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NEW WEAPONS TECHNOLOGIES: IMPLICATIONS FOR DEFENSE POLICY

by

ROBERT KENNEDY

The following article is adapted from a presentation given at the NATO Defense College in Rome on 19 March 1979.

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Both the Soviet Union and the United States have invested heavily in new weapons technologies over the past few decades. Successes in component miniaturization, computer electronics, nuclear fusion, small engine design, high energy/heavy hydrocarbon fuels, guidance technologies, and a host of other areas have combined to mark the rapid pace of technological advance. An understanding of the impact of these new technologies and their capabilities and limitations is essential if a balance is to be maintained in the military force postures of East and West which guarantees the long-term security of the nations of the Atlantic alliance. With that in mind, let me focus on several prominent technologies and explore some of their potential implications.

DETERRENCE AND STRATEGIC STABILITY

Advances in computers, missile guidance, engine technologies, and miniaturization have increased the reliability and accuracy of US and Soviet strategic nuclear forces and have permitted the development of multiple independently targetable reentry vehicles (MIRVs). As a result there has been a tremendous expansion in the strategic arsenals of both the United States and the Soviet Union—an expansion that many contend not only devalues the deterrent utility of the US strategic arsenal, but also threatens strategic stability.

On the first point, it is argued that in light of MIRV technologies, the consequent multiplication of Soviet strategic forces, and the destruction such forces now portend should a strategic exchange occur, the United States is less likely to respond to Warsaw Pact aggression with its strategic arsenal than it might have been a decade ago. As a result, many Western defense analysts contend that US strategic nuclear forces no longer serve as a credible deterrent to aggression in Europe. Rather, they believe that US strategic deterrent forces are now themselves deterred by the promise of the holocaust that would be produced by a Soviet response.

However, such a proposition ignores several important factors which are likely to bear on the question of deterrence. First, the Soviets have proven themselves to be very conservative defense planners. They appear to be sensitive to the uncertainties of conflict and have demonstrated a preference for low-risk initiatives. While technological improvements in strategic forces have permitted the Soviet Union to dramatically increase the size of its strategic arsenals, technology has also enhanced the destructive potential of US strategic capabilities. Any conflict in Europe that chanced the involvement of the strategic arsenals of the superpowers would be a high-risk venture. Second, many in the Soviet Union believe that the United States has demonstrated its willingness to use force in high-risk endeavors, as evidenced by US military initiatives in Korea and Vietnam. Moreover, they are concerned not only over US capabilities for conducting limited strategic nuclear options in support of conflict in Europe—capabilities which have been enhanced by technological improvements in accuracy, real-time intelligence, and rapid missile retargeting—but also over US policy pronouncements which openly proclaim the utility of such limited options. As a result, the Soviet Union is aware of and concerned over the potential for escalation should conflict occur in Europe. Hence, Soviet leaders are likely to remain deterred from any deliberate aggression in Europe in the foreseeable future, as they were when the United States possessed an unquestioned strategic superiority.

While the expansion in the Soviet strategic arsenal may have had little effect on the value of US strategic forces as deterrent to deliberate aggression in Europe, this continuing expansion may well threaten the value of strategic forces as a means of achieving a satisfactory conclusion to a conflict resulting from accident or miscalculation. On the one hand, while a limited or threatened use of strategic forces in support of limited options may signal US resolve and force Soviet leaders to consider negotiated solutions and conflict termination, it is equally compelling to assume that they may see that same limited use as a movement toward an inevitable and total US-Soviet strategic exchange. As a result, they might decide to preempt with the full weight of their strategic and tactical nuclear forces. On the other hand, if NATO chooses to reply to a Soviet aggression with a total rather than a limited strategic and theater nuclear response in order to avoid an impending battlefield defeat, the exchange of nuclear weapons likely to ensue would be so highly destructive that even if the Soviets were forced to terminate their aggression, the conclusion of conflict could hardly be called satisfactory. Hence, it would appear from either of the above cases that the value of strategic forces as a means for forcing a "successful" conclusion to conflict in Europe has diminished.

To fill this void, NATO must now focus its attention on its theater nuclear and conventional forces. If any conflict which might occur is to be satisfactorily terminated, these forces must not only promise to deny the Soviet Union and its Warsaw Pact any hope of success on the battlefield, but must also be capable of extracting costs exceeding benefits should deterrence fail.

Strategic Stability

The most potentially threatening effect of technological improvements in US-Soviet strategic forces, however, is not on deterrence or conflict resolution, but rather on strategic stability. Before the advent of the MIRV and improvements in accuracy, neither the United States nor the Soviet Union could contemplate a successful preemptive first strike. For example, in order to have had a high assurance of destroying one US intercontinental ballistic missile in its silo, the Soviet Union would have had to fire two or three missiles. When one added to that the requirement not only to neutralize the SLBM force at sea, but also to destroy a well-dispersed strategic bomber force, the problem was compounded. Conceivably, the Soviet Union could expend its entire missile force, while only destroying a relatively small portion of the US strategic retaliatory capability. The United States would have been confronted with a similar, although not

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identical, problem. Thus, in the pre-MIRV/high accuracy era, there was an inherent stability in the strategic equation. Neither side would benefit from a strategic preemption which left its society and remaining military forces at the mercy of the strategic retaliatory forces of its adversary.

The "MIRVing" of strategic forces, however, has dramatically increased the total number of warheads available to both the Soviet Union and the United States, while improvements in accuracy are reducing the number of warheads required to assure the destruction of a single target. The balance remains stable today; however, the continued MIRVing of missile forces and further improvements in missile accuracy threaten stability at the strategic level in the future. Soon both the US and the Soviet Union may have a theoretical preemptive first strike capability.

Using equations popularized in 1974 by Kosta Tsipis, senior researcher at the Stockholm International Peace Research Institute, one can calculate the hard-target kill capability required to destroy (within a given probability) US and Soviet strategic missile forces in their silos (KS)[1] and the hard target kill capability available to each of the superpowers (KN).[2] Such calculations indicate that both the United States and the Soviet Union will soon possess more than sufficient hard-target kill capability to execute a preemptive first strike which, at least theoretically, would be able to destroy a large portion of the land-based missile forces attacked.[3]

While many factors affect not only the ability to execute a successful counterforce preemptive strike, but also the incentives to initiate such an attack, the aggregate impact of improvements in MIRVs and accuracy may well be the development of dynamic instability at the strategic level. In situations where some form of great power conflict appears likely, each superpower, fearing loss of a sizeable portion of its strategic arsenal, may be tempted to use rather than lose it. This may be particularly true of the Soviet Union, since they have invested much of their strategic capability in land-based missiles.

Strategic Stability and Mobile Missiles

However, while technological improvements in MIRVs and accuracy appear to threaten strategic stability by increasing the vulnerability of land-based retaliatory forces, other advances in technology offer the promise of reducing potential strategic vulnerabilities and thus preserving stability at the strategic level. Two such advances are modern cruise missiles and mobile ICBMs.

As numerous defense analysts have noted, the adaptability and versatility of the cruise missile permit its deployment on a wide variety of platforms. Moreover, because of its small size, its specific deployment location could be concealed. Cruise missiles might thus be deployed on any number of aircraft, surface ships, submarines, or on land-mobile launchers. As such, they might constitute an almost totally invulnerable strategic deterrent retaliatory force. Likewise, the deployment of mobile ICBMs would seriously complicate Soviet targeting problems and thus reduce the vulnerability of strategic forces to preemptive attack.

Critics of these programs, however, have been quick to point out that the very factor that contributes to their invulnerability—that is, the ability to conceal their location—also enormously complicates the verification problem. In the absence of verification, it is argued, SALT limitations would be meaningless. Hence, many statesmen and defense analysts are concerned that cruise and mobile missiles will spell the end to efforts designed to constrain the upward spiral in arms acquisitions.

In response, one might argue that the advent of a virtually invulnerable strategic retaliatory force may well obviate SALT. In theory, at least, there is an upper limit on the number of targets that must be successfully attacked in order to promise the destruction of an adversary and thus preserve the deterrent value of one's strategic retaliatory forces. If through technological advances the forces required to strike these targets can be made invulnerable to preemptive attack, then presumably the size of strategic arsenals need not greatly exceed that necessary to destroy the required number of targets, even in the absence of SALT.

On the other hand, if the action-reaction cycle of technological advance were to produce weapons capable of threatening the destruction of such seemingly invulnerable or low-vulnerability systems as cruise missiles or mobile ICBMs, the absence of SALT might set in motion a costly and seriously destabilizing expansion of strategic armaments that might otherwise have been avoided.

ENHANCED RADIATION WEAPONS AND NATO DEFENSE

Next, we need to direct our attention to a recent advance in nuclear technology which, some have argued, promises to drastically improve NATO's theater nuclear capability—the neutron bomb. Those who have supported neutron or enhanced radiation (ER) weapons have argued that ER weapons are not only more effective against Soviet armor formations than the current generation of nuclear weapons, but also will enhance the deterrent utility of NATO's theater nuclear forces. However, critics have argued that such weapons obscure the boundary between conventional and nuclear weapons, with a potential consequent lowering of the nuclear threshold. Furthermore, they contend that ER weapons are intrinsically inhumane—preserving property while killing and sickening people. Let me address these issues in reverse order.

To those who argue that ER weapons are intrinsically inhumane, I would suggest that radiation effects are not peculiar to enhanced radiation weapons. Over a specific area of intended military effect, the same levels of radiation would be present whether targets were attacked by ER weapons or by larger-yield standard fission weapons employed to achieve comparable military effects. Moreover, if in war a principal moral objective is to avoid unintended harm to noncombatant civilians and to preserve those societal structures which not only represent the creative imagination and labor of man, but also permit a more rapid postwar recovery, then evidence suggests that ER weapons are clearly superior to standard fission weapons of comparable military effect.

To those who argue that ER weapons are likely to lower the nuclear threshold I would suggest that they fail to realize or understand the nature and magnitude of considerations likely to precede a decision to use nuclear weapons. The decision to cross the nuclear threshold will be principally determined by perceptions of the potential for escalation involving the strategic systems of the United States and USSR, the perceived urgency of the military situation, the likelihood and probable nature of a Soviet theater nuclear response, the potential military impact of use of nuclear weapons on Warsaw Pact forces, and the potential for de-escalation and conflict termination. In view of the magnitude of such considerations, any inhibitions imposed on the NATO nations by collateral damage concerns are not likely to weigh heavily. This is especially true since NATO currently has in its arsenal very low-yield nuclear weapons which could be employed to avoid unintended collateral damage.

Proponents of ER weaponry contend that the promise of reduced collateral damage increases the deterrent utility of such weapons. They argue that the Soviet Union is less likely to be deterred from the initiation of a conventional or nuclear aggression by current battlefield nuclear weapons which, while militarily effective, would produce high levels of collateral damage in Western Europe, than by ER weapons which because of their reduced collateral effects may be considered more usable by the West. This contention, however, deserves further analysis. If deterrence depends on Soviet perceptions of the total military effectiveness of NATO's nuclear arsenal, then NATO's current theater nuclear forces serve as an effective deterrent to Soviet aggression in Europe. These forces currently include a wide variety of air-, sea-, and land-launched weapons of multiple yields which are viewed by the Soviets as being sufficiently diverse to pose a major threat to the successful employment of Soviet forces on the continent of Europe.

Furthermore, if deterrence depends on Soviet perceptions of a NATO willingness to employ theater nuclear forces (TNFs), there is little evidence that the Soviets believe NATO would withhold its use of these weapons because of collateral damage considerations, should failure of the NATO defense seem imminent. Hence, the acquisition of ER weaponry is not likely to alter the deterrent equation in Europe.

Finally, concerning the military utility of the ER weapons, evidence currently available clearly indicates that ER weapons are useful additions to the battlefield. Since armor formations are inherently resistant to blast and heat, the primary kill criteria for armor has been radiation. A 1-kiloton (KT) enhanced radiation weapon produces the same desired military effects as a 10-KT standard fission weapon. However, it promises to reduce unintended casualties and collateral damage outside the immediate target area. Figures 1 and 2 are displays of data provided by Brigadier General Edwin Black and Sam Cohen. Cohen has often been called the father of the neutron bomb. From the figures, we can see that a 1-KT enhanced radiation warhead can incapacitate tank crews up to a radius equal to that of a 10-KT standard fission weapon, while nearby urban areas would be spared the effects of blast of the larger fission weapons and few casualties would result.[4] Hence, in the event of a conflict in which theater nuclear weapons are being employed, the availability of ER weapons would permit a more judicious and efficient use of nuclear weapons in certain situations than would the current stockpile of standard fission weapons.

PRECISION GUIDED MUNITIONS

I would also like to discuss a series of technological advances that have resulted in developments which some argue will serve to drastically alter the nature of conventional warfare. I refer here to the development of modern precision guided antitank weapons.

Following the Vietnam War and the 1973 Arab-Israeli conflict, precision guided munitions (PGMs) were heralded as marking the birth of a revolution in modern warfare. With respect to NATO, analyses suggested that the West no longer need choose between defense policies which either rely on nuclear escalation and the potential destruction of Western Europe or demand the enormous expenditures likely to be required to match Soviet investment in conventional military capabilities, especially in armored formations. Rather, precision-guidance technologies, it was argued, appeared to offer a potentially effective counterbalance to growing Soviet military capabilities by enhancing the inherent advantages of the defense, improving flexibility, reducing collateral damage, and reducing cost.

Nevertheless, major differences of opinion over the utility of modern PGMs continue to surface among statesmen, academicians, and members of the defense community on both sides of the Atlantic. Hence, an evaluation of PGMs—capabilities and limitations—is both timely and necessary as NATO addresses its defense requirements for the 1980's.

Defense Over Offense

First, the contention that PGMs inherently favor the defense is founded upon the notion that target acquisition is now the key to success on the battlefield: If a target can be seen, it can be hit with modern precision weapons. And as James Digby of the RAND Corporation and one of the early students of PGMs has noted: "For many targets, hitting is equivalent to destroying." Hence, it is argued, concealment has become an important feature of the battlefield. If a target moves, it can be seen; if it can be seen, it can be destroyed. Generally speaking,

Radius of Effects (Meters)				
Yield	Tank Crew incapacitation from radiation	Tank destruction from blast	Urban destruction from blast	Unprotected casualties
1 KT fission	350	150	500	800
1 KT ER	700	120	400	1,000
10 KT fission	700	350	1,200	1,200

Figure 1

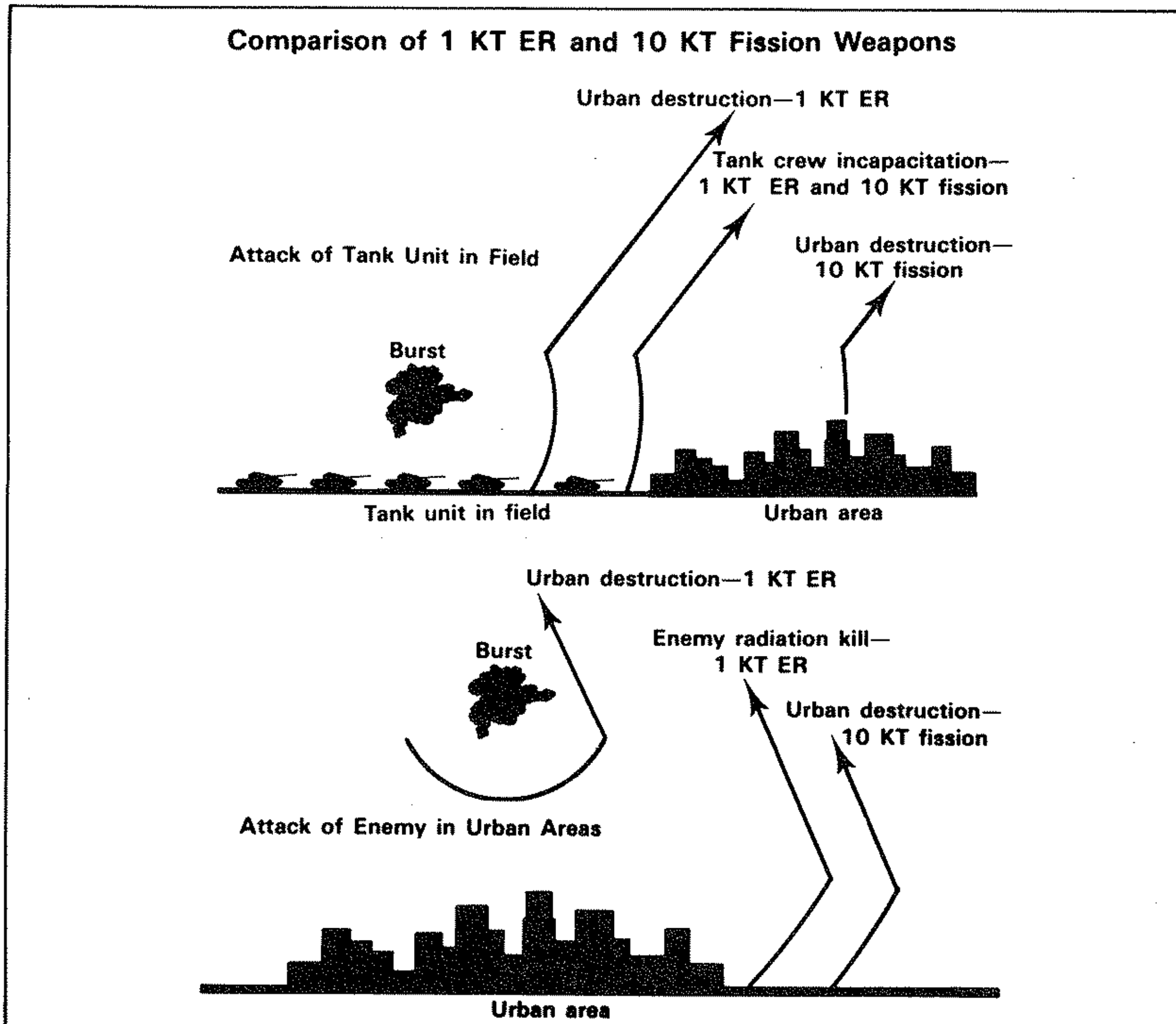

Figure 2

proponents of PGMs contend the attacker must concentrate his forces for an advance, usually through unfamiliar territory. His forces are thus exposed to detection and attack. Furthermore, they contend, it is usually much easier for the defender, operating in familiar terrain from prepared positions, to remain concealed.

Proponents of precision weaponry contend that the topography of Western Europe serves to enhance the advantage likely to accrue to the defense should war occur in Europe. Unlike the Sinai and the Golan Heights, both of which for the most part are characterized by open country which is not often amenable to concealment, much of Western Europe favors concealment. On the flanks, PGMs are well suited for operations in Norway along the fjords or in its rugged terrain which sits astride the principal north-to-south approach routes. Soviet forces advancing southward would be naturally channeled by the terrain. PGMs could be employed to inflict heavy casualties on Soviet forces while NATO mobilized and dispatched troops for defense.

Likewise, it is argued that precision guided munitions should prove valuable in the mountain passes of Italy or in the rough terrain of Greece or Eastern Turkey. Such terrain favors the mobility, concealment, and capacity for rapid dispersion likely to be characteristic of a well-organized defense based on precision weaponry.

In central Europe, it has been argued that topography also promises to favor antitank defense—that the forests of central Germany and the increasing urbanization throughout central Europe provide natural and man-made concealment and will tend to channel attacking forces. Viewed from the eyes of a Soviet planner, every village, town, and city must be considered a potential barrier, every house a potential pillbox from which concealed NATO forces could employ PGMs to devastate attacking armor. As a minimum, it has been argued that such an environment offers the prospect of slowing the tempo of major Warsaw Pact offensive thrusts, thereby gaining for NATO time to mobilize its vast resources.

One must be careful, however, not to fall prey to an unqualified optimism concerning a defense of Western Europe based on modern antitank munitions. First, the Soviets have already acquired a substantial arsenal of precision guided antitank and antiaircraft weapons which, in many instances, can be used effectively against NATO. In the air, NATO relies heavily on its fighter aircraft for interdiction and ground support. The increasing sophistication of Soviet surface-to-air missiles (SAMs) and antiaircraft artillery (AAA) may make it prohibitive to conduct large-scale air-to-ground attack missions. Likewise on the ground, despite the West's defensive orientation, NATO will be engaged in a number of "local" offensive initiatives. I refer here to the wide variety of operations such as armored probes, armored counterattacks, and perhaps even amphibious assaults designed to regain allied territory.

Correspondingly, not all Warsaw Pact forces would be involved in offensive or blitzkrieg operations. Such operations are likely to be restricted to those areas chosen for breakthrough. The remaining Pact forces, some 95 percent, would be tasked to defend a much larger portion of the front against a NATO counterattack.

Second, while terrain features afford protection and concealment to the defender, they also provide a terrain mask for attacking forces. The hills, forests, villages, and vegetation serve to break the field of fire and line-of-sight necessary for defending PGM crews to recognize and fire upon attacking armored targets at ranges where PGMs are at a distinct advantage. For example, if an antitank guided missile (ATGM) attacks a target at 3000 meters, the missile time of flight is approximately 15 seconds. If a gunner acquires and fires in 20 seconds at a tank moving toward him at the rate of 8 miles per hour, the tank must remain exposed for 126 meters for the ATGM to score a hit. The probability of a tank remaining exposed for 126 meters (even if no evasive maneuvers or countermeasures are employed) is only .35 on the North German plain and only .64 in the Fulda region.[5]

Third, while urban sprawl offers an opportunity for NATO to enmesh attacking armor in a grid of antiarmor defenses, it is by no means clear that such a strategy is politically feasible in Western Europe. For fear of collateral damage, NATO—especially Western Germany—might well decline to develop plans and provide those types of forces which could transform its villages, towns, and cities into effective strongpoint defenses.

Fourth, relatively simple countermeasures are currently available (smoke, aerosols, camouflage, and maneuver). Moreover, more sophisticated countermeasures such as radio link jamming, laser blinding of electro-optical systems, and flares for imaging infrared systems can be foreseen. Perhaps the single most significant countermeasure, however, has been the new armor materials which are capable of withstanding multiple attacks by virtually all known types of ATGMs, a development that has taken place in a number of NATO countries and is likely to be echoed in future variants of Soviet tanks.

Finally, Soviet tactics may offset a number of the advantages which appear inherent in the defensive employment of PGMs. Phillip Karber, the Director of Strategic Studies at BDM Corporation, contends that three major tactical options designed to overcome defenses based on PGMs appear to be under discussion in the Soviet Union: the nuclear option, the artillery option, and the maneuver option.

According to Karber, several Soviet writers have argued recently that the use of nuclear weapons would force the defender to disperse his forces to an extent that would permit attacking Soviet infantry to remain mounted in armored personnel carriers and proceed at high rates of advance.

Other Soviet writers have argued that traceable signatures, the inability to operate ATGMs by remote control, the lack of "fire-and-forget" systems, the absence of crew protection, and certain constraints on mobility render many currently operational ATGMs highly vulnerable to suppressive artillery fire. Karber has pointed out that Soviet artillery officers have emphasized that the suppression of the enemy's antitank defenses is the most important task of the artillery.

Perhaps the most troubling tactic now under consideration is the surprise or maneuver option. Karber contends that Soviet armor advocates are calling for preemptive maneuver as the best means of overcoming the challenge of antitank weapons. Rather than slow the offensive through the massive use of artillery or through infantry sweeps, they would prefer to attack the defense before it mobilizes and deploys its dense antitank defenses.

This is the worst-case scenario to which such observers as Senator Sam Nunn, General Johannes Steinhoff, Lieutenant General James Hollingsworth, Brigadier General Robert Close, and others have addressed their alarms. Such an attack using in-place theater forces might provide NATO with little or no prior warning. Given the current peacetime NATO deployment patterns, failure to receive adequate warning of an impending attack could be catastrophic.

Along with Karber's three options, I think we must consider a fourth option as we plan for NATO defense in the coming decades. That option, the chemical one, is often overlooked. Nevertheless, one of the most impressive lessons of the October War was our realization that Soviet equipment was designed to operate in a highly sophisticated chemical environment.

The use of chemicals against NATO forces, which on balance are neither adequately equipped nor effectively trained to fight in a chemical environment, might be an attractive alternative should a bold Soviet offensive thrust encounter stiff resistance by NATO antiarmor PGM teams. Rather than dismount infantry from APCs or wait for artillery support to counter NATO ATGM teams and risk slowing an offensive heavily dependent on surprise and rapid maneuver, the Soviets might choose to use toxins or incapacitants. Such agents might be very effective in neutralizing NATO's antiarmor teams while permitting Soviet infantry to remain mounted and their attack to proceed at a high rate of advance.

Flexibility

Next, let us look at the issue of flexibility of forces. Proponents of PGMs are quick to point out that many ATGMs are lightweight and easy to operate. They can be hand-carried or mounted on trucks, helicopters, or fixed-wing aircraft. As a result, modern ATGMs can be moved more swiftly around the battlefield and more rapidly concentrated than can tanks for an effective defense against attacking armor. It is argued that ATGMs mounted on helicopters or aircraft, operating from safe zones or rear area havens and using "nap-of-the-earth" techniques, could be used to swiftly transit the battlefield under almost all but the worst weather conditions. Such a capability promises to combine speed and firepower and to provide NATO with an ability to concentrate antitank defenses rapidly at the points of significant stress. In the absence of such air-delivered ATGMs, it might take days to move sufficient armored forces and their logistic support train to meet the same threat. Moreover, proponents contend that helicopters can also be used to transport air-mobile infantry and their antitank weapons to remote locations in order to bolster ground antiarmor forces.

Finally, it is argued that the ease of operation and reduced training requirements of many ATGMs make it possible for NATO to create special antiarmor units. Such units could be part of the regular armed forces or could be maintained in a cadre status to be rapidly fleshed out by reserves and transported to the battlefield in time of conflict. They could also be held in reserve as ground or airmobile forces to be swiftly transported by truck or helicopter to the battlefield as weaknesses in the defense are identified.

Again, however, one must be careful not to overemphasize the potential utility of modern precision weapons as a means of enhancing flexibility. Experiences under actual combat conditions during the recent conflicts indicate that the helicopter may be more vulnerable than results of the trials in Europe have demonstrated. In the Middle East, both sides used helicopter-borne commando raids during which it was reported almost 50 percent of the helicopters were destroyed in the air. Moreover, in Europe helicopters are likely to be vulnerable to the Soviet ZSU, a highly effective antiaircraft weapon.

Furthermore, the intratheater mobility of infantry antiarmor teams may well be constrained by the added weight of the vehicles needed to provide protection to the crews operating against an enemy which has placed great emphasis on artillery.

Finally, weather may seriously reduce the employment flexibility of current-generation PGMs, especially antitank guided munitions.

During the 1973 Middle East War, surface visibility and minimal cloud cover presented no significant barrier to the use of PGMs during the daytime, although the effective use of precision guided antitank weapons was somewhat limited at night. On the other hand, weather will be a significant factor in any European conflict. During the winter months, the area is plagued by bad weather or covered by darkness more than 80 percent of the time.

In Northern and central Germany, cloud ceilings and visibility are below 3000 feet and 5 miles respectively more than 50 percent of the time from October through March. Moreover, fall, winter, and early spring are characterized by frequent fog which often severely restricts visibility and does not clear until midday.

Night is also likely to impose greater constraints on the successful employment of ATGMs in Western Europe than it did in the Middle East or Vietnam. Much of the most seriously threatened terrain of central Europe is located above 47° north latitude—a line which generally corresponds with the US-Canadian border. As a result, the winter days are very short. For example, if the Warsaw Pact chose to attack in midwinter, they could be assured of 15 to 16 hours of darkness every day.

The difficulty of employing current-generation PGMs successfully at night could prove to be a very serious limitation as the Soviets continue to emphasize surprise and continuity of operations through shock power and around-the-clock operations.

Despite the growing Soviet emphasis on all-weather and night operations and the current PGM limitations, recent advances in sensor, secure data link, and other technologies provide some hope of overcoming the aforementioned limitations. Use of magnetic and acoustic sensors in conjunction with automated readout equipment may provide not only all-weather surveillance, but also early-warning alert and target acquisition capabilities. Such initiatives, coupled with technological advances in radar, acoustic, laser, and thermal imaging systems, promise to significantly enhance NATO's night/adverse weather battlefield intelligence and attack capabilities.

Collateral Damage

The third issue I would like to address is that of collateral damage. Many analysts have argued that the accuracies of modern PGMs not only raise the nuclear threshold by making it possible to destroy some targets with conventional weapons which previously would have required nuclear munitions, but also make it possible to destroy with a single precision guided conventional munition certain targets (bridges, for example) which might have taken thousands of other conventionally delivered munitions to destroy in the past. In either case, it is argued that damage to the surrounding population and territory is likely to be reduced if conventional PGMs are employed in place of nuclear weapons or large-scale deliveries of standard conventional munitions.

Should the Warsaw Pact, however, place a heavy emphasis on artillery and rocket fire to suppress antitank and air defense units, the incidence of collateral damage in the battle area may well remain high. This would appear to be especially true in the areas chosen for breakthrough, where NATO can expect to be confronted with as many as 70 to 100 Soviet artillery tubes per kilometer, deployed in support of leading Soviet maneuver forces.

Moreover, if NATO chooses to create an interlocking net of antiarmor defenses based on urban sprawl, even greater collateral damage may result as the combined effects of artillery and air strikes are used by the Soviets to force defending units from villages, towns, and cities.

Thus, it would appear that while PGMs can destroy many targets with pinpoint accuracy, thereby eliminating the need for multiple attacks, it is by no means certain that the employment of PGMs by NATO will result in any sizeable reduction in collateral damage should a conventional war occur in Europe.

A more fundamental problem stems from the fact that while PGMs tend to raise the nuclear threshold, a number of defense specialists feel that PGMs actually lower the conventional threshold; that is, it has been the threat of escalation to nuclear war which has deterred conflict. The acquisition of any new weapons system which would appear to reduce the requirement for escalation to nuclear war is therefore considered by some as an invitation to aggression—and the resultant high level of collateral damage which could have been avoided altogether.

Cost Considerations

The final matter I would like to explore is the issue of cost. The argument is made that fewer men, hauling fewer munitions of greater accuracy, promise reduced cost for NATO. High-value targets can now be destroyed by a single round costing less than $5000.

The debate over cost, however, is far from concluded. Evidence increasingly suggests that while PGMs may be a fundamental requirement of the battlefield of the future, they are not likely to result in reduced defense costs for NATO.

First, while the unit cost of a modern precision guided round is low in relation to the target it is designed to destroy—approximately $4000 for a tube-launched, optically-tracked, wire-guided (TOW) missile versus $500,000 to $1 million and more for a main battle tank—system costs are likely to be high. For example, according to figures released by the Department of Defense, it would cost approximately $130,000 to field a complete TOW system, including launcher, night sight, and 10 missiles. Moreover, while progress is being made on developing advanced PGM systems capable of overcoming current limitations such as operations at night and in poor weather, these systems will be significantly more expensive than those currently being deployed. Hence, one can anticipate that as more advanced PGMs come into the inventories of the NATO nations, not only will unit costs of missile rounds be greater, but system costs expressed in terms of the required missiles, launchers, and vision/target acquisition equipment will rise significantly.

Second, as mentioned earlier, there will be an increasing need for protection for PGM crews. Such a requirement, however, will substantially increase the cost of precision guided systems. Even a minimum system such as the M-113 armored personnel carrier (APC)—currently being modified to mount readily available, relatively inexpensive ATGMs like the TOW—is likely to cost several hundred thousand dollars once the cost of the vehicle, its modifications, and costs for the ATGM system are accounted for.

Finally, the prospect of a war in Europe in which both sides are equipped with PGMs is likely to require significant expenditures to increase the quantities of pre-positioned war reserve materials.

During the 1973 Arab-Israeli War, by the end of the 17th day, 1700 tanks and 500 guns had been destroyed on the Arab side alone—losses roughly equivalent to the total of like weapons in the US Seventh Army in Germany. As a result, the next conflict in Europe is likely to be a "come as you are" war. Attrition is likely to exceed replacement capabilities. Hence, the earlier—and perhaps the most significant—portions of the war will be fought with the stocks of equipment and munitions available in the theater before the outbreak of the conflict. Without sufficient pre-positioned stocks, a war in Europe may well be lost before NATO's reserve potential can be effectively brought into play.

In view of the foregoing analysis, what might we conclude concerning the potential utility of modern precision guided weapons as a means of enhancing NATO defense? As a minimum, it would appear that the initial euphoria with which the age of the modern PGM was greeted is unsupported by an analysis of the evidence at hand. For those that were forecasting a "revolution" in modern warfare—a revolution which would provide a flexible and effective deterrent at reduced cost—it would appear that this new wave of advanced technology represents, rather than a revolution, an evolution in the age-old process of action and reaction in arms developments.

This is not to suggest, however, that no advantages are likely to accrue to NATO as it seeks to exploit its superiority in technology. Nor am I denying that steps might be taken which will significantly enhance the utility of these new generations of weapons within given bounds. Rather, it is to caution that technology must not be asked to do too much, and to emphasize that, as with those technological improvements at the strategic and theater nuclear level mentioned earlier, advances in precision guidance provide few solutions to the complex problems which confront defense planners. Rather, they offer alternatives which must be thoroughly examined before decisions are made which will affect defense policies and force structures in the coming decades.

NOTES

1. $KS = 2S \times (H)^{2/3} \times 0.144 \times [\ln(1-P)]$: where S = number of silos, H = silo hardness, and P = the desired probability of destruction. See Kosta Tsipis, "The Physics and Calculus of Countercity and Counterforcė Nuclear Attacks," *Science*, 7 February 1975, p. 397.

2. $KN = NY^{2/3}/CEP^2$: where N = number of warheads, Y = warhead yield, and CEP = accuracy (circular error probable). *Ibid.*, p. 396.

3. Assuming all Soviet SS-9s have been replaced by SS-18s and all but 200 SS-11s have been replaced by SS-17s and SS-19s, and assuming all earlier US and Soviet missile silos are hardened to 300 psi (US: Titan and MMIIs; Soviet: SS-11s and SS-13s), and all other missile silos are hardened to 100 psi, the Soviet countersilo kill capacity needed (KS) to destroy with a 97

percent probability (P = .97) all US ICBMs in their silos is 54,170. Likewise, the US countersilo kill capacity needed to destroy all Soviet ICBMs in their silos (P = .97) is 89,290. Within a few years the Soviet ICBM forces could have a countersilo kill capability (KN) greater than 250,000. This assumes, in addition to the Soviet force modernization stated above, that the Soviets achieve accuracies of .15 nm on their newer ICBMs. Similarly, the US ICBM forces could have a KN of almost 90,000 (if all MMIIIs are fitted with MK12A warheads and NS-20 guidance systems) and over 250,000 if terminally guided reentry vehicles (MARVs) are deployed on the MMIII.

4. Edwin F. Black and S. T. Cohen, "The Neutron Bomb and the Defense of NATO," *Military Review*, 58 (May 1978), 59.

5. US Department of the Army, *Operations*, Field Manual 100-5 (Washington: US Government Printing Office, 1976), pp. 13-15.