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TACTICAL PGMs: IMPLICATIONS IN PERSPECTIVE

by

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Precision guided munitions (PGMs), also referred to as "smart" weapons, are frequently viewed as modern scientific marvels and as *new* technology with great potential to revolutionize the battlefield of tomorrow. Their attributed unerring accuracy and relatively low cost in relationship to their targets gives them the much-sought-for potential not only to reduce the destructiveness of war but at the same time to reduce the massive cost of standing army, navy, and air forces. A proponent of this position is the Boston Study Group. In a recent article in *Scientific American*, the group outlined the essential aspects of its position by stating that PGMs can form the basis for not only a new arms control approach, but also one that can be adopted unilaterally and thereby stop the irrational momentum of the arms race. PGMs would allow the United States to cut the number of land-based Minuteman intercontinental ballistic missiles from 1000 to 100, the number of aircraft carriers from 13 to 3, and the number of Army divisions from 17½ to 11⅓.[1]

Others view PGMs, as well as technology in general, with much more cautious respect. For instance, Dr. Robert R. Fossum, Director of the Defense Advanced Research Projects Agency (DARPA), stated before a subcommittee of the Senate in March 1978:

> I bring to DARPA an experienced appreciation for the power of technology, but I also bring what I consider a healthy skepticism that technological advance alone can solve all problems.[2]

Richard Burt, former assistant director of the International Institute for Strategic Studies, also cautions that it is dangerous to view technological developments as instant solutions to long-standing dilemmas.[3]

Between these expressed positions of exaggerated optimism and caution lie many gradations of opinion, and the views are very much divergent on precisely what PGMs can and cannot do. It is the purpose of this article to examine some of the issues underlying the various conceptions and propositions concerning tactical PGMs, to briefly review PGMs from a historical perspective, and to address their implications for: ground and air forces; force structure and composition; the field of battle itself; and, finally, the Soviet Army. Emphasis will be on tactical precision guided air-to-ground and short-range antitank guided munitions (ATGM). It is specifically these weapons which, according to Dr. Perry, Under Secretary of Defense for Research and Engineering, have the potential for revolutionizing warfare.[4] The scope of the article precludes a thorough review of specific PGMs or their employment in the naval arena. However, comprehensive tables and descriptive data on PGMs can be found in such publications as *Jane's Weapon Systems* and the annual "Aerospace Forecast and Inventory" issue of *Aviation Week & Space Technology*.

WHAT ARE PGMs?

The term "precision guided munitions" includes such long-familiar families of tactical air-to-air guided missiles as Sparrow and Sidewinder and surface-to-air missiles

(SAMs) like Hawk and the Soviet series of SAM systems from SA-1 through SA-10, to mention only a few. When perusing the available literature on PGMs, it becomes quite readily apparent that there is not a common understanding of what the term stands for and what systems it encompasses. When hearing the term PGM, one frequently thinks of the smaller, tactical varieties, such as the Soviet Sagger guided antitank missile which wrought havoc with the free-wheeling, infantry-shy Israeli tank formations early in the Yom Kippur War of October 1973.[5] However, a PGM really is any electromechanical weapon which through mid-course or terminal guidance corrects its flight path sufficiently to insure a high degree of target intercept. Precision is thus a relative concept depending on target characteristics, warhead capabilities, and degree of destruction or damage required, which explains the reason for the diversity of weapons which can fall into the PGM category. However, there are significant differences in terms of probability-of-hit between individual PGM systems in any given category. For instance, the old Soviet SA-2 SAM, still widely used by Soviet air defense forces and by many Soviet allies, falls into the general category of PGMs. Its combat record, however, makes this a questionable contention. For example, between July 1965 and February 1967, it took an average of 50 SA-2s for the North Vietnamese to down one US aircraft. This rate increased in 1967 to 59 and in 1968 to more than 100 missiles per aircraft shot down.[6] It therefore becomes quite obvious that many a guided munition has a combat record which is far from "precise." Although PGMs such as Hawk and Maverick have superb combat records, they represent a performance peak for tactical PGMs rather than the norm.

US DEVELOPMENTS BEFORE 1945

Although the tactical PGM is frequently referred to as significant *new* technology, this statement is only partially true.[7] Certainly, the antitank versions of PGMs are relatively recent innovations, but even in this area research had yielded practical results by the end of World War II.[8] However, in the air-to-ground arena, precision guidance has been available for a long time.

Efforts started as early as 1917, when Messrs. Kettering, Wright, and Sperry tinkered with the idea of preset flying bombs. Although their "Kettering Bug" never saw any combat in World War I, it in effect laid the very foundation upon which more promising research activities would be based.[9] From the practical standpoint, the US developed a rather impressive number of air-to-ground tactical PGMs during World War II. The first useful "glide bomb" was the GB-1, a 2000-pound general purpose bomb with attached aerodynamic surfaces and preset controls. On 25 May 1944, 116 of these bombs were used against the city of Cologne, Germany, in a B-17 raid.[10] Other noteworthy glide bomb developments were Bat, a US Navy radar-guided "fire-and-forget" weapon, and Kingfisher, a glider-borne torpedo.[11] Only Bat saw combat action, its most spectacular achievement being the sinking of a Japanese destroyer in April 1945 at its maximum range of 20 miles.[12]

Another development category was the "vertical bomb," the most important of which probably was the "azon" bomb—standing for azimuth only—also known as VB-1. This was a radio-guided, 1000-pound bomb used in Europe against locks on the Danube River and against bridges across the Seine in France in preparation for the D-Day landings.[13] Its most spectacular results, however, were achieved in Burma. Because of continuous Allied air raids on Japanese shipping, the Imperial forces relied heavily on rail transport for their supply shipments. Rail lines had to traverse numerous bridges which formed ideal but difficult targets for air interdiction. Between 7 December 1944 and 3 March 1945, the 7th Bombardment Group used 459 azon bombs and destroyed 27 bridges, with 10 to 15 percent of the bombs being direct hits.[14] A further refinement of the azon was the "razon" (VB-2), which was steerable in range and azimuth; however, it did not see any combat.[15]

Other developments included the VB-6

Felix, a heat-seeking bomb; the VB-10, 11, and 12 "Roc" series with TV, heat-seeking, and light-seeking homing devices, respectively; and the VB-13 "tarzon." The tarzon, a modified British 12,000-pound Tallboy bomb, survived the post-World War II development cuts and served for some years as an armament for B-29, B-50, and B-36 aircraft.[16]

GERMAN DEVELOPMENTS BEFORE 1945

On the German side, developments in air-to-ground tactical PGMs were also quite impressive. One development was a 3000-pound armor-piercing glide bomb, the SD 1400X, also known under the code name of Fritz-X. The Fritz-X was first used in August 1943 in the Bay of Biscay against British naval vessels. There it sank the corvette HMS *Egret*, which thus gained the dubious distinction of having been the first naval vessel sunk by an air-launched PGM.[17] The most remarkable accomplishment of the Fritz-X, however, was the sinking of the then-modern 42,000-ton Italian battleship *Roma* on 9 September 1943 as it was in the process of defecting to the Allies.[18]

A second German development in the glide bomb category was the rocket-assisted Hs-293. It was designed to be used against lightly armored ship targets. Although it was radio-controlled, like the Fritz-X, it allowed the launch aircraft considerably greater freedom of action in that it did not have to overfly the target. Additionally, while the Fritz-X had a minimum launch altitude of about 4000 meters,[19] the Hs-293 could be launched from as low as 300 meters, a significant improvement in view of Allied strengths in radar technology.[20] All in all, the Germans claimed that the two bombs were operationally quite successful and proved the value of precision guided munitions. The Germans, unlike their American counterparts, also encountered one of the major limitations of a slow-moving guided projectile; namely, it made the launch and control aircraft very vulnerable to enemy countermeasures. German guided weapon aircraft suffered heavy losses to Allied fighters when used during the Anzio landings, and by late 1944, the guided weapon threat to the Allies had been practically eliminated.[21] Other than the wire-guided Hs-293B, the Germans also developed the Hs-293D TV-guided model.[22]

World War II precision guided weapon developments had by 1945 achieved a respectable level of excellence and proven themselves in combat as valuable additions to unguided munitions. Therefore, by no stretch of the imagination do PGMs fit into the category of "new" technology as is so often maintained today. What *is* new about PGMs is the appreciation of the value of precision as a concept, as well as the development of electronic technology in the post-World War II era. Such innovations as transistors, integrated circuits, microprocessors, and advances in electro-optics and microwaves, to mention only a few, provide affordable guidance and control capabilities in small packages and at a high degree of reliability far superior to the vacuum tubes and hard wires of World War II systems.[23]

THE POSTWAR LAG

If tactical air-to-ground PGMs proved their value in World War II beyond

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reasonable doubt, then one must wonder why they were not brought into the inventory until the late 1960's. One reason for the delay probably is that weapons are produced and deployed as part of a larger cultural and military matrix and because of their appeal to a set of social values.[24] Air-to-ground PGM development in the immediate post-World War II era must, therefore, be viewed in context. In 1945, the Allies achieved total military victory over two technologically sophisticated adversaries, and the contribution of the PGM to the outcome of the conflict had been negligible. Additionally, the United States had to cope with the impact of a truly revolutionary new weapon—the atomic bomb—which at once brought the promise of absolute military superiority and relief from the immense budgetary pressures of the time.

Under President Eisenhower, the concept of massive retaliation, built around the new atomic technology, evolved into a full-fledged combat doctrine with the accompanying force structure. According to this doctrine, atomic weapons would be used on the first day of any war with the Soviets, and any war with them was presumed to be a general war.[25] Under these circumstances, the development of precision technology to benefit general purpose forces to conduct conventional war seemed ludicrous. General of the Army H. H. Arnold's cautioning comment in his last public statement in 1946—that preparedness cannot be built around atomic weapons alone, and that for the Air Force to carry out its mission it must have the latest and most efficient air power weapons, quite apart from atomic weapons and explosives—appeared to have never been heard; if it was, it was soon forgotten.[26] "The bomb" so overshadowed objective thinking at the time that when the Korean War erupted in 1950 it was difficult to muster a fighting force appropriate to the threat. Nevertheless, the limitations of nuclear weapons were not to be realized for some time to come.

Attitudes and the Lessons of War

The apparent lessons of World War II provided another cogent reason why PGM technology seemed irrelevant. The prestigious and comprehensive *United States Strategic Bombing Survey*, completed shortly after cessation of hostilities, concluded that Allied air power was decisive.[27] No one could argue that point. One had only to look at the cities of Germany to be convinced of the accuracy of that finding. But aside from obvious impressions of destruction, the survey found that only 20 percent of the bombs aimed at precision targets fell within a 1000-foot target circle. The peak of accuracy achieved was 70 percent in February 1945.[28] It seems that this finding plus the well-known effect of PGMs in Burma should have relegated the ballistic iron bomb to its proper place. But nothing of the kind happened. It is possible that the awe-inspiring sight of a bombed-out Germany was a greater lesson in itself than the small print in a survey which told in detail how it had been achieved.

There were, of course, other factors working against development of conventional air-to-ground precision guided munitions. For instance, Dr. Vannevar Bush, head of the Office of Scientific Research and Development during World War II, was acutely aware of PGM developments on both sides of the conflict but saw only a limited future for them. In his book *Modern Arms and Free Men*, he acknowledged that in Burma one controlled bomb was worth a hundred ordinary ones. He went on to say, though, that such bombs could hardly be expected to hit with certainty a target such as a building in a city, and that a bomb with a TV transmitter in its nose verged on the warfare of Buck Rogers or Flash Gordon.[29] The impact of the thinking of such influential and knowledgeable men as Dr. Bush was, of course, crucial to the further development of guided weapon technology.

Air Force Independence

In addition to these perceptions militating against the development of precision technology, there was the fact that in 1947 the Air Force had just attained independence from the Army. The newly formed air arm in the late 40's and early 50's was busy building a force structured around the new superweapon, the atomic bomb, and it did not have any real interest in activities which could detract from that all-important effort.[30] Therefore, it does not seem strange at all that the Army, although losing the Army Air Corps, had retained the facilities and personnel involved in conventional bomb development and production. The Air Force was little interested in such mundane capabilities. Although the Army no longer had a need for bombs, it was responsible for their continued development and production.[31] With such an arrangement where the user of a product shows little interest in it and the manufacturer and developer has no use for it, any innovation would likely be the exception rather than the rule; as should have been expected, conventional weapons development languished for years.

Certainly there was no one specific factor that alone militated against continued development of the conventionally armed tactical PGM. However, the very obscurity of the technology and the lack of strong advocates with respectable stature were sufficient factors to insure that little would be accomplished in this area.

PGMs REDISCOVERED

The supreme confidence provided by the effective monopoly of the atomic bomb and strategic delivery systems such as the long-range bomber was shaken severely by the late 50's.[32] When the crises in Lebanon and the Taiwan Strait occurred, the limitations of nuclear doctrine became all too apparent. The forces employed in those crises had been structured around nuclear weapons, and they showed all the deficiencies of such a policy. A Tactical Air Command staff officer who visited Adana Air Base in Turkey during the Lebanon crisis reported:

> There is considerable doubt as to the conventional combat capability of the F-100 units. Only a few of the F-100 pilots had strafed; none had shot rockets or delivered conventional bombs.[33]

He also regarded the B-57 crews as incapable of performing efficient conventional weapons delivery. From that point onward, the Air Force "played catch-up" to recover from the omissions of the past.

Between 1945 and 1965, there were limited developments in guided air-to-ground munitions to satisfy rather unique mission requirements. For instance, the Mach 2, radio-guided Bullpup air-to-ground missile was the only noteworthy development of its kind. It was developed as a direct result of lessons learned from the Korean War,[34] but it did not prove a satisfactory weapon in the more sophisticated combat environment of Vietnam. The only other development of note was the Shrike antiradar missile, deployed in 1964 to counter radar-guided antiaircraft artillery and the Soviet SA-2 SAM, which had jolted planners in earnest when the Soviets used it to down the U-2 of Francis Gary Powers in 1960.

The first laser-guided bombs made their appearance in 1968 in attacks against truck traffic in Laos.[35] By 1972, they were in wide use and had been joined by electro-optically guided bombs (EOGB), also known as HOBOs (homing optical bombs).

Vietnam

The new generation of guided bombs made its truly spectacular debut in North Vietnam during Linebacker I.[36] The reason for the sudden rediscovery of the earlier technology can best be illustrated with the example of the Thanh Hoa bridge in North Vietnam, which is widely cited as a major example of PGM effectiveness.

The Thanh Hoa bridge, located between Hanoi and the port city of Vinh, was a major rail and highway link in North Vietnam. During the Rolling Thunder campaign between 1965 and 1968, F-105s and F-4s based in Thailand attacked the bridge numerous times.[37] Between 450 and 600 sorties are mentioned in publications, and the overall results of this concentrated air campaign were poor. Several hundred thousand pounds of conventional gravity bombs were delivered against the bridge, and in the ensuing attacks, at least 18 aircraft were shot down and many more damaged. On 16 May 1972, this pattern changed. Twelve F-4 Phantoms using 2000-pound and 3000-pound laser-guided glide bombs destroyed the bridge in one attack.[38]

It was not so much the relatively low cost and operational effectiveness of the new generation of PGMs that cast the die in their favor, but the ineffectiveness of ballistic bombs when delivered in a hostile combat environment against defended point targets. Not only were important targets not destroyed, but a large amount of available combat capability was dissipated. It is probably well to remember that a tactical fighter-bomber sortie represents the end product of a long chain of effort, and every sortie flown ineffectively represents a great loss in irretrievable combat power at very high cost. This is what Professor Edward Luttwak calls "invisible" attrition.[39] It hurts because it occurs with such overwhelming frequency compared to catastrophic aircraft losses. Invisible attrition provided the immense incentive to substitute advanced precision technology for the iron bomb and the conventional bombsight.

The results of PGM employment in Vietnam and during the 1973 Yom Kippur War were so spectacular that they not only vindicated the proponents of PGM development but also led a number of them to ignore their still profound limitations and indulge in an excessive euphoria when it came to attributing capabilities to the "new and revolutionary" weapons. PGMs at last appeared to have achieved a fundamental described in Douhet's book, *The Command of the Air*. He stated that the objective must be destroyed completely in one attack, making further attack on the target unnecessary. Bombs, according to him, only had to fall on their target to accomplish their purpose.[40] It is the falling on the target that continues to prove more difficult than Douhet ever imagined.

PGM IMPLICATIONS

Although the TV- and laser-guided bombs of the Vietnam era are still with us today, significant strides have been made in tactical PGM development since then. Maverick, a solid-fueled, supersonic, TV-guided, and highly reliable air-to-ground armored vehicle killer has been widely deployed with US and allied air forces. The GBU-15, a much more sophisticated glide bomb than those employed in Vietnam, is in the development stage. TOW and Dragon are widely deployed antitank guided munitions which give the infantry for the first time the ability to effectively combat the main battle tank at short and long ranges. The low cost of weapons such as TOW and Dragon (less than $10,000 per round)[41] has resulted in a total of 193,000 ATGMs of various types in the NATO inventory.[42] Surface-to-air missiles, which aim to wrest control of the air over the battlefield from the tactical fighter, have been under development for a much longer time than either air-to-ground or antitank guided munitions, and they are plentiful on both sides of the inner German border.

The consequences and implications of such large numbers and diverse types of tactical PGMs are addressed by numerous authors. They urgently call for changes in doctrine, strategy, tactics, and force structure; for new types of equipment; and for improved deployment of forces to take advantage of the perceived capabilities of the new munitions. All the while they fear that military conservatism will result in incrementalism which somehow will deprive NATO of a potential advantage over or equalizer with the Warsaw Pact. However, the implications of major technological developments are as difficult to foresee as the lessons that should be learned from past wars are to deduce, and the incremental approach in such a situation may therefore not be inappropriate after all.

The Germans, for instance, recognizing the advantages of early 20th century technologies and choosing a more revolutionary approach, married the mobility and firepower of the tank and tactical air forces to concepts of surprise and combined arms operations and came up with a successful formula for waging war, the blitzkrieg. They failed, however, to take that extra step and to understand the full implications of the new technologies—

especially air power—over and above immediate tactical applications, resulting in the eventual defeat of the blitzkrieg concept by those who did. PGMs, surprisingly enough, seem to lend themselves to incremental integration—allowing for the proper time-phased adjustment of force structure to the new technology, the development of appropriate employment tactics, the modification of strategy, and finally the development of doctrine—thereby possibly avoiding the gross oversight committed by the blitzkrieg innovators, as well as the rigidity of force structure which evolved from a later US concept built exclusively around nuclear weapons.

Implications for Ground Forces

Implications for ground forces are primarily viewed by authors on the subject in terms of the advantages PGMs confer upon defensive and offensive concepts of warfare and the deployment and employment of forces under these two basic precepts. A large body of literature categorically states that PGMs inherently favor the defense or are currently particularly suitable for defensive purposes.[43] Some suggest, based solely on the capabilities of PGMs, that smaller nations could very well opt for a unilateral strategy of defensive deterrence without necessarily being members of a defensive alliance.[44] The concept that technological developments in firearms favor the defensive is, of course, not new.[45] The rationale behind the defensive argument is essentially that PGMs and their carriers are hard to detect and easily concealed; that when employed in proper quantity they can offset the advantages of the major offensive weapons, such as the tank; and that through high-attrition tactics, such as concentration and accuracy of fire, they can stop a blitzkrieg tank thrust in its tracks.[46] To accomplish this, PGM-armed forces would be deployed in depth in well-prepared positions in what one author calls a "checkerboard" pattern to exact the necessary degree of attrition.[47] The underlying assumption is that the tank has met its match in the tactical PGM. Therefore, rather than being the prime instrument of offensive warfare, the tank will again become what it originally was, an infantry support vehicle.[48]

The disadvantages of rigidly defensive concepts are, of course, well known. A static, dispersed defense—as implied by the "checkerboard" concept—would leave the enemy with the initiative, allowing him to overcome defensive positions at the time and place of his choice and while retaining the necessary numerical advantage. Technology can compensate for inadequate numbers of men and weapons, but it cannot substitute for lack of initiative. The most recent example of the inherent weakness of a static, defensive, and reactive posture based on fixed positions is the Israeli experience in the October War of 1973 along the Suez Canal. The static defensive positions in this case provided neither warning from surprise attack nor defense, but proved to be traps for their occupants. As noted by Israeli General David Elazar, defense is a powerful form of combat, but in order to win, one must attack.[49]

Other than surrendering the initiative to an aggressor, the static defense approach presents other significant problems for the commander of a defending force. Dispersed forces are inherently more difficult to command and control. Although dispersal provides a degree of protection against nuclear attack, it also denies the defense the ability to concentrate its forces rapidly for effective counterattacks. Additionally, antitank PGMs are not as easily hidden and concealed as one might assume. The launchers are often clumsy and large; the missiles, slow and vulnerable to countermeasures. One Seventh Army battalion commander stated recently that he will not employ his ATGMs along with his tanks because they give away the tank positions.[50] Once discovered, ATGM crews and launch systems are also vulnerable to concentrated enemy counterfire. Additionally, all of them are subject to adverse weather and night limitations which reduce their efficiency just at the time when Soviet doctrine calls for attack.

Changes caused by PGMs in the ground forces appear essentially to be evolutionary rather than revolutionary in nature—a rather desirable situation considering the current limitations of many PGMs. It may be well to recall that air-to-air guided missiles introduced in large number in the 1950's replaced the guns on many Air Force interceptors and fighters; only later, in Vietnam, were the significant limitations of air-to-air PGMs discovered.[51] This resulted in the reintroduction of the guns, using air-to-air missiles as complementary rather than exclusive armaments.

Implications for Air Forces

Implications for tactical air forces are significant not only in terms of providing aircraft precise munitions with standoff capabilities, but also in terms of where and how tactical air forces can operate and best support the land battle. Notwithstanding the development of the A-10 ground support aircraft—which is significantly more survivable against ground fire than any other aircraft in the inventory[52]—the battlefield support mission, including close air support and airborne forward air control, is threatened by surface-to-air missiles, radar-controlled antiaircraft artillery, and small arms fire.

The typical Soviet combined arms army, comprising four to five armored and motorized rifle divisions, is well-equipped to conduct its own air defense operations. Its complement of 416 guns and 338 surface-to-air missile launchers, plus quantities of hand-held SA-7 Strela missiles, is arrayed in depth and breadth to wage a war of attrition against tactical air forces at any altitude. Five Soviet armies are assigned to the Group of Soviet Forces Germany, not counting lesser-equipped East German forces.[53] Even when considering the imperfections of the Soviet tactical air defense systems, the sheer number of surface-to-air missiles and antiaircraft artillery make close air support, at least initially, a questionable investment unless dictated by the seriousness of the situation. The effectiveness of a similar air defense system was demonstrated during the Yom Kippur War. Initial Israeli saturation raids against the fixed Arab air defenses of surface-to-air missiles and antiaircraft artillery resulted in high, almost prohibitive losses to the attackers; conversely, Arab ground forces suffered heavily from air attack when they moved beyond their static SAM air defense belts. The assumption, however, that Soviet maneuver battalions would suffer the same fate is fraught with a significant degree of risk.[54]

The implications for close air support operations are unmistakably either to obtain an adequate ability to suppress the threat of surface-to-air missiles and radar-controlled guns or to operate in such an environment only when losses of high-value aircraft and highly trained crews are justified by the extremity of the situation.[55]

Others join this approach to tactical air operations by counseling that close air support is too costly in relation to the benefits gained[56] and that one-on-one dueling between expensive aircraft and armored fighting vehicles in a dense air defense environment should be approached with caution.[57]

The extreme position for this line of argument is that surface-to-air missiles employed in sufficient quantities would in a few days destroy available tactical air forces and substantially reduce offensive power.[58] The future utility of the tactical aircraft over an extremely hostile battlefield is viewed as questionable at best, with technological trends favoring PGMs rather than manned aircraft.[59]

Another line of argument also questions the utility of tactical air forces in the roles of close air support and interdiction, not because of the lethality of the battlefield SAM and its supporting gun systems, but because of the attributed capabilities of other tactical PGMs. Improved standoff weapons launched from modified cargo aircraft or by artillery and rocket launchers would, so the argument goes, largely replace tactical air support and reduce its utility—as well as that of the SAM air defense systems, which would then lack the necessary targets.[60] Interdiction and close air support, as far as still needed, could in most cases be accomplished with cruise missiles, helicopters, and artillery-launched PGMs.[61]

I fail to share these overly pessimistic forecasts for the tactical air operation and its future lack of utility. Nevertheless, PGM development generally implies that close air support in its traditional sense should be reevaluated and that new approaches capitalizing on the inherent mobility of air power should be sought instead.

There are factors other than those related to PGMs which make close air support operations less than ideal for tactical air forces. Problems in the areas of target identification, communications, and airspace management, among others, impose significant constraints. The tactical air force thus finds itself in the immediate battle area with numerous disadvantages and is unable to capitalize on its own strengths. Considering Army capabilities in PGMs—and the addition of Copperhead cannon-launched guided projectiles[62]—there may be a strong case for autonomous Army operations in the immediate battle area, supported by Air Force elements in situations when indigenous Army capabilities are no longer sufficient to handle the threat.

Implications for Force Structure

Precision guided munitions have a subtle impact on the structure, size, and quality of armed forces. On one hand, they represent technology at its best by providing weapons that are reliable and simple to operate, such as Stinger, TOW, and Dragon; on the other hand, one is faced with the complexities of such systems as Shrike, Hawk, Roland, and, in the future, Patriot. The technology determines the numerical requirements for personnel; it also determines the degree of technological sophistication required of these people, and this presents a dilemma. PGM technology, according to many, is supposed to reduce requirements for expensive manpower. But the effective application of this technology often appears to have exactly the opposite effect. Although such antitank guided munitions as TOW and Dragon increase the lethality of the infantry in combating armored vehicles, they also demand dedicated crews, and they must be employed in sufficient numbers up to a critical threshold or the simple cost and effectiveness arguments for these weapons become meaningless.[63]

Additionally, the frequent call is heard for the fielding of large numbers of cheaper, lighter, and more mobile armored vehicles with the heavy antitank punch of PGMs in preference to fewer, more expensive, and supposedly more vulnerable main battle tanks.[64] There is, in fact, some pressure to concentrate less value in one place or in one vehicle and to have instead many relatively inexpensive lightly armored vehicles.[65] However, this would require increases in personnel rather than decreases. Thus it is an option which runs counter to the proposition that, with drastic increases in defense budgets unlikely in the future, funds for new technologies must be sought at the expense of manpower.[66]

Aside from quantitative implications, PGMs affect the quality of the force. The easy-to-operate, reliable, simple PGMs can be maintained and employed by personnel with low educational and training levels. They are favorable for a draft-based force with a relatively high turnover. The complex PGM systems, however, require personnel with much higher educational levels, and extensive training is often needed to properly maintain, operate, and employ them. The short-term recruit is not the answer here, and people with such skills obviously are also in great demand in the civilian economy. One solution over the longer term may be to develop systems which have significant congruency with civilian technology to allow a much easier entry into areas requiring highly skilled personnel directly from civilian life.[67]

The implications for force organization, especially for the Army, draw as mixed a response from various writers as do the implications for personnel and equipment. One author has variously suggested an in-depth "polka dot," "arresting gear," and "checkerboard" defense. Such defense concepts are based on dispersing highly mobile, infantry-shy, and PGM-powerful forces in a "polka dot" or "checkerboard" pattern to arrest the momentum of the enemy attack and then counterattacking his major thrusts at the appropriate time.[68] The major reorganizational adjustments required to satisfy such proposals do not really appear to be called for by current-generation PGMs. To insure their effective employment, it appears to be more a question of properly integrating them into existing forces. One can take for granted that gradual organizational changes will occur as a result of such an incremental and evolutionary approach. Finally, PGMs do not appear to alter the fundamental roles and missions of the respective services—the one thing which would indeed call for major structural adjustments.

Implications for the Nature of War

A substantial group of writers suggests very strongly that the kind of destructiveness and confusion of war witnessed in World War II is a thing of the past because of the high accuracy of PGMs. These writers suggest that as a result of their high probability-of-hit, PGMs are likely to cause much less collateral damage to civilians and their economies. They believe that precision technology may allow carefully controlled combat, and that by doing so, it may reverse past trends of targeting nonmilitary facilities.[69] Yet if the intended use of PGMs as effective tank killers to stop a blitzkrieg attack by the Soviets is successful, then the war would not only be longer than commonly expected, but it would be just as destructive as its predecessors. Steven Canby, a well-known defense analyst, argues that a long war in central Europe is an unlikely prospect and that a short conflict, regardless of intensity, would not be as destructive as in the past. He cites the example of the German victories in 1940 in France and the Low Countries, which caused little civil destruction.[70] The German victories were indeed achieved in a short campaign, because they caught the Allies by surprise, poorly deployed, and with a force structure largely irrelevant to the new kind of mobile, combined-arms warfare. PGMs are supposd to preclude the success of that type of a blitz; if they do, the ensuing heavy fighting will insure the destruction of military and nonmilitary targets on a large scale. The German success in 1940—and the lack of destructiveness of that campaign—was only achieved with the unwilling cooperation of the Allies. There is no intention to repeat that performance in the future, making analogies of this type of questionable value.

Another critical factor in the current environment is the number of armored fighting vehicles in the inventories of the potential protagonists. In the 1940 campaign against France, Germany employed only about 2500 tanks against the 3600 of the Allies.[71] Only 3000 tanks were employed in the initial attack against the USSR, which took the German Army as far as Moscow.[72] Today, nearly 21,000 Warsaw Pact and 7000 NATO main battle tanks face each other in the northern and central regions of Europe, not counting large stocks of tanks in reserve.[73] Adding to this incredibly large force of tanks the more numerous armored personnel carriers and other armored fighting vehicles makes the central region of Europe an area saturated with armor. Such a concentration of armor and firepower does not speak well for concepts of limited destruction, regardless of PGMs and their degree of precision. It is much more conceivable that the conflict would offer a degree of destruction not yet experienced in Western Europe on such a large scale.

Also, the PGM is not employed in a vacuum; it exists alongside proven, relatively imprecise area weapons. Artillery, for instance, has not lost its importance on the field of battle since World War II. In the Yom Kippur War, artillery again proved its worth and inflicted heavy casualties against dug-in infantry and columns on the move.[74] In central and northern Europe, 2700 allied guns of all types face 10,000 Warsaw Pact guns, an indication that the capabilities of artillery are well-appreciated.[75] Considering the totality of this equipment, it is difficult if not impossible to make a case for PGMs reducing the ferocity of war and its attendant destruction.

A frequently mentioned implication of PGMs is that they will raise the tactical nuclear threshold—an imprecise term which addresses that point at which tactical nuclear weapons (TNWs) are employed. TNWs are viewed by some as an anachronism of another time, a chronic flaw in the NATO defense posture which PGMs can correct.[76] PGMs are not substitutes for TNWs, because the requirement is based on warhead capabilities rather than on weapon accuracy per se. Considering the size and doctrine of the Warsaw Pact armored forces, the large-scale destructive power of TNWs is needed today as much as in the past. The argument is not convincing that employment of TNWs does not assure success on the battlefield, that it risks nuclear escalation, that it would not be in the Soviets' own best interest to occupy a nuclear wasteland, and that therefore the full exploitation of the new technologies of conventional weapons is called for in lieu of TNWs.[77] Full exploitation of new technologies is indeed called for, and NATO may decide to raise its own TNW threshold, but this would not be done solely because of PGM developments at this time. Soviet combat doctrine does not make allowance for subtle threshold arguments and views nuclear weapons as an integral part of the Soviet arsenal, to be employed against NATO force concentrations and installations as part of the overall attack plan. Soviet military writers, the equipment of Soviet forces, and their training leave little doubt that this is the case.[78]

Richard Burt cogently sums up the implications of PGMs for the nature of war on a potential European battlefield:

> By making 'short-war' strategies less likely to succeed in land war, deployment of a new generation of conventional weapons could raise the threshold of deterrence against resort to force. But the deployment of such weapons, whether conventional or nuclear, could be a more prolonged and destructive conventional conflict if deterrence fails.[79]

Implications for Soviet Forces

The appearance of large numbers of precision air- and ground-launched antitank munitions in the arsenal of NATO has obvious implications for the Warsaw Pact. What are the Soviet options to respond to a development which challenges the very vitality of its doctrine and forces?

Soviet options to respond are limited if only because one does not very quickly restructure a force of 50,000 tanks and 55,000 armored fighting vehicles.[80] The very nature of the investment argues against significant near-term changes in force structure and strategy, even if the desire to do so is there. Soviet doctrine, formulated in the crucible of World War II, has shown relative consistency over the years and has found its expression in the current force structure and weapons inventory. The Soviets learned that a static warfare of attrition could only be avoided through the massive use of tanks, artillery, and aircraft and that the offensive is primary to achieve their objective—victory. In other words, mobility provides the basis for offensive action, and concentration of fire power and shock action are the means to achieve victory.[81]

Indications are that the Soviets expect to meet the ground antitank threat through appropriate tactics using existing equipment. Attacks over a wide area with many axes are expected to tear apart any coherent NATO defense, and motorized infantry units supported by massive artillery and rocket barrages would then shatter the remaining defenses.[82]

In his book, *Time and the Tank*, Soviet author P. A. Rotmistrov specifically addresses the problem of the antitank guided munition. He acknowledges that some claim that the weapons will cause severe tank losses, but he feels that the launchers will be destroyed by an avalanche of attacking tanks soon after their first rounds are fired. He attaches great significance to the continuity of combat operations and the coordinated combined arms operations of tanks, artillery, airborne troops, infantry, and aviation to overcome enemy defenses.[83] He deems most important that large numbers of tanks strike simultaneously to defeat the enemy antitank defenses. Indecisive action of tank forces is to be avoided at all costs because it gives the defense time to act, time to create new defenses, and time to employ their weapons effectively.[84] The infantry is to advance along with the attacking tank units in support, as is the artillery, which is not only needed to insure the breakthrough but also for continued operations in depth.[85]

Soviet reactions in the face of PGM developments within NATO appear to be primarily tactical in nature and aimed at using the existing force to its best advantage. However, as one author succinctly states, there is a point beyond which even the most sophisticated tactics cannot cope with advanced technology.[86]

PGMs IN PERSPECTIVE

Although the new generation of air-to-ground and antitank PGMs appears to promise utopia to some defense analysts, these weapons have significant limitations. TV-guided systems are heavily influenced and limited by adverse weather and the fall of night. Laser and infrared systems have increased night capabilities, but they also are susceptible to environmental influences and countermeasures. If the guidance systems of the PGMs are limited in capability, so are the air and ground crews who must employ them. Target acquisition and identification are difficult problems for launch crews and will continue to be so in the future. Antitank guided munitions have the additional disadvantage that in many cases they are too slow for their armored vehicle targets.

PGMs have significant implications for ground and air forces. Ground forces have to integrate the new capability so that it can exist side by side with friendly armor. Through the cannon-launched guided projectile, artillery has gained increased significance. So has the infantry benefited, because PGMs provide a lethal capability against tanks at long and short ranges. For tactical air forces, the proliferation of surface-to-air missiles and radar-controlled antiaircraft artillery has made the immediate battlefield so perilous that it calls for revised close air support employment concepts.

PGMs exert a subtle but persistent pressure on force structure, people, and equipment. The technology calls for both increased and decreased human skill levels, thereby accommodating short-term draftees as well as longer-term volunteers. The impact on ground forces does not at all portend a reduction in force levels, considering the emerging trends to acquire large numbers of lower-cost tanks and aircraft.

The nature of war itself is affected by PGMs in the air and on the ground. PGMs in the hands of well-trained and disciplined forces will insure a high degree of major weapon system attrition, but the future battlefield promises no less destructiveness than those of past wars of major scale in spite of the precision of the new weapons. The number of Warsaw Pact armored vehicles and their conventional countermeasures against NATO defensive capabilities seem to insure that destruction would be extensive.

The impact on the Soviets of widespread PGM deployment in NATO is undoubtedly significant. Current Soviet efforts appear to counter PGM deployments with tactics such as heavy artillery and rocket barrages and resolute behavior by tank crews. But tactics have limited potential to overcome basic system deficiencies. The massive Soviet investment in armor may be a major error in strategy. The force not only inhibits flexibility through its very presence, but it is inherently predictable in its employment.

Tactical PGMs in all their various forms are a potentially decisive force on the field of battle when properly matched and integrated with the right kinds and numbers of unguided bombs, area-denial and area-kill munitions, and gun-fired projectiles. The decisive aspect of PGMs today is the application of the concept of precision to small devices of destruction and their distribution to the front-line fighting elements on a large scale. However, their impact in the future could be revolutionary if the concept of precision is coupled with a capability for multiple target kills per engagement. While strategic PGMs on both sides have developed into force postures of extreme rigidity and inflexibility, the tactical variant has had exactly the opposite effect and has provided commanders new flexibility of action and options of employment.

PGMs are not *Wunderwaffen* and do not promise major reductions in defense expenditures; they appear to have exactly the opposite effect by calling for more, lower-cost systems requiring more personnel to maintain, operate, and employ them. The operational importance of PGMs today is a direct reflection of the strategic nuclear stalemate between the US and the Soviet Union. To quote General Alexander Haig, "When both sides move toward parity in nuclear systems—which is the fact today—then credibility depends increasingly upon conventional abilities."[87] One, and only one, important part of that conventional capability is the tactical precision guided munition.

NOTES

1. Philip Morrison and Paul F. Walker, "A New Strategy for Military Spending," *Scientific American*, 239 (October 1978), 48.

2. US Congress, Senate, Committee on Armed Services, *Hearings on S. 2571*, 95th Cong., 2d Sess., 1978, p. 6105. [Robert R. Fossum, "Defense Advanced Research Projects Agency Fiscal Year 1979 Research & Development Program Statement," delivered to the Subcommittee on Research and Development, 9 March 1978.]

3. Richard Burt, "New Weapons Technologies: Debate and Directions," *Adelphi Papers, No. 126* (London: International Institute for Strategic Studies, 1976), pp. 30-31.

4. US Congress, House, Committee on Armed Services, *Hearings on Military Posture and H. R. 10929*, 95th Cong., 2d Sess., 1978. p. 1633. [Ruth M. Davis, "Statement on the Science and Technology Program," delivered to the Research and Development Subcommittee, 20 March 1978.]

5. During the early days of the Yom Kippur War of 1973, Arab infantry, using Soviet wire-guided Sagger antitank missiles, inflicted heavy losses on Israeli tank formations operating independent of infantry and artillery support. Israeli tactics were quickly modified to include these two force elements and thereafter coped very well with the antitank PGM threat. During the conflict, most of the tanks lost on both sides were lost to other tanks.

6. Peter Borgart, "The Vulnerability of the Manned Airborne Weapon System," *International Defense Review*, 10 (December 1977), 1064.

7. Steven Canby, "The Alliance and Europe: Military Doctrine and Technology," *Adelphi Papers, No. 109* (London: International Institute for Strategic Studies, 1974/75), p. 12. The author calls the three most significant new technologies tactical nuclear weapons, the helicopter, and precision guided munitions. References to PGMs as new technology are found throughout contemporary literature on the subject.

8. T. Benecke and A. W. Quick, *History of German Guided Missiles Development* (Brunswick, Germany: Verlag E. Appelhaus & Co., 1957), p. 10. This refers to the X-7 monowing antitank missile developed by Dr. Max Kramer.

9. US War Department, Office of the Chief of Staff, "A report by the War Plans Branch on an automatic carrier called the 'Bug,'" 19 December 1919.

10. W. F. Craven and J. L. Cate, *The Army Air Forces in WW II, Vol. VI—Men and Planes* (Chicago: The University of Chicago Press, 1955), pp. 253-59.

11. Information drawn from the air-to-surface weapon system descriptions at the Air Force Museum, Wright-Patterson Air Force Base, Ohio. Hereafter cited as Air Force Museum descriptions.

12. I. V. Hogg and J. Batchelor, *Allied Secret Weapons* (London: Phoebus Publishing Co., 1975), p. 51.

13. J. P. Baxter, *Scientists Against Time* (Cambridge, Mass.: The M. I. T. Press, 1968), p. 196.

14. Craven and Cate, pp. 253-59.

15. Air Force Museum descriptions.

16. US Department of the Air Force, *Standard Aircraft Characteristics, YASM-A-1A Guided Bomb* (Washington: US Government Printing Office, 1953), p. 3.

17. A. Price, *Profile Aircraft, Dornier Do 217 Variants* (Windsor, England: Profile Publications Ltd., 1974), p. 59.

18. *Ibid.*, p. 63.

19. Benecke and Quick, p. 154.

20. *Ibid.*, p. 12.

21. Bernard Fitzsimons, *Tanks and Weapons of World War II* (London: Phoebus Publishing Co., 1973), p. 151.

22. Benecke and Quick, p. 154.

23. US Congress, Senate, Committee on Commerce, Science, and Transportation, *Hearings on S. 365*, 95th Cong., 1st Sess., 1977, pp. 1625-27. [Robert N. Parker, "Statement on Department of Defense Activities in Space and Aeronautics, Fiscal Year 1978," delivered to the Subcommittee on Science and Space, 9 March 1977.]

24. Richard G. Head, "Technology and the Military Balance," *Foreign Affairs*, 56 (April 1978), 553.

25. Samuel F. Wells, Jr., "America and the 'Mad' World," *The Wilson Quarterly*, 2 (Autumn 1977), 61-66.

26. H. H. Arnold, "Air Force in the Atomic Age," in *One World or None*, ed. Dexter Masters and Katharine Way (New York: McGraw-Hill, 1946), p. 32.

27. US War Department, *The United States Strategic Bombing Survey, Summary Report (European War)* (Washington: US Government Printing Office, 1945), p. 15.

28. *Ibid.*, p. 5.

29. Vannevar Bush, *Modern Arms and Free Men* (New York: Simon & Schuster, 1949), pp. 44-45.

30. See Perry M. Smith, *The Air Force Plans for Peace, 1943-1945* (Baltimore: The Johns Hopkins Press, 1970), for an interesting discussion on Air Force efforts for autonomy.

31. Edgar Ulsamer, "Eglin's ADTC—Business End of the Air Force," *Air Force Magazine*, 55 (August 1972), 26.

32. Melvin Kranzberg, "Science, Technology, and Warfare: Action, Reaction, and Interaction in the Post-World War II Era," in *Science, Technology, and Warfare*, ed. Monte D. Wright and Lawrence J. Paszek, the proceedings of the 3d Military History Symposium at the US Air Force Academy, 8-9 May 1969 (Washington: US Government Printing Office, 1971), pp. 137-55.

33. Quoted in Albert P. Sights, Jr., "Lessons of Lebanon:

A Study in Air Strategy," *Air University Review*, 16 (July-August 1965), p. 42.

34. US Department of the Air Force, *Releasable Data on USAF Aerospace Vehicles*, Air Force Pamphlet 190-2-2, Vol. III, Section II, "Air-to-Surface" (Washington: US Government Printing Office, 1964), p. 86. [This pamphlet was rescinded in 1967; it was replaced by Air Force Pamphlet 190-33, *USAF Aerospace Vehicles*, dated 1 July 1974.]

35. William W. Momyer, *Airpower In Three Wars* (Washington: US Department of the Air Force, 1978), p. 212.

36. Linebacker I (May to October 1972) and Linebacker II (18-29 December 1972) were bombing operations above the 20th parallel in support of cease-fire negotiations between the US and North Vietnam. Linebacker I involved tactical aircraft only with the objectives to destroy enemy stockpiles, to restrict resupply from external sources, and to interdict the flow of any remaining supplies to the battlefield. "Smart bombs" (PGMs) were widely and effectively used during this campaign. Linebacker I operations were no longer peripheral in nature but struck decisively at vital targets which to a large extent had been exempted from attack during Rolling Thunder. When cease-fire negotiations again began to drag, Linebacker II was launched. The operation differed from the previous effort in that it employed tactical aircraft as well as B-52 strategic bombers. Tactical forces, many of which were supportive in nature, flew 2123 sorties and employed PGMs as well as general purpose bombs. A total of 729 B-52 sorties were flown, all at night using precision radar bombing against selected targets. Linebacker II was a major contributing factor to the 23 January 1973 cease-fire agreement. There were a number of key lessons evident from the two operations: (1) Linebacker I, conducted during favorable weather, demonstrated the effectiveness of "smart bombs" beyond a reasonable doubt; but Linebacker II, conducted during the monsoon season, also showed the limitations of these weapons and the high effectiveness of unguided bombs delivered by B-52s against appropriate targets; (2) The formidable SAM PGM system around Hanoi and Haiphong began to collapse after the third day of sustained air attacks and thereafter had no significant impact on air operations. Although ardent SAM PGM proponents often state that the B-52s could not have long continued to sustain the losses experienced during the first three days, they tend to forget that the SAM at that point had been eliminated as a coherent instrument of air defense; (3) As demonstrated in World War II, Linebacker reaffirmed the fact that air power, properly employed to use its strengths, can decisively influence the enemy and modify his behavior. See Momyer, p. 358.

37. Rolling Thunder was the air campaign from 2 March 1965 to October 1968 against North Vietnamese supply operations in Laos and North Vietnam. The campaign was gradualistic in nature, initially restricted to targets below the 19th parallel and subsequently expanded to the 20th parallel and to selected targets beyond. Because of the restrictions placed on tactical air operations, it was relatively ineffective and failed to significantly inhibit North Vietnamese operations. See Momyer, p. 358.

38. See Ulsamer, pp. 24-29; Robert A. Moore, "The GBU-15 Modular Guided Weapon System," a statement prepared for the Defense Subcommittee of the Appropriations Committee of the US Senate, 10 October 1978, p. 5; and "Neue Flugzeug und Waffentechniken in den USA," *Soldat und Technik* (December 1972), 658.

39. Saadia Amiel, et al., "The Art of War—East and West," in *Military Aspects of the Israeli-Arab Conflict*, ed. Louis Williams (Tel Aviv: University Publishing Projects, 1975), p. 56. Hereafter cited as *Military Aspects*.

40. Giulio Douhet, *The Command of the Air* (New York: Coward-McCann, Inc., 1942), pp. 19-20.

41. Ronald D. Pretty, ed., *Jane's Weapon Systems 1977* (New York: Franklin Watts, Inc., 1976), pp. 44-46.

42. Michael Getler, "Army Counts on Mobility," *The Washington Post*, 21 November 1978, p. 1.

43. For discussions on this point of view, see: S. J. Dudzinsky, Jr., and James Digby, "New Technology and Control of Conventional Arms: Some Common Ground," *International Security*, 1 (Spring 1977), 150; Anthony Farrar-Hockley, "The Scope and Direction of New Conventional Weapons Technology," with Johannes Steinhoff, in "New Conventional Weapons and East-West Security, Part 1," *Adelphi Papers, No. 144* (London: International Institute for Strategic Studies, 1978), p. 22; Canby, p. 33; and Burt, p. 9.

44. Frank Barnaby, "Precision Warfare," *New Scientist*, 8 May 1975, p. 307; Burt, p. 9.

45. Douhet, p. 11. Douhet gives elaborate reasons why the defensive has relative and absolute advantages over the offensive.

46. Dudzinsky and Digby, pp. 151-59; Canby, p. 33.

47. Canby, pp. 23-30.

48. F. O. Miksche, "Prazisionswaffen Verandern das Kriegsbild," *Wehrtechnik*, 5 May 1977, p. 23.

49. Benyamin Telem, et al., "The Yom Kippur War: A Review of the Main Battles in Retrospect—and Their Lessons," in *Military Aspects*, p. 250.

50. Getler, p. 1.

51. US Air Force air-to-air weapon kills versus firing attempts in Vietnam between May 1972 and January 1973 were as follows: AIM-4D-8, 0 kills/5 attempts = 0%; AIM-9E, 6/69 = 9%; AIM-9J, 4/31 = 12.9%; AIM-7E-2, 23/216 = 10.6%; 20 mm cannon, 7/14 = 50%. See Momyer, p. 157.

52. Alexander V. McDermont, "Engineering for Survivability," *USAF Fighter Weapons Review* (Fall 1978), 13-14; D. B. Dahm, "Probability of Survival," *USAF Fighter Weapons Review* (Fall 1978), 16-23.

53. D. K. Malone, "Air Defense of Soviet Ground Forces," *Air Force Magazine*, 61 (March 1978), 78-83; US Department of the Army, *Operations*, Field Manual 100-5 (Washington: US Government Printing Office, 1976), p. 8-3.

54. Lawrence Whetten and Michael Johnson, "Military Lessons of the Yom Kippur War," *The World Today*, 30 (March 1974), 101-10.

55. Field Manual 100-5, p. 8-4.

56. Telem, p. 249.

57. S. J. Deitchman, "The Implications of Modern Technological Developments for Tactical Air Tactics and Doctrine," *Air University Review*, 29 (November-December 1977), p. 38.

58. Farrar-Hockley, pp. 20, 22.

59. John H. Morse, "New Weapons Technologies: Implications for NATO," *Orbis*, 19 (Summer 1975), 508.

60. Steven L. Canby, "Regaining a Conventional Military Balance in Europe: Precision Guided Munitions and Immobilizing the Tank," *Military Review*, 55 (June 1975), 26-38.

61. Burt, p. 19.

62. Robert A. Doughty, "Copperhead," *Armor*, 87 (March-April 1978), 45-47.

63. Johan J. Holst and Uwe Nerlich, ed., *Beyond Nuclear Deterrence, New Aims, New Arms* (New York: Crane, Russak, 1977), p. 154.

64. Canby, "The Alliance and Europe: Military Doctrine and Technology," p. 18.

65. James Digby, "Precision-Guided Weapons," *Adelphi Papers, No. 118* (London: International Institute for Strategic Studies, 1975), p. 4.

66. Christopher Bertram, "Introduction," in *Adelphi Papers, No. 144*, p. 2.

67. For a valuable discussion on technology and force

structure, see Wehrstruktur Kommission der Bundesregierung, *Die Wehrstruktur in der Bundesrepublik Deutschland, Analyse and Optionen* (Bonn: Wehrstruktur Kommission der Bundesregierung, 1973), pp. 297-308.

68. See Canby, "Regaining a Conventional Military Balance in Europe: Precision Guided Munitions and Immobilizing the Tank."

69. Digby, pp. 5, 11-12; also see Burt, p. 3, and Barnaby, p. 307.

70. Canby, "The Alliance and Europe: Military Doctrine and Technology," p. 7.

71. R. Ernest Dupuy and Trevor N. Dupuy, *The Encyclopedia of Military History* (New York: Harper & Row, 1977), p. 1057.

72. "NATO Meeting," *World Affairs Report, No. 2730* (London: Aviation Studies International, 2 June 1978), p. 4.

73. International Institute for Strategic Studies, *The Military Balance, 1978-1979* (London: International Institute for Strategic Studies, 1978), p. 111.

74. Whetten and Johnson, p. 13.

75. *The Military Balance, 1978-1979*, p. 111.

76. Alton Frye, "Tactical Nukes," *The New York Times*, 7 October 1977, p. 31.

77. Morse, p. 503.

78. See V. Ye. Savkin, *The Basic Principles of Operational Art and Tactics* (Moscow: [n.p.], 1972), translated and published under the auspices of the US Air Force (Washington: US Government Printing Office, 1974); and A. A. Sidorenko, *The Offensive* (Moscow: Military Publishing House, 1970), translated and published under the auspices of the US Air Force (Washington: US Government Printing Office, 1973).

79. Burt, p. 30.

80. *The Military Balance, 1978-1979*, p. 2.

81. Sidorenko, pp. 12-13.

82. J. K. Davis and R. L. Pfaltzgraff, Jr., *Soviet Theater Strategy: Implications for NATO* (Washington: United States Strategic Institute, 1978), p. 12.

83. P. A. Rotmistrov, *Time and the Tank* (Moscow: [n.p.], 1972), translated and published under the auspices of the US Air Force (Dayton, Ohio: USAF Systems Command, Foreign Technology Division, 1972), pp. 48-49.

84. *Ibid.*, pp. 54-55.

85. *Ibid.*, pp. 55-57.

86. Phillip A. Karber, "The Impact of New Conventional Technologies on Military Doctrine and Organization in the Warsaw Pact," in *Adelphi Papers, No. 144*, p. 35.

87. William Currie, "Haig's Views On What May Cause War," *Chicago Tribune*, 26 September 1977, p. 1.