations reliably and on time. Attacks coordinated in time depend upon many units arriving at planned objectives precisely on schedule, not upon inflicting casualties along the way. This provides for mass timed to exploit an enemy's vulnerability, the essence of surprise. This mass also provides for built-in redundancy; more weapons can engage each target, reducing the need for accuracy; suppressive effect is greater, reducing the effect of defender's fire; and with reduced vulnerability the attacker can advance more rapidly and meet his rate of movement norm. Time is the all important factor.

Time is also important in U.S. concepts but in a different sense: individual systems must be capable of destroying large numbers of attacking vehicles in a short time. This requires engagement at

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maximum range, undegraded high performance, and optimum distribution of fire by defending weapons. The time-sensitivity of these requirements reinforces a long-standing U.S. tendency to measure effectiveness on a one-on-one basis, i.e., first shot fired, first round hit, in each duel. To get so many capabilities, U.S. technology has been pushed hard against the constraint of the budget. Small numbers of high technology items result, and such precious items are used with restraint stemming from fear of loss. Bold usage of small numbers of valuable systems becomes unlikely, whereas greater risks might be acceptable with greater numbers. Perhaps more demanding is the requirement for high effectiveness of scarce systems--degradations that seriously reduce nominal effectiveness are devastating.

Automation on the battlefield is directly related to the Soviet emphasis on timely decision and action. Automation offers the potential for the commander to examine quickly more options, analyze more data, and call upon factors validated from previous experience or found to be acceptable within the command system. It can also cue the commander that a decision must be made on a specific item by a certain time. Such notions fit well with Soviet offensive concepts and add an additional dimension of control to massive, scattered operations.

In contrast, U.S. use of battlefield automation is not so clearly related to its battlefield MOE or armored vehicle kills. The contributions are more indirect, and credible methodology is lacking for measuring interactions and results. Combat commanders have yet to accept system reliability and prefer to use devices that they know and understand. The type of high-level support noted for the Soviets appears to develop slowly in the United States.

As to degradation of capability on the battlefield, the Soviets seem to expect it, plan for it, and seek means and ways to overcome its deleterious effects. Norms include consideration of degradation based upon a realistic view of the true difficulties of the combat environment. Accepting as commonplace the limitations imposed by hostile and often lethal surroundings leads to easier recognition and acceptance of enemy influences designed specifically to degrade performance. Thus firepower suppression, smoke, EW, mine warfare, chemicals, and

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the like are accepted by the Soviets are normal battlefield threats. The doctrinal emphasis is upon continuing to operate and perform assigned tasks in spite of their presence. Until quite recently, U.S. development with its focus on high efficiency of individual items, has failed to take such a completely realistic view of the entire combat environment. The effects of smoke, for example, on ATGMs and laser designators was not tested quantitatively until 1976. The smoke issue itself typifies much of the U.S. problems as well as Soviet propensities.

(U) Testing of new technology appears to follow a similar pattern. U.S. tests are primarily technical and with small numbers of items, a clear environment is used, degrading influences are lacking, and evaluations are usually one-on-one. Obviously this permits a more scientific and controlled means for measuring performance and keeps costs down. But equipment tests under operational conditions by real users appear to be the only means for providing proper feedback on performance to be expected under combat stress.

(S) Soviet testing has greater operational emphasis, typically involves large numbers of items in the hands of operational troops for extended periods of time, and is subjected to realistic conditions including degradations. Although the Soviets may gain some insights into the operational value of new technology through this procedure, they have experienced some difficulties that suggest that all is not so well in the system; some new tank engines and the tank cannon automatic loader are examples of mechanical breakdown still occurring after the items have been fielded.

V. INFLUENCES ON TECHNOLOGY IN DEVELOPMENT AND APPLICATIONMATERIAL DEVELOPMENT

(U) As noted earlier, Soviet technology developments appear as part of a continuous stream of technological change, whereas U.S. developments more typically are discrete ones, in which resources are allocated and design and engineering teams are formed for the purpose of developing and producing a specific system.

(U) One of the clearest and most significant differences in the development systems of the two countries is the Soviet emphasis on production requirements even at the expense of performance, with a limitation on new subsystems, as contrasted with the U.S. emphasis on meeting high technical performance requirements, using more new subsystems than the Soviets,⁽²⁰⁾ and with production requirements playing a much less significant role in affecting design and development initially.

(U) Alexander has elaborated the long-term Soviet philosophy of mass production:

The demands of mass production and mass use have placed firm constraints on tank design that continue to be felt today. Comparatively simple designs, easy and cheap to mass produce, have characterized Soviet armor since the 1930s. A weapon produced and used in large numbers should also be easy to operate and maintain, reliable, and yet not be markedly inferior to enemy weapons. Standardization of parts, multiple use of components between different models of the same generation, limited change between models of succeeding generations, and, most important, a restrained selection of functions and performance levels have been the means for achieving Soviet weapon design goals. (14)

(U) Soviet doctrine has always emphasized the necessity of having mass and large numbers. High production rates are facilitated by designs that do not require very tight tolerances, and by using as few new parts and subsystems in a new system as possible. Both of these features are exemplified in Soviet design. Whalen suggests "The common tendency, from the onset of the first step in the product cycle,

is to 'negotiate down' on technical complexity and performance. This phenomenon, in contrast to U.S. practice, is active beginning with the earliest proposal stages."⁽⁵⁹⁾ The workings of the economic system itself force a greater attentiveness to production factors.

The unreliability of supply from the civilian sector imposes a reluctance on designers to ask for new components, or to go to suppliers with whom they have not dealt in the past. Supply problems create incentives to use previously developed components that may not be optimal from an overall design standpoint, but that can be counted on to perform to known specifications and that are known to be available from proven suppliers. The rigidities of the planning process allow little flexibility in substituting one material or device for another, or in making reallocations within a given budget level. All of these conditions encourage a conservative evolutionary approach that minimizes the necessity for flexibility and reallocation. (14)

One of the means by which the Soviets are able to develop confidence in the performance and producibility of subsystems is through maintaining stable design bureaus to incorporate new technology into the design of various subsystems in a routine, continuous manner, independent from the demands of any particular new systems. Designs developed in this manner are available in handbooks which are used by system developers to choose components and subsystems for new systems. For any routine type of subsystem, such as engines or tank guns, extensive testing would occur before the design is certified as sound, and little technical risk would be permitted in incorporating the subsystem into an overall system. New types of subsystems, however, for which there is less experience and for which a series of incrementally improved models do not exist, can be expected to have greater problems. To restate an earlier example, an automatic loader for T-64/T-72 series tanks was in early designs: although mechanically quite simple, it is probably susceptible to failure to a greater extent than the manual system it replaces. When higher risk technologies such as this are incorporated, the system can be expected to undergo subsequent modifications as operational experience reveals potential improvements or refinements.

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The current Soviet tank series of T-64 and T-72 seems to include several similar vehicles, with major differences such as engine design as well as minor differences. The HIND helicopter, although introduced in 1974, has already undergone a significant modification in leading to the HIND D model, with changes made in its gun armament, fire control, and ATGM type. These changes, or the provision for the design to accommodate such changes, appear planned from the start and illustrate the extent to which the Soviets design and field new systems while simultaneously planning for their modification as new subsystems are developed. No system is thought of as having achieved an absolute standard that cannot be improved upon as part of the natural course of technical change.

In the United States, systems are not typically designed to accommodate future modifications. The 120-mm gun for the XM1, as a follow-on to the initial deployment of XM1s with the 105-mm gun, is a notable example to the contrary, but the decision for its incorporation was made on international political grounds and was strongly resisted by the Army and the U.S. R&D community. More typically, the advent of more advanced systems is downplayed, their development is submerged or delayed, and their funding is deleted or reduced to keep them from threatening the more imminent system, or the system already in place. In ATGM technology, the long development and deployment time for TOW and DRAGON kept such developments as laser beamriders and HELLFIRE-type systems from being developed more rapidly; these competitors might have detracted from the high effectiveness of TOW and DRAGON that were being reported in order to continue to justify these programs. The possibility that all of these systems can be developed compatibly, rather than competitively, and that technological change is normal is not viewed as politically or budgetarily acceptable, although the Soviets would not have comparable difficulty in this regard.

Developers or backers of these new systems have to feature the improvements over TOW and DRAGON that they offer, in order to justify their programs, thereby putting them into an adversary relationship. Although such competitiveness can be, and certainly has been, the

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source of great technological progress and innovation, the adversary relationships that ensue can also *greatly inhibit the rate of modernization of technology, once it has gotten its initial boost.*

Development of TOW

Analyses and thoughtful assessments of the material development and acquisition process, for both the United States and the Soviets, have been performed by a number of authors. Their findings will not be repeated here. Rather, it is useful to relate the development process to other areas of concern in this study. Of major concern are the relations among technology development, perceptions of the battlefield, and the nature of combat. The development of the TOW missile has been examined in some detail.

Conceived on a cocktail napkin in about 1958, TOW did not emerge from the development and testing system and reach IOC until 1970. In the initial planning, about five years was allocated to field the system. Two major program changes extended this and a number of others perhaps contributed; it took over twice as long to field TOW as was originally estimated.

In view of the urgency and top level interest associated with this [TOW] program, I have authorized certain deviations from our normal way of doing business. Initial development will consist of several contractor competitive design programs which will be evaluated at the end of approximately six months in a system feasibility demonstration. There will also be a parallel in-house effort. It is intended that the system winning this competition will be placed in final development and production starting at the beginning of FY 63. (60)

With this level of attention and urgency, the TOW development program got under way. The milestones of the program are outlined in Table 11. Not shown are the major problems which caused the IOC slip-page from late 1965 to September 1970 and a 160 percent cost overrun: (1) Unforeseen technical difficulties in meeting the original TOW requirement; (2) technical problems arising from significant changes in the original QMR, primarily the increase in range from 2,000 to 3,000

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Table 11

MAJOR MILESTONES, TOW PROGRAM

<u>Milestone</u>	<u>Completion</u> ^a	
	<u>Planned</u>	<u>Actual</u>
Draft QMR	1958	1958
Engineering development contract	1963	1963
Initial coordinated test program completed		1964
QMR approved		1964
Engineering/service test began	1965	1966
R&D acceptance test completed		1967
Limited production type classification approved	1965	1968
First production contract awarded		1968
Engineering/service test completed	1965	1969
Delivery of first production missiles	1966	1969
Type classification standard	1965	1970
First unit equipped (IOC)	1967	1970

SOURCE: Reference 61.

^aDue to changes in milestone descriptors and program elements during TOW development, no effort has been made to synthesize exact parallels.

meters;* and (3) production problems that threatened system reliability.

Details of the development program are well documented and will not be repeated here. Rather, we shall examine in some detail the concepts of TOW mobility with relationship to its infantry role, and the resulting confusion in getting TOW on a vehicle and under armor (or at least providing some protection). Despite the general mechanization of infantry during the 1960s, TOW when fielded was still a weapon system primarily for dismounted infantry.

*In 1964 the Army also added a requirement for a night-sighting device for TOW. This eventually was broken off into a separate parallel effort and did not delay developments of the basic TOW system.

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The Mobile, Protected TOW. Two prime characteristics to be achieved by integrating a weapon system with a vehicle are mobility and protection. These in combination provide an increased measure of survivability.** But when the prevailing attitude and doctrine hold that the infantry will conduct the majority of its combat missions in a dismounted mode, mobility becomes only that means for getting to the battle.

In the conceptual development stages of TOW, little real emphasis was placed by infantrymen planners on the notion of mobile, protected firepower. Few infantry formations then were mounted in personnel carriers, other than those assigned to armored units. The situation today has significantly changed, but a 1978 observation reflects this long-standing attitude: "The present Infantry concept concentrates its emphasis on supporting the unprotected dismounted soldier on the ground and Armor leaders concentrate on supporting the mounted man servicing a mobile, protected, destructive weapons system."⁽⁶²⁾ The accuracy of this assertion is not argued, it is used only as an indication of the persistence of views on roles and missions that were factors in early decisions on how TOW would be employed.

Early documentation suggested some interest in vehicle mounting:

It is recognized that the TOW system is considered primarily as an infantry weapon system; however, consideration will be given for vehicular adaption. Included in these preliminary design studies will be the M-15 infantry vehicle, the M-60 tank and the AR/AAV vehicle. Particular attention will be paid to the study involving TOW and the AR/AAV vehicle to insure compatible weapon-vehicle coupling. This study will include the investigation of launching tubes having fixed or removable gas ducts, in order not to jeopardize on-board operation of the launchers.*

A key issue submerged in this statement is recognition of the need to dispose of exhaust gases if the TOW launcher is mounted inside the

* Such a broad generalization eliminates discussions of the necessary trade-offs among armor protection, vehicle agility, silhouette, etc. These are essential in complete systems design, but not pertinent here.

** Reference 63, pp. 4-5.

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vehicle. Technology to achieve this was in existence, but little or no attention was paid to integrating TOW into a vehicle system.*

The above quotations followed a section discussing the ground mount, a single wheel, split trail, joy stick device, which was to be a modification of the 120-mm recoilless HAW mount--clearly pointed toward the dismounted infantry support role. It suggested a strong tie with old materiel (a new weapon on an old mount) while emphasizing the absence of change in employment doctrine.

Frankford Arsenal qualified itself to perform the preliminary engineering design study on the basis of eighteen years experience in development of *infantry* weapons,** but it had little background in systems mounted on or in armored vehicles. Although it had completed some studies of artillery munitions and some rocket systems, the effects of such systems on exposed personnel and unprotected weapons were not covered.

From this, it may be inferred that initial studies of TOW were conducted from the dismounted infantry viewpoint, with little reason to consider a complicating excursion into interior vehicle mounting for a system being developed under such considerable urgency. Brief discussions of vehicle mounting appeared to be considerations of placing TOW *on* vehicles rather than *in* vehicles with one exception: TOW was initially to have been capable of being fired from a 152-mm tube, this in the M60 tank and the AR/AAV. There was no suggestion that this was to be the Shillelagh tube, but the connection seems clear. The citation reveals a number of interesting items:

Configuration must:

Permit the crew to man-handle the system for short distances.

Impose minimum space requirements when mounted on and fired from a vehicle. Vehicles from which the system must be fired:

Lightly armored vehicle for mechanized battalion use.

Unarmored vehicle for Infantry and Airborne use. Helicopter (UH1B). Desirable but not required.

Should not delay development of the weapon for other modes of employment.

* George Schechter, personal interview, 22 November 1978. Schechter worked with the Hardison group and authored the Frankford evaluation plan, Ref. 63.

** Ref. 63, p. 1-3 and Appendix 5.

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From the XM60 Tank and the AR/AAV. In this mode the guided missile and companion free round must be capable of firing from a 152mm tube.

Permit rapid, easy ground emplacement.

Result in low silhouette in ground firing position.

The system must have the ability to engage targets in all weather and under all conditions of visibility.*

This last item, bearing on battlefield obscuration and night capability, also got little attention at this juncture.

We shall briefly examine separately the mobility question and the requirement for overhead armor protection against the effects of suppression.

TOW and Vehicle Mobility. In the early days of TOW development, there was some visualization of its use in a mounted mode. "It fills a requirement for a weapon capable of operation from the ground, unarmored or lightly armored multipurpose vehicles, and helicopters."** But the catch is that the notion, developed somewhat later in the document, envisions the TOW being "stowed in such a manner that permits quick emplacement for firing from the deck of the vehicle or quick removal for ground emplacement."*** What appears to have been important at that time was that, when stowed, the TOW did not give the vehicle a distinctive signature. But it could not be fired from the stowed position and when mounted on top of the vehicle (the "deck" mentioned above) the TOW had no armor protection and the crew also had to be exposed. Although it could be fired from the vehicle using an adapter kit, this was not in any way to detract from its capability to be dismounted and carried in man-portable loads. The concept provided only a means for transporting TOW at the same speed that infantry could be transported in carriers.

A major advantage of vehicle employment was the ammunition-carrying capability provided by the vehicle. For the M-113 version, ten TOW missiles could be carried in addition to the launcher system and the crew. For the

* Ref. 63, pp. A4-2 and A4-3.

** Ref. 64, p. 1-1.

*** Ref. 64, p. 4-45.

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M-151 vehicle (jeep) system, two vehicles could carry one complete TOW launcher system, the crew, and eight missiles. The M-274 (Mule) system used one vehicle to carry the complete TOW launcher system and five TOW missiles, the crew transportation not being discussed. Apparently the Mule was to be purely transport for the system, although a firing capability was designed and tested.

Consideration of mounting TOW on vehicles was driven mainly by the perceived need to have the system as mobile as its prime user, the dismounted infantryman. It would ride to battle with some protection, but be used dismounted, on foot.

At about this time at the Infantry School and in infantry units, there was a controversy in progress as to the desirability of providing the infantry the capability to fight while mounted in vehicles. In 1963 and 1964, for example, the Second Infantry Division expanded to full division strength by activating a second tank battalion and two battalions of mechanized infantry. With the armored cavalry reconnaissance battalion, this provided the division with a five battalion armored brigade. Elements of school troops at Fort Benning were similarly organized and equipped, and instruction of infantry-tank tactics and operations formed an integral part of the infantry school's courses. But in unit training and maneuvers, the infantry rode to battle and fought on foot. The controversy was over what type of weapon to mount on the carrier for use in support of the dismounted infantry squad; it had nothing to do with how the squad was to fight. Antitank training was extensive and intensive, but it was designed to pit a dismounted infantryman against an enemy tank. Mounted antitank warfare was for tankers, not infantrymen. Tank support for infantry had evolved considerably from World War II notions of the "infantry" tank, but the two branches remained aloof when not integrated within the structure of an armored division.

Curiously, at about this time, there was awakening awareness of the expansion of the artillery capabilities of Pact armies. The dispersion tactics adopted as a counter to nuclear concepts in the late 1950s were refined to fit the situation; radar gap surveillance, improved communications means, and longer range firepower had made it practical

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