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PRECISION-GUIDED MUNITIONS:
CAPABILITIES AND CONSEQUENCES

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PRECISION-GUIDED MUNITIONS: CAPABILITIES AND CONSEQUENCES

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Something quite remarkable has been added to modern military forces: weapons in large number, each having a high probability of hitting its target with a single shot. Long discussed in theory and long possible under laboratory conditions, it took the demonstration of effective laser-guided bombs in Southeast Asia to show that such weapons were economically and operationally feasible. First called "smart bombs," these guided bombs were soon moved into an officially designated larger class of "Precision Guided Munitions" or PGMs. Usually this simply means a bomb or missile that is guided during its terminal phase.

Today I shall spend little time on the mechanics of how these weapons work; instead I will focus on some important and as yet unresolved implications of these weapons for force posture and for the conduct of warfare. For example, what is their effect on the relative usefulness of the advanced tank, the complex fighter-bomber, and the big aircraft carrier? What will be the consequences for the organization of land forces and for their tactics? There is the prospect that land forces may need to adopt a kind of molecular posture of many highly mobile -- but powerful -- squads. There is the possibility that less weight of munitions will have to be hauled to the battle area. What are the political consequences? If barrage fire and carpet bombing are not needed, there may be less collateral damage to civil populations and to the economy. There are prospects for raising the threshold at which nuclear weapons would be used

report
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and the consequences of this are both encouraging and urgently in need of study. Again, on the positive side, there is a likelihood that the resulting postures will be advantageous for defense and will lead to greater stability. And, hopefully, assuming about the same PGM technology for the Soviet side and our own, these new weapons and postures will, on balance, probably be advantageous to NATO and to U.S. strategies.

The serious thinking through of many of these points has only begun, and I must attach a tentative label to much that I shall say. Military analysts foresaw only dimly the implications of some very predictable technologies; it took the 1972 bombing raids and the October war in the Middle East to get a serious discourse under way.

I will say something about what PGMs are and describe several that are quite different from one another. Next I will offer some ideas on their implications for warfare 15 years from now, then return to the near future to discuss some changes that are already upon us, and in so doing pay special attention to their effect on NATO. Finally, I shall suggest some overall conclusions. I will not be saying very much about technological trends nor about countermeasures and counter-countermeasures.

EXAMPLES OF PGMs

Let me describe several PGMs -- each of a different kind -- to give you a better idea of the scope of what we shall be discussing. I do not think we need a pedantic definition of a PGM, but it would run something like this:

A guided munition whose probability of making a direct hit at full range on a tank, ship, radar, bridge, or airplane (according to its type) is greater than a half.

Many discussions exclude surface-to-air missiles, principally because they have been quite precise for a long time. What is new in this category is being precise *and* relatively cheap *and* easy to operate. Note that I said *relatively* cheap. Many of the new weapons are fairly sophisticated and can only be called cheap relative to earlier guided missiles or relative to the destructive capacity of other weapons that might be used to do similar jobs. But they are not too expensive to preclude an abundant supply -- and the possibility of abundance accounts for much of the significance of PGMs.

General awareness that something new had happened was triggered by the performance of the unpowered *Pave Way laser-guided bombs* in Vietnam in 1972. A two-part kit was attached to Mk 82 500-lb bombs or Mk 84 2000-lb bombs. The kit provided steerable front fins controlled by a laser receiver that homed on energy reflected from the target. In earlier systems a laser beam, from a unit called the "designator," was aimed at the target from a spotter airplane, but a later version avoided mixups by designating from the F-4 bomb carrier. Excellent accuracies could be obtained, making it possible to destroy a bridge span in one or two sorties that might otherwise have required dozens.

The Soviet *Sagger AT-3* wire-guided anti-tank missile saw extensive use in the October war. Often mounted in sixes on the BRDM-1 armored car, it weighs 11 kg, has a 2.7 kg warhead, and takes 25 seconds to reach its maximum range of 3000 meters. That is long enough to allow the intended target to seek cover or to distract the guider by taking him under-fire. On the NATO side, similar missiles are the U.S. TOW and the French-German Euromissile HOT, both of which are faster and have semiautomatic tracking features that permit the gunner to track only the target rather than having to "fly" the missile into the target. The British Swingfire is less automatic, but its guidance can be offset from the launcher by 100 m. All three have helicopter-mounted versions.*

Maverick AGM-65A is an air-launched anti-tank missile developed by the U.S. Air Force. It is guided by a television camera in its nose. Six can be carried on F-4s, A-7s, and A-10s. It has a lock-on circuit which permits the aircraft to leave after launch, or the crew can launch against other targets. It carries a relatively heavy warhead, and the whole round weighs 210 kg. A laser-guided version and an infrared version are under development.**

U.S. forces first saw the Soviet *Strela SA-7* (with the NATO nickname GRAIL) used in action in Vietnam. It can be carried by an infantryman and launched from the shoulder. It has an infrared seeker and 2.5 kg

*Data from *Flight International*, March 14, 1974.

**Ibid.

warhead. Reports from the October war indicate that it was fired in salvo at single Israeli fighters, "damaging the jetpipes of many Israeli A-4s but not achieving a very high kill ratio."* However, the Egyptian forces who used SA-7s probably proved a point on its operability. The current U.S. Redeye is similar; Redeye is being replaced by an improved version called Stinger. The British Blowpipe is also similar.

To round out this list of typical PGMs I shall describe two hypothetical missiles of a somewhat larger size class. The necessary *pieces* of missiles like these are in development, and may even have been tested as complete systems, but no fully operational missiles like these exist in quantity.

First, consider a *200-km range surface-launched cruise missile* that gets its mid-course guidance from Loran or some similar navigation system. Then, for the last 10 km, it corrects its course to target using an infrared area correlator. This is a device whose electronic circuits compare a received map-like picture of the terrain below with a reference picture taken on a reconnaissance flight. This kind of missile would be well-suited to attacking a depot or airbase, and its map-matching terminal guidance would be very hard to jam.

Finally, consider an alternative way to do the same job: a *remotely piloted vehicle (RPV)* of about the same size and range, but air-launched and guided by a pilot who watches a relayed television picture. His steering and throttle signals are sent by radio. In addition to attacking fixed targets, this missile could be used against moving or movable targets. Actually, the U.S. Navy's Condor AGM-53A has these properties, among others. But I hesitate to use Condor as my example, because refinements in guidance and anti-jamming features have driven its price up over \$200,000. A simpler design, more like ARPA's experimental Praeire, a remotely piloted model airplane of lower performance, may do many of the same jobs.

That is enough to indicate that the term PGM covers a broad class of guided bombs and missiles. I mentioned that air defense missiles are sometimes excluded; remotely piloted vehicles are usually included if they are intended to hit a target.

* Ibid.

I apologize for going over familiar subject matter for many of you, but in the course of this meeting I expect these missile names will be invoked many times and I hope these remarks will make their concrete forms easier to recall.

* * * * *

Now I turn from what these weapons are to some speculations on the consequences of having them. Let me remind you that I shall use a kind of funnel approach, taking the broadest consequences -- those of the more distant future -- first, then go to the near future, and then to some specifics relating to NATO.

IMPLICATIONS OF PGMs OF TWENTY YEARS IN THE FUTURE

By discussing PGMs in the context of operations in the 1990s I will not have to be held back by many practical and bureaucratic constraints, as I will be in discussing implications for the earlier period. Let me begin by stating the basic proposition about precision-guided weapons:

Accuracy is no longer a strong function of range, and if a target can be acquired, it can usually be hit. For many targets hitting is equivalent to destroying.

A second statement may be equally important:

Precision-guided munitions can now be mass-produced in great quantity; for many of these the cost per round ranges from the order of \$1000 to the order of \$10,000. Moreover, many can be operated by average soldiers.

A number of important propositions flow logically from those two lemmas. I will first put forward seven propositions in simple terms, then discuss some complications and the degree to which the simple ideas are applicable in the practical world.

Proposition 1. It will become much less desirable to concentrate a great deal of military value in one place. This will be especially true where great value can be destroyed by a single incoming warhead. For instance, a combatant would be less likely to want a large fraction of his capability at risk as, for example, when he exposed a single transport airplane, or a single surface vessel in the Mediterranean. He would probably prefer to have many inexpensive armored vehicles instead of fewer more expensive ones. Consider that the attacker has a limited number of PGMs, any one of which has a high probability of destroying either a valuable or a less valuable target. It is better to force him to spread his PGMs over many targets; at the least, this would strain his supply of PGMs sooner.

In addition, this proposition is more likely to be true if a few very valuable targets can be seen and their location tracked more readily than a larger number of less valuable targets. And before a final determination, we must consider the degree to which the concentration can be sheltered, or protected by active defenses, by comparison with sheltering or protecting dispersed targets.

Note that there have always been reasons to worry about having great force concentrations, and that even the availability of tactical nuclear weapons did not, in practice, result in a full set of corresponding actions to decrease vulnerability. PGMs, with their high probability of destroying targets that can be seen, make the problem of force concentration even more acute.

Proposition 2. Hiding will become more important. Recall that with PGMs seeing a target can usually lead to its destruction. Smallness and mobility will make hiding easier, and both of these qualities are consistent with the need to disperse stated in Proposition 1.

Proposition 3. Adding to the trend toward small units is the fact that even small units can be very powerful when equipped with PGMs or designators that can call in and guide remote PGMs. In land warfare the natural size of many independently mobile units might be a 3- or 4-man

squad, and these squads might get around by walking or using inexpensive vehicles, *not* expensive tanks; they might carry air defense weapons as well.*

Suppose, taking the European case, that the NATO forces were the first to change appreciably in this direction -- that is, toward numerous, dispersed, concealable, independently mobile front-line units. This makes sense as a unilateral move as long as their capability to deal with a Pact armor thrust is not seriously degraded. It helps reduce vulnerability to both PGMs and nuclear weapons. But eventually, there seem to be good reasons for both sides to go more and more toward a kind of molecular posture for forward units. There would be a problem of protecting such units from conventional overrunning attacks by infantry, but their mobility and their ability to call in PGM firepower would help. One can speculate that the FEBA would become even fuzzier and, over time, these forward units would have fewer important targets to designate. Later, I shall mention the pressures to reach for more distant, rear-echelon targets.

Proposition 4. A large fraction of the munitions used need not be hauled all the way to the FEBA. An exception might be air defense munitions, which could both protect the forward units and add to attrition over the area. Since the units up front will generally serve as spotters and designators, the munitions they call in might be ground-launched or air-launched from tens of kilometers farther back. Over a wide range of types of conflict, the weight of munitions delivered to the launch point *for a given effect* on enemy forces need not be nearly as great as in the past, because each round fired has a high probability of killing its target. Later on, I will say something about how the quantity of munitions *used per day* may be very large. One must consider both the changes in total needs and in the rate of use before understanding the implications for the size of support elements and the implications for vulnerability of the supply lines.

*Over the past two years T. F. Burke of The Rand Corporation has developed this and a number of related ideas and discussed them in lectures at the Army War College and other service schools; no published version is available.

Proposition 5. A natural consequence of having a high hit probability is that collateral damage to civil populations and economies is likely to be much less with precision munitions. In the NATO case, this prospect has substantial consequences over the long run for German attitudes toward preparing for actual fighting on German territory in contrast to a trip-wire strategy.

Proposition 6. Ground-based air defenses will become extremely lethal. The Soviet SA-7 is a step toward a potentially powerful way to keep air off the backs of mobile units, and proves the operational feasibility of this class of weapons. However, as already implied, it seems to be under-designed in warhead, range, and speed, even against present generation aircraft. These deficiencies must have made themselves known to the Soviets during the October war, and correcting them should be a routine matter. In any event, air defenses which derive from systems like the ZSU-23-4 four-barrel gun, the SA-6 mobile missile, and the SA-7 are likely to be proliferated in great numbers over the area occupied by ground troops.

Any of these classes of weapons may well be added to the mobile squads mentioned above, along with anti-tank weapons. The end result of this trend may be to shift much of the job of protecting ground forces from enemy air attacks away from air base attacks and air-to-air duels to ground-based anti-aircraft defenses.

These ground defenses may not have a kill probability even as high as 5% for the defended area of any one weapon, but flying over many defended areas will be very costly. One thing the air defenses have going for them is the high contrast of an aircraft -- which generates great energy -- against a relatively blank sky. The other thing they have going for them is that aircraft cost on the order of \$10,000,000 and the weapon to shoot them down costs less than \$10,000.

Proposition 7. Finally, these new weapons properties may well lead to a major revision in the assignment of roles and missions to the Services. It is no longer very important just what form of transportation carries a munition to the place where it is launched; it gets its effectiveness from terminal guidance. This makes it more logical that forces be organized in terms of the type of target to be attacked. Let me give some examples.

The job of dealing with an enemy ship in the Mediterranean has traditionally been a navy job. But with PGMs it is not immediately apparent whether the efficient way is with a ship-launched, air-launched, or ground-launched missile, or with some combination of these. Organizationally, a task force that had no bias against any of the three types would be best equipped to plan the attack. Over the long haul, an organization that specializes in the *task* will be best suited to decide how to allocate money over the various weapon types.

Similarly, the job of attacking air bases might be handled by PGMs launched from land or sea as well as air, and one can see that it might be efficient to allocate anti-aircraft defense funds among fighters and sea- and land-based systems from a common budget.

SOME COMPLICATIONS

The practical application of PGMs will naturally have a full share of complications, and the strategy of their use will be more involved than the seven propositions I have just stated.

To begin with, the technology for accurate guidance that is most fully developed requires transmission through the atmosphere in the visible spectrum or the near-visible spectrum. Simple radar guidance is not sufficiently accurate. Thus many present systems do not work at night, or through smoke, clouds, or heavy dust. Systems using long-wave infrared will be in widespread use by 1980. These will be useful at night and will do fairly well through smoke, dust, and haze, but they will be fairly expensive and may be significantly harder to maintain in the field. Nevertheless, the majority of PGMs will require clear daylight for many years.

Another problem is command and control. In past wars, commanders tens of miles behind the front concerned themselves with entire enemy divisions, or, at the smallest, battalions. With PGMs a division may consist of 500 separately targetable, individually moving objects. The temptation will be to handle this problem with data processing technology from a centralized operations room, into which a great volume of data can be fed. There has been a trend in recent years for higher echelon commanders to make full use of the profusion of multichannel communications gear supplied

by all-too-willing signal officers. Some senior U.S. officers have called for an "automated battlefield," and now I read that some Soviet military writers are calling for a "cybernated battlefield."* My own judgment, however, is that dealing with precision weapons will require a reversal of this trend. While it will be necessary to draw heavily on advanced data processing techniques, I believe much of the solution will be found in the delegation of authority and the use of standing procedures, even though the officers doing the detailed weapon control may well also be many kilometers away from the target.

A third complication is what we might call the "sublimation" problem. If the units near the FEBA become too small, or too mobile, or too well hidden to target, then the natural tendency will be to target depots and other valuable concentrations in the rear area support structure. Thus, there is likely to be a shift to targets farther and farther back as the missiles able to handle this job become more practical. Let me discuss this with special reference to NATO.

For some years this shift might find NATO at a relative disadvantage -- since it has been the NATO style, and especially the American style, to build great depots and to rely on a much larger support structure than the Pact forces use. Quite apart from any argument about less vulnerable forward forces, the simple fact is that as stand-off missiles get better and more practical there must be actions to reduce the vulnerability of rear area concentrations, even those formerly thought safe from any but the most determined air attack. Like several other moves to become better prepared for PGMs, this would also make NATO less vulnerable to nuclear attack, and thus help make a nuclear attack less attractive.

A further consequence of shifting attacks to targets farther back will be some new attitudes toward sanctuaries. For example, hardly any of NATO's rear area targets, except atomic-capable aircraft, have been a major subject of concern with respect to their vulnerability. Now those concerns must be extended to *any* concentration of military forces or equipment targetable by standoff weapons.

*See John Erickson, "Soviet Military Power," in *Strategic Review*, Spring 1973, p. 71 and pp. 103-106.

Another impurity is added to the simple picture when we consider that concealment and camouflage may work very well against PGMs. When this is the case the attacker might logically revert to area barrage fire or to carpet bombing. This must give us pause before we decide to use cities as defensive strong points. Similarly, there would be a tendency to use barrage fire and area bombing if dispersal resulted in a target occupying an area many times the effective area of a single PGM warhead.

In fact, before certifying that my seven propositions move out of the tentative category and become military axioms, there would need to be some force-on-force calculations of a type that has not been done so far. While we can marvel at a \$3,000 TOW-sized ATGM being able to kill a \$500,000 tank, we really need to calculate how many of these relatively short-range anti-tank weapons would be required on an entire front. At the same time it would be necessary to compare such a system with one where the individual PGM might have a higher cost, but be effective over a much wider sector -- for example, a remotely piloted vehicle (RPV) of 50-km range. One has to think back to the advice of General Giulio Douhet who wanted to destroy enemy bombers in the nest and not on the wing: "How many guns [in World War I] lay waiting month after month, even years, mouths gaping at the skies on the watch for an attack which never came!"

IMPLICATIONS APPLICABLE BY 1980

It seemed useful to discuss warfare of the 1990s first, to give a sense of direction. But some quite important changes are already upon us. In this section I shall talk about changes that will be important over the next five years, changes that are already affecting force postures and procurement decisions

Some weapon developments -- and not just PGMs -- with important consequences for our present consideration are these:

- (1) Weapons which, though small, have effective anti-armor warheads -- like the Soviet-built RPG-7s, the small unguided rockets used to good effect by the Egyptians last October.

- (2) Anti-aircraft weapons operated by individuals or small crews, immediately ready to use after movement, and cheap enough to be available in large numbers. I mentioned several hand-held missiles, like the Soviet SA-7. In the October war these, along with the Soviet-supplied SA-6 missile and ZSU-23-4 guns provided the Egyptians such good protection that their troops could advance without friendly air cover.
- (3) The war in Vietnam showed the value of helicopters to those who could afford them. In particular, units could be placed in difficult places without being isolated and *light payloads* could be delivered tens of miles with little regard to difficult intervening terrain. For our present purposes, the point of special interest is that precision weapons pack a great deal more capability into a helicopter-sized payload.
- (4) Precision weapons for use against surface targets are available in great quantity. The Soviets supplied hundreds of Sagers to their Arab allies; the U.S. is buying 30,000 TOW missiles and 6000 Mavericks this fiscal year.*

The important consequence of all this is that through the 1970s -- nuclear war aside -- the military balance between large scale forces is likely to be dominated by a new war of numbers. The \$100-million cruiser, \$500-thousand tank, and \$15-million fighter will be challenged by the proliferation of less expensive weapons. Most are light enough to be moved easily and many operate with almost no set-up time. There will be competition to field quantities of these relatively cheap weapons and to be ingenious in designing them so only modest skills are needed to operate them.

* Schlesinger, James R., *Annual Defense Department Report, FY 1975*, Department of Defense, March 4, 1974, pp. 107-108, 152.

By the same token, destroying or countering these abundant weapons will also take on a high priority.

Before turning to the specific case of NATO, let us consider the effects these new weapons may have on the relative position of the smaller countries. Some years ago it would have been out of the question for most small countries to install a radar network and to maintain Nike-size missile batteries. Nor would those in exposed locations have had much chance of stopping a thrust of modern armored units. The new style of arming goes a long way toward making the small countries more defensible on both counts. For some, this will mean a new set of relations between the client nation and the larger power; in other cases the small power may have much independence of action and there may be an effect on the market for munitions. Perhaps many of these countries will find it in their interest to buy more anti-tank and anti-aircraft weapons, and fewer weapons more suited for the offense. With good fortune, the net effect in many regions may be a trend toward postures that are stabilizing.

PRECISION ANTI-TANK WEAPONS FOR AND AGAINST NATO IN THE NEAR TERM

Let me go from the general case to a consideration of how NATO might use these modern weapons to face down the 15,000 or so Pact tanks which are opposite NATO's central front. Again, I shall be talking about the situation between now and 1980.

On the Soviet side there will be the fierce air defenses I have already mentioned and quantities of at least the three anti-tank missiles: Swatter, Snapper, and Sagger, or their descendents. The Sagger has been seen mounted in the BRDM-1 armored car, under a kind of steel umbrella, and in the BMP infantry combat vehicle. The Soviets do not yet seem to have an air-launched anti-tank missile.

On the NATO side there is a great profusion of types of surface-launched missiles -- I counted 16 due to be operational in the late 70s. Nearly all of these are wire-guided. These include the previously mentioned TOW, HOT, and Swingfire, with a maximum range of 3 to 4 km, and the shorter range missiles, Dragon and Milan.

Air-launched munitions include the laser-guided Rockeye (a cluster anti-tank munition) and Maverick. There are helicopter-launched versions of TOW, HOT, and Swingfire.

One of the biggest problems for all of these systems is target acquisition; once acquired, unless it moves out of sight, a target has a high probability of being destroyed. Cost per round for the TOW class missiles is of the order of \$3000 to \$6000; their launchers cost \$30,000 to \$60,000. For the Maverick, the current procurement is expected to cost just under \$10,000 per missile. Thus, the numbers of PGMs will be legion.

For the automatic systems, like TOW, crews may be trained quickly and there is no great problem in selecting potentially expert individuals.

Most of these systems are light and small. They can easily be adapted to be helicopter-mobile (though surface-launched) and should be natural candidates to serve as reinforcements or a *masse de manoeuvre*.

If all these potent properties of the new weapons are realized, then it follows that there will be some new priorities on the battlefield.

First, I should expect a kind of war of seeing and hiding at the newly significant ranges of 2, 3, or 4 km. If being seen at 3 km leads to a high probability of being destroyed, there should be an increased use of smoke, camouflage, and shielded paths for movements. And this is a competitive matter, in which the advantage is to the side which acquires at the longer range.

Second, I expect tactics will place high priority on destroying PGM and air defense units -- either by attacking crews or by attacking equipment. This might be by barrages of anti-personnel artillery fire, by air dropped weapons, or by trying to take launchers under direct fire.

These thoughts lead naturally into a listing of some deficiencies of the present generation of anti-tank PGMs, Soviet and NATO.

- (1) They need to be usable at night, in bad weather, in smoke and dust, but almost all current PGMs depend on the visible and near-visible spectrum for guidance.
- (2) The launchers and crews need to be as invulnerable as possible to physical attack; they need to be protected against artillery barrages and scatter bomblets.

- (3) The rate of fire of most PGMs is lower than the probable rate at which targets would appear. And the time of flight of most PGMs permits evasion when targets see they are under attack.
- (4) Many use small shaped charges; their damage can be repaired; armor can be redesigned to withstand them. (Maverick is an exception -- it has a heavy enough warhead to give rise to an anecdote from the October war. An Israeli tank Colonel is reported to have expressed dismay that the Israeli Air Force was using Maverick: "The damn thing blows up those Russian tanks so much that we can't fix them up for our own use.")

The defender can do something about most of these problems. For example:

- (1) Long-wave infrared systems will work well on clear nights and fairly well in dust and smoke. Scout helicopters and electronic battlefield surveillance systems will help with target acquisition.
- (2) Simple means of crew protection should not be expensive, such as operating anti-tank missiles from under armor.
- (3) For the time being, it is desirable for the defender to have a mix of guns with high-kinetic-energy rounds and missiles with shaped charges. The guns have a high rate of fire close in, where seeing is less of a problem. Also, armor redesigned to handle shaped charges may be vulnerable to high-kinetic-energy rounds.

In sum, then, the PGMs of the next five years -- the Class of '80 -- have their potentials and have their problems. But many of the problems seem susceptible to fixes at a tolerable cost.

Let us suppose that most of the needed fixes are made, that anti-tank PGMs are working at some level near their full potential, and then

consider a simple numerical example. *This example is very much a creature of its assumptions; it is not a forecast.* Consider a NATO division facing an offensive thrust by a Pact tank army having 1000 tanks and many other vehicles. Our division has at its disposal during the first two days of conflict:

- o 250 anti-tank land-based PGM launchers (TOW, HOT, Dragon, etc.)
- o 50 PGM-equipped helicopters capable of flying 200 sorties
- o 50 fighters which can fly 150 anti-vehicle sorties, loaded with 6 Mavericks each
- o Tanks, artillery, and mines sufficient to account for 100 Pact tanks.

Let us take as the NATO goal the stopping of 800 of the 1000 tanks, and assume that the 350 total sorties by helicopters and fighters take out 400 tanks (plus numerous other vehicles). Our 250 PGM launchers must then stop 1.2 tanks per launcher to stop the remaining 300 tanks.

It is not my intent to engage in a detailed speculation on the practicality of killing 1.2 tanks per launcher, or of the kill rates per helicopter or fighter sortie. But what I do want to say is that if a tank-killing potential of about these magnitudes is possible, then a very different, more hopeful, picture of NATO's defensive potential will emerge in comparison with past estimates.

SOME OVERALL POINTS

I should have liked at this point to say more about the interrelationship of PGMs and tactical nuclear warfare. However, I have decided that this is a subject deserving full and separate treatment, and my own thoughts are far from being well ordered at this stage. Instead let me ask you to think about a few questions. First, the potency of RPVs and PGMs for attacking rear area targets will be quite high by the 1980s. Does this mean that they will be thought of as a substitute for nuclear

strikes? Second, will there be a tendency to use precision-guided mini-nukes, sacrificing the nuclear fire break for engineering efficiency? * Third, some Soviet strategic writings seem to regard non-nuclear war as a phase preceding nuclear war. If PGMs do, in fact, halt a Pact tank thrust, how will the Soviets calculate the value of going nuclear at that point? Two points seem more straightforward: Operating in small, separated units is a good tactic for PGM warfare and for avoiding tactical nuclear vulnerabilities. And passive protection and dispersal of rear-area support facilities is a good idea in any case.

Another topic I shall not treat is how the introduction of chemical warfare would affect these conclusions about PGM defenses. There have been a number of warning signals in Soviet writings that they take chemical war preparations seriously. The recently captured Soviet-supplied chemical warfare equipment carried by Arab troops during the October war had led to a public statement by the U.S. Defense Department on the need for defensive preparations. At the least, this should make U.S. force planners look favorably on PGM systems that can be operated from enclosed vehicles or bunkers.

With these omissions in our consideration noted, I submit three main conclusions.

First, the advent of PGMs is probably advantageous to the defender. Target acquisition is the key to successful use of PGMs, and it is much easier for a defender to hide than for his opponent, who is moving through unfamiliar terrain, and without the opportunity to prepare positions. Then, too, the relatively light PGMs can be moved quickly to where they are needed -- perhaps by helicopter -- while heavier systems, including tanks, might arrive

* On May 23, 1974 the United States made a statement to the Geneva Disarmament Conference which "gave assurance ... that it would not develop a new generation of miniaturized nuclear weapons that could be used interchangeably with conventional weapons on the battlefield." In an interview, Dr. Fred C. Iklé, director of ACBA, said, "We have no intention to move in a direction that could blur the distinction between nuclear and conventional arms." (*New York Times*, May 24, 1974.)

too late. Current PGMs are not well-suited for an offense, most being designed for specific defensive tasks. Thus, hopefully, the acquisition of PGMs by both sides will lead to a more stable situation.

However, it is necessary to be cautious about concluding definitively that these developments always operate to the defender's advantage. Consider NATO again. Even a massive Pact offensive may involve the Pact holding defensively along 95% of the front, while thrusting offensively along the other 5%. And NATO forces must, in many places, go locally on the offense. So weapon trends advantageous to efficient holding also suit Pact purposes in a majority of places; their problem is to confute NATO's capability to hold defensively in just a few places. Normally, this would entail a great concentration of offensive strength; so again we come back to the question that requires detailed study: Just how vulnerable to PGMs are such concentrations?

Second, an important consequence of the dispersal of so much destructive power down to small units, and the natural delegation of authority to use it, is that the pace of war will be faster. In places with large concentrations of forces there will be an unprecedented intensity of non-nuclear conflict. Even though, as I said earlier, the total weight of munitions to do a job may decrease over the entire time of the conflict, the *rate* of use is likely to go up. The material destroyed *per day of fighting* is likely to be an order of magnitude greater than we have been thinking about for non-nuclear war. We had a glimpse of this in the sudden logistic demands of the October war; a war in Europe could dwarf those consumption rates. Will this pace lead to escalation or negotiation as forces find munitions largely spent after three or four days?

Third, there is a hopeful sign that the trend of the first part of this century toward the inclusion of non-military target systems and civilian populations in military campaigns will be reversed. Precision delivery means that military targets can be destroyed with less total explosive power and less collateral damage to non-military targets. The faster pace I mentioned above means that tactical forces in being count more, strategic forces count more, and the general economy less, in achieving a favorable outcome.

An interesting hypothesis is that adhering to a rule which strictly limits civil damage may now be possible, given precision weapons, during both offensive and defensive operations, with no loss of military efficiency. I should like to see this hypothesis explored in a broad analysis. If the result is favorable, this could be an appropriate subject for international discussion and negotiations leading to an agreed limitation.

Finally, I shall raise one other prospect for an arms limitation agreement, one which seeks stability through an emphasis on defensive capability. Expensive, large, multi-purpose weapons are usually well-suited to the offense: the tank, the F-14 class fighter bomber, the nuclear carrier. To the extent that smaller PGM-equipped units are making such systems less viable perhaps it can be demonstrated that both opponents would be served by limiting the numbers of such large systems. For a given budget or manpower ceiling, more resources could go into defensive units that would perform so well in holding against an attack that a generation from now service school graduates would quote a new maxim: "The best defense is a good defense."