The Counterrevolution in Military Affairs

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PROLOGUE

Sometime after the turn of the century, two countries are at war. One decides to attack the other. Its tanks, in regular columns, cross the border between the two combatants. However, its approach to war and its approach to the border have been constantly and comprehensively monitored by the defending side.

Suddenly, without warning, small missiles silently attack the invading tanks. Each "brilliant" [1] missile hovers momentarily above the tanks, selects one and attacks it by firing a high-speed projectile at the weakest part-the turret and engine cover. The deadly accurate missiles are very selective: they don't attack any tank that has been selected for attack by another missile. These missiles are fired from 30 to 40 kilometers away, far beyond the range of the tank's guns. Few survivors crawl out of the burning wrecks, since red-hot pieces of metal ricochet around inside and hot, suffocating gases spread rapidly throughout. Only three of the tanks survive. Their morale shattered, the crews decide to retreat [2].

INTRODUCTION

Since the victory in DESERT STORM, there has been a slowly but steadily growing chorus claiming that we are entering a new era in warfare. In this conception of a "Revolution in Military Affairs" (hereafter RMA [3]), the evolution of military technology has reached a critical mass, a point where the impact of this technology is becoming so pervasive as to justify a total rethinking of our conduct of and organization for warfare. If correct, this promises an immensely, and possibly uniquely, favorable military future for America. As the world leader in the application of these military technologies--and one of the few nations that can afford to apply these technologies on a large scale--the US can expect to dominate any major future battlefield as decisively as we dominated the Iraqis. The American military can expect that future wars will largely parallel the scenario of the prologue.

But what if the optimistic projections are wrong? For a start, as some authors have noted, the technologies in question are likely to be of, at best, very limited use in situations like Haiti, Somalia, or Chechenya, which are the most likely type of conflict we will face for at least the immediate future [4]. Further, these new technologies are likely to be of limited use in urban scenarios, such as Beirut. More central to this article, questions must be raised as to how effective these technologies will be even in their most favorable paradigm: against a highly mechanized regional threat. For while the US military can justifiably claim to have established a new standard for warfare in the Persian Gulf War that some claim is the harbinger of the RMA, that standard is now known worldwide. As was the case with the Germans and Blitzkrieg in 1940, the US must expect that everyone who can will try to match or exceed the standard, and--central to the purpose of this article-- that everyone who cannot match it (probably most of the

world, since it is enormously capital-intensive and therefore enormously expensive) will try to devise ways to defeat it. Since comparative disadvantage is a spur to innovation [5], what countermeasures might be used to defeat the RMA? What are the prospects of a COUNTERrevolution in military affairs?

To evaluate such prospects, this article will do three things. First, it will give a summary describing the reasoning behind the claims of an RMA. Next, it will evaluate the limits and weaknesses of the RMA and how an enemy might try to target them. Finally, it will analyze the dangers and implications of overestimating the impact of the RMA and embracing it as the center of future American military strategy.

CHAPTER I: THE REVOLUTION IN MILITARY AFFAIRS

The concept of the RMA is based on the assumption of technological revolutions in three overlapping areas [6]. When integrated, these are expected to produce a profound change in the nature of warfare.

> 1. INFORMATION SUPERIORITY. America is assumed to be acquiring the technology to permit comprehensive and constant surveillance of the battlefield and relevant adjacent areas in real-time or near-real time. The US is further assumed to be acquiring the ability to process the information into usable intelligence and rapidly distribute it to users who need it. This is expected to dissolve much of the fog of war--the uncertainty and confusion that comes from incomplete and/or inaccurate information on the battlefield and the situation on it.
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> 2. BATTLESPACE DOMINANCE. America is assumed to have command, control, and communications superiority, so that US forces will be able to exploit their information superiority. The US is assumed to be able to move faster and control its forces more effectively than the enemy and disrupt his control of his forces, so that the US will be able to inflict operational paralysis on his military and strategic paralysis on his government.
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> 3. WEAPONS SUPERIORITY. It is assumed that with advanced weapons, especially increasingly sophisticated precision guided munitions (PGMs), America will be able to stand off and defeat the enemy military with few friendly casualties and, possibly, comparatively minimal enemy military casualties and minimal civilian casualties or damage.

If these capabilities are deployed and work as their proponents expect, the RMA will indeed be a revolution in warfare. The capabilities demonstrated in DESERT STORM, devastating though they were, were actually, in many ways, a rather rudimentary example of its potential. However, to reach its full potential, the RMA requires the effective integration of developments in each of the three areas. As is generally the case with integrated efforts, if a key part of the effort fails the entire effort may be subject to massive degradation, and possibly to massive failure. Much of the necessary technology is, at best, only partially in existence at present, and it may be several (or many) years before such technology is fully developed and deployed. Since the RMA is only

partially mature, potential enemies can be expected to exhaustively study the concept and its relevant parts and, at the very least, to seek to devise effective countermeasures. The military legacy of the former USSR, in particular, will be a rich lode to be mined, refined, and applied.

CHAPTER II: THE COUNTERREVOLUTION IN MILITARY AFFAIRS; A COMPETITIVE STRATEGY

How might an enemy seek to counter or defeat the RMA? An obvious approach would be to use what was called a competitive strategy in the 1980s, which seeks to identify and target enduring weaknesses of an enemy or his strategy [7]. If done effectively, such an approach will render that enemy's forces or strategy ineffective before fighting him. When the components of the RMA are examined, it does not take long to identify a wide variety of potential points at which a competitive strategy might be directed. The weak points chosen for attack will depend on a combination of the imagination of the enemy, his available resources, and his technological sophistication. As a point of reference, this article will divide countermeasures into two general approaches, which are somewhat arbitrarily called LOW TECHNOLOGY and HIGH TECHNOLOGY. Low technology (which will include no technology) will, as a rule, tend to favor a mixture of human cleverness, defensive countermeasures, brute strength, and unsophisticated firepower, while high technology will tend to favor a mixture of technological cleverness, offensive measures, precisely targeted strength, and selective firepower, and is likely to be used by an enemy with a more sophisticated economy and society with more resources to spend. It should be noted that low technology does not necessarily mean simple or unsophisticated: the deception strategies and technologies used in the Second World War were, by today's standards, low technology, and the deception strategies and technologies of our enemies in the Korean and Vietnam Wars even more so, but they were all too often effective It should also be emphasized that the low tech and high tech approaches are not mutually exclusive: the use of one does not preclude the use of the other, and, in fact, they are likely to complement each other.

1. DISRUPTING INFORMATION SUPERIORITY: THE BATTLE FOR INTELLIGENCE

Central to the RMA is the assumption of American "dominant battlefield awareness"--intelligence superiority or supremacy [8]. The US intention is to decisively cut through the fog of war by integrating information from a complex variety of sources and sensors, above all advanced battlefield airborne surveillance systems such as Joint STARS-the Joint Surveillance Target Attack Radar System [9], and then distributing it through a variety of mechanisms. This being the case, an obvious countermeasure is to deceive or blind friendly reconnaissance. There are any number of ways to do this, and many of them have the advantages of being readily available, cheap, and requiring minimal advanced technology. The low tech approach will tend to be defensive, favoring passive measures to lower enemy vulnerability to friendly detection and to reduce our ability to understand what they are doing. The high-tech approach, on the other hand, will tend to have a more offensive cast, employing a variety of measures to actively interfere with and obstruct friendly reconnaissance. This article will consider two main approaches to disrupting information superiority: A) Clouding Our Minds; and B) Going For God's Eyes.

A. CLOUDING OUR MINDS aims to encourage confusion at all levels and defeatism in the minds of American decision-makers. It can do this either by raising the level of background noise so that accurate intelligence cannot be extracted from the static, by confusing or manipulating friendly decision makers by providing bogus or selectively accurate information that will encourage those leaders to make bad decisions, or both. The Russian term for such an effort, which this analysis will use, is MASKIROVKA: an integrated program of camouflage, concealment, and deception. Maskirovka can be done in either peacetime or wartime, although the techniques used will vary accordingly. There are three reasons why maskirovka deserves considerable attention. First, because, despite the West having been the target of Soviet maskirovka for decades, there is still only a limited appreciation of how widespread an impact maskirovka has had and can have. Second, since many maskirovka techniques are comparatively cheap and straightforward and strike at the core of the RMA, it is likely to be a favored response. Finally, it has the advantage of exploiting what is likely to be a key American weakness in a future crisis: the shallowness of understanding America is all to likely to have of many future crisis areas and the circumstances and enemies it will be facing there.

Enemy aims in using maskirovka will depend on the circumstances of the crisis and the phase of its evolution (prewar, opening phase of war, later phase of war), whether the overall enemy strategy is offensive or defensive [10], and the level of the organization controlling the maskirovka program. Maskirovka's general aims will be to confuse friendly decision makers as to whether there actually is a threat, to hide its magnitude, to degrade friendly ability to accurately discern its development and likely evolution, to weaken friendly will to respond, and to disrupt the effectiveness of American and Allied response.

Strategic maskirovka is likely to be heavily political and psychological, with the aim of at least insuring strategic and operational surprise and at most precluding outside--especially US--intervention. It will attempt to create and exploit divisions within and between friendly governments and to divide the US against itself, to persuade some or all friendly leadership that there is no real threat of war, or that if there is a threat that it is America's fault or that of America's allies, and that the hostile government's aims are fundamentally defensive or limited or at least not a threat to American interests. It is likely to attempt to persuade American leadership that any attempt to intervene will be a costly failure. As the threat of war increases, maskirovka is likely to seek to persuade US and Allied leaders not to risk bringing forces to a higher state of alert lest it inflame the situation. Low-tech strategic maskirovka will attempt to do this through the traditional methods of psychological and political manipulation, while high-tech strategic maskirovka will reinforce and add an additional dimension to the psychological and political efforts with deceptive cyberwar efforts, such as by inserting contradictory or spurious information directly into friendly data links or data bases [11]. Once actual combat starts, and possibly before, the enemy can be expected to try to disrupt at least the national command and military command systems of the targeted country--and any countries moving to support it--through destructive information warfare ("information strikes") against government, military, and possibly economic computer systems [12].

Maskirovka at the operational level of war will be primarily military, and will presumably be the responsibility of the higher-level staffs of the hostile military commands. With an offensive enemy strategy, it will aim to achieve operational surprise, while with a defensive strategy it will aim to maximize the appearance of defensive strength, in the hope of deterring an attack. The techniques used will depend on the situation and the plan of attack or defense, and are virtually infinite in number. The low-tech approach can be expected to use a centrally controlled campaign of deception through information control and selective disinformation, such as the British and the Americans did in preparation for D-Day [13], and is likely to emphasize using the enemy civilian population (and civilians in any friendly territory the enemy occupies) as human screens, as the Communists did during the Vietnam War. An enemy using a high-tech approach can be expected to reinforce these efforts with a centrally controlled and selective program of electronic jamming and countermeasures against friendly surveillance systems and communications systems, which this analysis will refer to by the term formerly used by the Soviets for such an effort; "radioelectronic combat"--REC [14].

Tactical maskirovka will be the tactical unit-level aspects of operational maskirovka, and will primarily be undertaken by the enemy military units themselves, especially by engineers. It will attempt to maximize the chance of operational and tactical surprise by misleading friendly forces as to the actual magnitude, location, and timing of the threat through the intelligence equivalent of increasing the background noise. If the enemy posture is defensive, it will seek to sow confusion about enemy strengths and weaknesses, so that if push comes to shove key targets will be missed and efforts wasted on hitting the wrong ones. Tactical maskirovka can be expected to do the following: employ extensive visual, thermal, and radar camouflage of actual positions and units [15]; mingle military units and stockpiles with the civilian population, society, and economy in order to disguise them; massively use decoys, including sophisticated decoys that provide radar, visual, and thermal signatures similar to actual vehicles and helicopters; and undertake rigorous communications security and operational security, including extensive counterreconnaissance efforts and severe restrictions on the civilian population and civilian communications. The major difference between the low-tech and the high-tech approaches at this level of warfare will be in the level of technology used in the camouflage, decoys, and security measures.

> B. GOING FOR GOD'S EYES is the second major approach to disrupting information dominance. Stated simply, you can't hit what you can't see. Proponents of the RMA tend to assume that the surveillance systems of the RMA will give a comprehensive overview of the battlefield in real time, often termed a "God's-eye view." An obvious countermeasure is to attack the surveillance systems. While this might be done in the prewar phase (probably using terrorists as cutouts), it is likely to move to center stage with the start (or, as in Kuwait, the renewal) of hostilities. In keeping with the traditional Soviet REC concept, an enemy should be expected to mount a systematic effort to destroy friendly intelligence systems and platforms. The high altitude stand-off surveillance platforms and their data downlinks and downlink sites are likely to be priority targets for attack. The low-tech approach will concentrate on the downlink receivers, targeting them with commando raids (or, depending on the circumstances, with terrorist attacks) and missile barrages, while targeting the

surveillance platform bases with commando/terrorist attacks and longer-range missiles. The high tech approach will concentrate on the ground sites with barrages of more sophisticated missiles [16] and will, in addition, attempt to destroy the airborne surveillance platforms while they are on station [17]. In the future, attempts to neutralize at least low-orbiting reconnaissance satellites with some kind of rudimentary antisatellite capability should be expected [18]. Finally, an enemy will attempt to degrade what surveillance capability survives through a campaign of jamming and other electronic countermeasures against the surviving airborne radars and the data links from airborne surveillance platforms to ground sites.

2. COUNTERING BATTLESPACE DOMINANCE: SAND IN THE GEARS OF PROGRESS

The RMA assumes a tightly integrated battle, where all parts will work together win. There are two major approaches to disrupting such an integrated battle. The first is to disrupt the command, control, communications, and intelligence (C3I) necessary to effectively organize and control an integrated battle. The second is to neutralize the weapon systems necessary for the deep attacks [19] which are central to the RMA's success.

A. DISRUPTING C3I obviously overlaps considerably with countering information superiority, and in Western military thinking the two have often been combined in a category known in the recent past as "C3ICM"--C3I countermeasures. The obvious way to do this is to target the command nodes which will be integrating the data and running the war. For the foreseeable future the success of an integrated battle will be critically dependent on a rather limited number of key command nodes, especially ground headquarters at corps level and above and the Air Operations Centers (AOCs) (or their local equivalent) which will run the offensive air war. Disrupting or destroying these can be expected have an immediate and massive impact on integrated operations. This can be done through either physical destruction through the most expedient means or disrupting C3 links. The tactics used to do this will obviously again overlap with those used to disrupt information superiority, since there will be extensive overlap between the two target sets. The low-tech countermeasures approach will again concentrate on targeting the C3 nodes with commando raids (or, depending on the circumstances, with terrorist attacks) and missile barrages. The high-tech approach will again concentrate on the ground nodes with barrages of more sophisticated missiles and further degrading what C3I survives through a campaign of jamming and other ECM and information attacks.

B. NEUTRALIZING KEY FORCES is the other approach to disrupting the ability to wage an integrated battle. At present, use of long-range stand-off firepower to minimize the risk of friendly casualties is central to the conception of the RMA, and for the foreseeable future, this stand-off firepower will primarily be delivered by air units, especially fighter-bombers, although long-range attack helicopters [20] and long-range artillery, rocket, and tactical surface-to-surface

missile units will gradually become increasingly important. If these units are taken out of the war the RMA starts to collapse. There are four major approaches which can be used to target these units, and an enemy must be expected to use all of them. These approaches are:

1. Active Defenses

2. Targeting Deep Attack Forces

3. Operational Techniques

4. Tactics

1. ACTIVE DEFENSES can be used as part of either an offensive or defensive posture. The character of such defenses can be expected to vary according to the sophistication of the enemy and, equally important, their available financial resources, as late-generation aircraft, surface-to-air missiles (including tactical antiballistic missiles), radars, and the C3 systems needed to tie them together into an effective integrated air defense system (IADS) are expensive. For those without the hard currency to buy SU-27/35/37 aircraft and SA-12s from the Russians [21] and therefore forced to use the low-tech approach, antiaircraft artillery (AAA) and shoulder-fired SAMS such as the STINGER are straightforward to use, comparatively cheap, and potentially very deadly. Further, when netted with sensors and command and control systems, such weapons can provide considerably more than a point-defense capability [22]. At present, only partially noticed but extremely ominous is the potential use of lasers as an antiaircraft blinding weapon [23].

2. TARGETING DEEP ATTACK FORCES is the second approach. An enemy can be expected to adopt an air denial strategy, and to expend massive efforts to neutralize the bases and units which provide deep attack firepower. Methods of doing this will be tailored to reflect enemy strengths, using a locally-tailored mixture of special operations forces (SOFs), air attacks, or missile barrages and/or attacks by missiles with various specialized warheads such as cluster munitions, fuel-air explosives [24], carbon-fiber warheads [25], and possibly chemical weapons. These attacks are especially likely to be effective against non-hardened assets and/or in the early stages of an Allied buildup, when such friendly forces (and most especially American reinforcements) are only partially available and likely to be at their most vulnerable [26].

3. OPERATIONAL STRATEGIES--the way an enemy intends to wage their war--are the third approach. Obvious possibilities for such an operational strategy are either launching an offensive, use of surprise, or both. Such strategies would aim, at best, to seize the initiative and win quickly, with the aim of presenting the US with an accomplished fact before America can intervene in force, or, at the very least, force us to fight at their initiative and on their terms, since if American

forces are hunkered down in a defensive crouch America will not be the one in control of the war.

4. TACTICS are the final approach that might be used to neutralize deep attack forces. The Soviets and NATO expected any conventional war in Europe to be fought under at least the threat of nuclear attack and escalation ("nuclear scared"). The tactics the Soviets in particular emphasized to minimize the potential effectiveness of any nuclear attack are also potentially effective against the precision guided munitions whose use is central to the effectiveness of the RMA. Such tactics include dispersion, mobility (rapidly moving forces are harder to attack and therefore less vulnerable), timing (attacking at a time and under circumstances which reduce the effectiveness of opposing reconnaissance and defensive systems) and having their forces hug civilian population centers to exploit our reluctance to cause collateral damage [27].

3. DISRUPTING THE BULLSEYE WAR: THE LIMITS OF PRECISION ATTRITION

Precision attack--generally using PGMs--is central to the RMA, so disrupting precision attack is the final approach to countering the RMA. There are two major approaches to doing this. The first of these is reducing the vulnerability of enemy forces to precision attack. The second is reducing the effectiveness of precision-guided munitions.

A. REDUCING THE VULNERABILITY OF ENEMY FORCES can be done in two ways.

First, through reducing the detectability of potential targets (their 'target signatures'), largely through the various techniques of tactical maskirovka and using the civilian population as human screens and shields. For the low-tech approach, visual signatures can be reduced through camouflage and decoys. Infrared signatures of vehicles can be reduced through the use of heat suppressers on exhausts and the use of track skirts on tracked vehicles. Radar signatures can be masked with decoys. The high-tech approach will supplement these with more sophisticated camouflage, reduction of communications signatures through the use of sophisticated communications [28], and, if "stealth" technologies become fairly cheap and/or such technologies or techniques of signature reduction can be retrofitted onto vehicles [29], the use of "stealth" materials and techniques on individual equipment to reduce radar signatures.

Second, through hardening or otherwise reducing the vulnerability of equipment and facilities which are going to be key targets, such as tanks, rockets/missile launchers and artillery, unit headquarters, and supply lines. The low-tech approach will favor the use of a variety of traditional mechanisms, including dispersal, redundancy, camouflage and maskirovka (hiding real targets while providing false targets), mobility (changing position frequently), increased distance from the forward area where feasible (especially for headquarters and supply depots), improved defenses, improved armor for individual tactical equipment, and an increased cushion of supply. The high-tech approach will supplement these with improved defenses, including terminal defenses for individual equipment [30], and more survivable individual equipment [31].

B. REDUCING THE EFFECTIVENESS OF PGMS: ENCOURAGING PRECISION MISS. While often, as previously noted, viewed as miracle weapons by the uninformed or semiinformed [32], PGMs and their launch and control platforms are actually subject to a wide variety of limits. These can vary broadly depending on the type of PGM in question and the launch system, and which will exist even without enemy countermeasures. Thus, while PGMs may well be among the world's finest ambush weapons, in a head-to-head fight against a thinking and prepared enemy they may well lose much of their usefulness [33]. A shrewd enemy would exploit any number of problems and limits, of which the following are prominent:

> 1. THE TARGET ACQUISITION PROBLEM. Target acquisition is the development of accurate targeting data once a possible target has been detected, so that the munition can be delivered precisely where required for maximum effectiveness. This may involve a very complex process, and, as with all complex processes, there are numerous points for things to go wrong. Target acquisition is likely to be extremely difficult in a war of maneuver where friendly reconnaissance systems are a high-priority enemy target and especially if friendly forces have not established air superiority.

Present PGMs generally need to have their targets acquired for them: to be used to their full potential, they still need human control at some point in the loop to tell them where to go. Many need to be guided all the way to impact, although not necessarily by the system that launched them. This may be a matter of considerable or extraordinary difficulty and danger, especially for aircraft-launched systems under combat conditions [34].

The march of technology will not necessarily solve these problems. Advanced standoff submunitions currently entering the inventory, such as SADARM (Search And Destroy ARMor) and SKEET, are expected to be able to acquire their own targets independently once launched. Unfortunately, such weapons cannot simply be pointed in the assumed general direction of the enemy and launched. Their sensors have only very limited scan areas [35], so their ability to autonomously detect and home in on targets depends on their being placed almost literally on top of those targets before they start to operate. They will still require detailed near-real-time targeting intelligence. As mentioned, whether that intelligence will be available when needed remains to be seen.

> 2. THE COMBAT IDENTIFICATION PROBLEM [36]. This consists of being able to tell friendlies from hostiles, and can be expected to compound the target acquisition problem. During the war with Iraq the Coalition used a variety of measures, including precision navigation equipment, infrared beacons, and thermal tape, and generally these were adequate. In a future war of maneuver, where hostile and friendly forces are intermixed, moving rapidly, and may be operating the same types of equipment, they are likely not to be, especially at night or in bad weather. Further, the steadily increasing ranges of both air-to-surface and ground weapons can be expected to increase this problem, especially for visual systems[37].

3. ENVIRONMENTAL FACTORS. Many of the sensors on which PGMs and their controlling platforms depend are subject to degradation by a variety of environmental factors, including bad or cloudy weather, smoke, and inability to penetrate foliage or structures.

4. LIMITATIONS OF THE WEAPONS. As previously mentioned, many existing PGMs require control all the way to impact. This requires the airborne or ground-based laser designator to stay within the line of sight to the target until impact, which increases the risk of the controlling aircraft being detected and shot down and the ground designator being suppressed before the weapon hits. In addition, laser-guided weapons in particular have a variety of other significant limitations [38].

CHAPTER III: CONCLUSIONS

With the concept of the Revolution in Military Affairs, the United States is considering embracing a new approach to war emphasizing advanced technology in reconnaissance, information processing, and weapons as the central focus for efforts to defeat any future enemy. Such a strategy would emphasize traditional American strengths: sophisticated technology and the quality and initiative of American troops. What remains very much open to question is whether such a strategy will ultimately work in the field. It must be assumed that the Saddam Husseins and Kim Il-Sungs (and, perhaps, the Leon Trotskys) America will face in 20XX will be at least equally ruthless and a great deal more sophisticated--and therefore even more dangerous--than the Saddam Hussein of 1991.

It is clear that a US embrace of the RMA carries at least two major risks.

First is the risk is that embracing the RMA as the basis for American military strategy means embracing technology that is at best only partially mature and at worst dangerously premature. In particular, the advanced surveillance technology necessary to make the RMA work at best only partially exists, as does the technology necessary to process and deliver information to where it is needed [39]. With the budget crunch extending as far ahead as we can see, the technology necessary for the RMA may never fully exist, or, equally important, may never exist in a form that can be expected to survive long enough to be useful once shooting starts. Many of the programs for the systems of the RMA are on the cutting edge of military technology, and if they run behind schedule or over budget they will be mortally vulnerable.

Second is the risk that, even if the RMA technologies do mature, they will not necessarily work as planned, a risk reinforced by the potential of dangerously underestimating the ability of a suitably inclined enemy to put sand in the gears. The RMA may therefore produce extremely powerful yet brittle instruments of war that are all too likely to failure needed the most. As this article has indicated, there are a wide variety of countermeasures available to degrade or defeat each of the components of the RMA. These countermeasures are frequently straightforward, cover a broad variety of methods, and are, generally speaking, not mutually exclusive (and may be mutually reinforcing), so an enemy must be expected to use them all. It should further be noted that few of these countermeasures are new: they are fundamentally the same approaches

the Soviets devised to use to reduce the threat of nuclear attack in any war in Europe. Many of them, especially the techniques of tactical and operational maskirovka, date back to the experiences and practices of any military that has had to contend with superior hostile airpower. The RMA will therefore give potential enemies more reason to do what they were likely to have already planned to do anyway. The war against Iraq cannot be considered a fair test because the Coalition had the initiative and only the Coalition was waging a war of offensive rapid maneuver, with Iraq intending to wage a defensive positional war of attrition. Therefore, it remains to be seen what will happen in a war where both sides have a grasp of the technologies in question, where both sides are seeking to gain the initiative in a war of maneuver, and where the enemy is using a competitive strategy and friendly command and communications and air power are central targets of enemy efforts. Finally, it remains to be seen if the future evolution of the technologies of the RMA will reduce or increase their susceptibility to countermeasures.

CHAPTER IV: IMPLICATIONS

The operational consequences of the new focus on the RMA are, as yet, limited. The US is considering it as the framework for emerging military technology, strategy, and tactics. There lies the ultimate potential danger. If the US military as a whole or individual services embrace a doctrine, strategy, and operational art based on technologies and tactics that will not reliably work in practice when needed, we risk surprise and defeat when applying them. And while the outcome of such a regional defeat will have far less massive implications than it would have had 15 years ago, when such a defeat might have meant the Soviet Army overrunning Western Europe, the potential costs of such a defeat should not be underestimated, especially in terms of the blood of the people who would be doing the fighting. Korea in the summer of 1950 is an obvious parallel. Because if, as happened in 1950, our superior technology fails to deliver an attempted quick and cheap win, the US will presumably then have to try it again, this time the hard way.

So what should be done? A potential alternative consists of a combination of four parallel courses:

> First, the US should continue a very robust research program in the RMA technologies, so as to avoid technological surprise, to explore the degree to which the RMA technologies can be reliably made to work, to identify the environments or circumstances where those technologies will not reliably work, and ultimately to see to what degree they actually can remove fog and friction from war. A critical part of this research must include rigorous investigation into all potential countermeasures to the RMA, not just because our enemies may use them but because ultimately the US may need them. An RMA-related subject that deserves comprehensive research is the extremely dangerous possibility that the success of the RMA will, like the earlier success of the blitzkrieg, be critically dependent on the circumstances in which the technologies are used. An appalling but all too likely possibility is that, to the degree that the RMA is successful, it will work best when employed in a carefully prepared surprise attack against an unprepared enemy: in other words, it will work best when employed by the Admiral Yamamotos of 20XX [40]. Unless America is prepared to hit first or manages to

> arrange to repeat the strategy of DESERT STORM, this means the RMA may work when used against us, not when used by us. Above all, research should seek to guarantee that the system of systems that RMA technology will produce will degrade gracefully rather than crash in the face of enemy countermeasures.

Second, it is vital that we keep a historical perspective on the impact of potentially revolutionary technology. It is necessary to walk before you can run, and to whatever degree the RMA actually comes about it should not be expected to have a revolutionary impact immediately: it is likely to need to attain a certain level of maturity first. A likely parallel is with the development of airpower: just because visionaries like Billy Mitchell ultimately turned out to be more or less correct does not mean they were completely correct--far from it--or correct all along. While the technology of the 1940s made much of what the prophets of airpower had proposed seem like simple common sense, in terms of the technology of the 1920s those prophets were ridiculously premature. This analysis suggests that, to whatever degree the RMA does occur, its impact will be more evolutionary and incremental than revolutionary. It is likely that it is safer that such is the case. RMA proponents may be expecting more than the presently available and foreseeable technology can actually ever deliver. Therefore, before buying the technology in large amounts and at high cost, making it central to American operational strategy, and reorganizing our forces around it, it is prudent to demand that the RMA prove itself. It should face the most rigorous operational testing, under geographic and climatic conditions closely simulating those of likely real world operating areas, and against targets permitted the widest possible independence in devising defenses and countermeasures. If the new technology works repeatedly and reliably in honest and fair tests, then it should be bought, but only then. To a degree, the Army has started--but only started--doing this with recent maneuvers at Fort Irwin in California [41]. The equipment should also be tested in places like Fort Drum, New York (simulating Korea and/or the Balkans), and Fort Polk, Louisiana (simulating a tropical or subtropical environment.)

Third, even if the RMA can be made to work routinely and reliably, it would be prudent to elevate our sights a little lower in regard to expectations about what it can ultimately accomplish. We shouldn't expect technology to abolish the fog and friction of war; the most it is reasonable to expect is that they will be reduced, and more likely they will just change their form [42]. Technology will not make Clausewitz go away [43]. And the RMA will not change the fact that an enemy who is dug in and willing to die is still extremely dangerous even if they are strategically and operationally paralyzed [44]

Finally, it cannot be overemphasized to all concerned, especially to Congress, the media, and the public, but also within the military, that cheap victories, however desirable, cannot be taken for granted, and we should not expect technological shortcuts to victory. Future enemies are not likely to be as conveniently stupid as Saddam Hussein, who in DESERT SHIELD and DESERT STORM allowed the Coalition to establish the terms and circumstances of the war and cooperatively provided a favorable target-rich environment [45]. It must be remembered that George Custer had a target-rich environment at the Little Big Horn, and it was that richness of targets that killed him. We must assume the next war will be against an astute enemy who will have both a good idea of how the US military intend to fight and a coherent strategy to defeat the US if it fights that way.

In conclusion, in considering the prospects of the RMA, a historical sense of perspective is worthwhile. For decades, the West has sought the mix of technologies that would automate warfare. In the 1950s it was called "push-button" warfare, in the 1970s it was called the "bulls-eye" war, in the 1980s it was called the "automated battlefield," and now it is called the RMA. It is now 1998, and the fact that we are still seeking that magic mix of technologies should tell us something.

EPILOGUE--OR PROLOGUE?

Sometime after the turn of the century, two countries are at the brink of war. One country decides to start it, and plans to open the war with immediate and decisive offensive military action, with the intention of winning as quickly as possible and of precluding or preventing foreign allies of the other country from intervening effectively. Prior to the war, it uses a variety of political strategems to try to isolate the intended victim, including announcing a willingness to make substantial concessions to defuse the crisis. When the intended victim, believing the crisis is passing, lowers its guard, the attack starts.

The opening attacks seek to do three things: blind the defending side's surveillance assets by physically attacking them; disrupt its command and control; and deny it the ability to use its air power. The attacks do these with a series of missile, commando, terrorist, and information strikes. Especially disruptive is its air denial strategy, consisting of missile attacks carrying carbon-fiber warheads on defending airfields. The carbon fiber filaments ruin much of the electronics at the bases without killing many people. The defending side, which planned its whole campaign around its superior air capability, has lost most of its high cards: its ability to gain air superiority and launch a strategic air campaign to cripple or destroy the attackers' ability to wage war is literally destroyed on the ground. Simultaneously, the attacker launches its ground offensive. As the attacking formations move to the attack, their tanks, infantry fighting vehicles, self-propelled artillery, and antiaircraft and support vehicles shift into widely dispersed tactical formations well before they approach the border. Their approach to the border and their actual attack is screened by a massive and integrated campaign of deception and countermeasures, involving jamming of radars and communications, extensive use of decoys, and corridors of metallic chaff (metal coated filaments that create false radar returns) designed to obscure and disrupt surviving surveillance systems. To the north and south of the sector chosen for the breakthrough stand additional immense formations of armored vehicles. These are actually composed largely of sophisticated decoys, which give radar and thermal reflections similar to actual vehicles, covered with camouflage and dispersed among trees to obstruct visual efforts to identify that they are decoys. The defenders suspect that many or most of these are decoys, but can't identify just which ones are not, so they must withhold much of their surviving firepower and leave defending units in place to deal with possible additional or follow-on attacks, of as of yet undetermined strength and location. Further compounding the difficulties of the defenders is the presence of large numbers of civilian vehicles throughout the hostile border area: surviving surveillance can only pasrtially screen out civilian from military vehicles.

It is only with extreme difficulty that the defenders are able to identify the first major axis of attack, and the units defending that sector of the border launch their first salvo of deep strike brilliant munitions. The attacking force immediately calls in long-range counterbattery fire. This

counterbattery fire consists of the same weapons and tactics the attackers are using to try to suppress the defenders' screen of surface-to-air missile sites: saturating the defending launch areas with massive salvoes of tactical missiles equipped with fuel-air explosive warheads. Therefore, many of the defending launchers are destroyed or damaged: the ability to counterattack by fire is disrupted. The fact that the defending launchers for deep-strike munitions are out of range of attacking tank guns is largely meaningless.

Meanwhile, the strike-deep munitions launched by the defenders have proceeded on their way. Some of them are shot down by the tactical anti-ballistic missile defenses. The surviving missiles launch their brilliant homing submunitions. However, these face additional problems:

1. The attacking tanks are moving rapidly but their actual ground speed is inevitably unpredictable, which means that by the time the defending missiles arrive in the target area, the attackers are usually not quite where the defenders expected them to be. Many of the missiles go where the attackers aren't, and are therefore wasted. Further, the strike-deep munitions are cluster munitions, and the time of flight before they disperse their submunitions has to be preset before launch. The longer the range, the more likely it is that this preset time will be incorrect. Some of the missiles prematurely eject their submunitions over areas where there are no attacking units, while others overfly the target and eject them too late.

2. Of those missiles that arrive in the area where the attacking formations really are, some of their submunitions either do not eject properly, or do not decelerate properly, or their sensors do not start to scan properly, or misfire. The fatal ifs of complex weaponry accumulate.

3. The attackers are fighting in widely dispersed formations. Each of the attacking submunitions can scan only a very limited area. Only a few of the attacking armored vehicles are within the scanned areas. Many of the submunitions do not find targets.

4. The area chosen for the breakthrough is rather wooded, although the forest has been largely cleared of undergrowth and thus is passable for armor. Brilliant munitions can't see through the forest cover, which obstructs both infrared sensors and millimeter wave radar sensors.

5. The attacker has chosen to launch his attack in bad weather, with moderate-to-high winds. This degrades or neutralizes the sensors on many PGMs. In addition, many of the submunitions are deployed from their carriers by parachute. As they deploy, the wind scatters them over a much larger area than projected, further diluting their effectiveness.

6. In spite of these problems, some of the PGMs and submunitions do detect and identify hostile targets. However, the attacking armored vehicles are equipped with terminal defenses, which destroy some of the submunitions before they can

fire. Other submunitions are neutralized because the attackers have partially covered the tops of their vehicles with special armor and covered THAT with bags of marbles [46]. As a result, only a small percentage of the attacking vehicles are destroyed or damaged.

7. As the attacking formation nears the defending lines, the defenders start using their ground and air mounted laser designators to illuminate individual targets for laser-guided munitions. However, the attacking vehicles, equipped with laser detectors, carry laser countermeasures: smoke grenades containing aerosols that disrupt laser reflections enough that incoming laser-guided rounds cannot accurately identify a target. In addition, artillery-launched laser-guided rounds are degraded by low-lying clouds, since they cannot acquire their targets while in flight.Therefore, only a few of the laser-homing rounds hit their targets. Although somewhat weakened, the unit is still combat-capable. And it is merely the first wave.

This attempt to build a defense using the RMA as a basis has been a spectacular failure. It turned out there were no technological shortcuts to victory. If this attack is going to be defeated, it will have to be defeated the hard and nasty way. Welcome to Korea, June 1950.

NOTES

1. "Smart" munitions are weapons that can be guided all the way to their targets or will automatically guide themselves to their targets after the target is acquired for them, thus yielding a high probability of hit. "Brilliant" munitions need only be the immediate area of a target, after which they are expected to be able to identify and acquire targets by themselves and guide themselves to impact.

2. Frank Barnaby, "How The Next War Will Be Fought", Technology Review, October 1986, Vol. 89, #7, P.27. A more elaborate scenario that reaches the same conclusion is laid out in Barnaby, The Automated Battlefield (New York, Free Press, 1986), chapter three.

3. This article concentrates on the technological aspects of the Revolution in Military Affairs, which might more properly be called the Military Technical Revolution. See Michael J. Mazaar and Jeffrey Shaffer, The Military Technical Revolution: A Structural Framework (Washington DC, Center For Strategic and International Studies, March 1993). Also see Adm William A. Owens, "A Report On The JROC And The Revolution In Military Affairs," Marine Corps Gazette , Vol 79, # 8, August 1995, pps. 47-55, and Jeffrey R. Cooper, Another View Of The Revolution In Military Affairs, (Carlisle, PA, US Army War College, 1994). Other sources consider the revolutionary change to be rooted in the collapse of Communism and the Soviet Empire and the current lack of a world-class enemy. See LtGen William Odom, America's Strategic Revolution: Strategy and Structure After The Cold War (Washington DC, American University Press, 1993). Finally, for the current US Government view and expectations on the subject, see General John M. Shalikashvili, Joint Vision 2010 (Washington DC, Government Printing Office, 1997)

4. See Capt Warren Caldwell, USN, "Promises, Promises," Naval Institute Proceedings , Vol. 122, #1, January 1996, 45-57.

5. See A. J. Basevich, "Morality and High Tech," National Interest, #45, Fall 1996, P. 41. Or as I prefer to put it, military inferiority is the mother of invention.

6. For simplicity sake, this article will examine only those aspects of the RMA that are of direct relevance to combat on the battlefield. There are other areas, including simulation and training. This draws heavily on Mazaar and Shaffer, The Military Technical Revolution, P. 18, and Adm Owens' article.

7. See Ronald Reagan, National Security Strategy Of The United States (Washington DC, Government Printing Office, 1987) P.20. A more currently fashionable term is evidently 'asymetric warfare.'

8. See "Redundancy, Robustness Protect Vital National Information Links, Signal, Vol. 50, #9, May 1996, P. 38.

9. For an overview of the role of Joint STARS in DESERT STORM, see Peter Grier, "Joint STARS Does Its Stuff", Air Force, Vol 74, #6, June 1991. For an enthusiastic assessment of the future role of Joint STARS on warfare, see Lt Col Prince T. Bingham, USAF (Ret), "Forward...From The Sea With Joint STARS," Marine Corps Gazette , V.80, #1, January 1996, Pps 26-30, and "Revolutionizing Warfare Through Interdiction," Airpower Journal, Volume X, #1, Spring 1996, 29-35. For more jaundiced evaluations, see "An Army Bosnia Review Rates JSTARS A White Elephant," Defense News, Nov. 25, 1996, P. 1, and General Accounting Office, Tactical Intelligence: Joint Stars Full-Rate Production Decision Was Premature and Risky: GAO/NSIAD-97-68. (Washington DC, Internet, 1996).

10. By 'defensive', I mean defensive in the sense that Saddam Hussein's strategy in Kuwait was defensive or the Japanese strategy in 1943-45 was defensive: they were trying to hold on to what they had already grabbed.

11. See Col Richard Szafraski, "A Theory Of Information Warfare: Preparing for 2020," Airpower Journal, Vol IX, #1, Spring 1995, 56-64. Szafaski regards information warfare as being, in many ways, a more sophisticated variation of psychological warfare on a new front.

12. See Szafraski, "A Theory of Information Warfare:...". Among the sources referring to information strikes, see Andrew F. Krepinevich, "Competing For The Future: Searching For Major Ellis," Marine Corps Gazette , Vol. 80, #11, November 1996, P. 31.

13. See Anthony Cave Brown, Bodyguard Of Lies (New York, Harper and Row, 1975)

14. The Soviet term was actually closer to "radioelectronic struggles." See David G. Chisum, Soviet Radioelectronic Combat (Boulder, CO, Westview, 1985) P.3.

15. Sweden, for instance, developed in the 1980s a camouflage net that it claimed defeated all modern sensors. "Can We Rely on Advanced Reconnaissance Methods In A World of Camouflage?" Military Technology, Vol. XI, #6, June 1987, P. 135.

16. Generally speaking, at present the ballistic missiles we are likely to face are, to put it charitably, area weapons. As such, they are suitable only for use either as terror weapons (as Saddam Hussein used his SCUDs in both Gulf Wars) or as carriers of weapons of mass destruction (WMDs). While possibly of political relevance to friendly governments in the theaters in question, in military terms they are merely a nuisance unless they carry WMDs. However, the People's Republic of China has reportedly used a guidance system using the Global Positioning System on some of its ballistic missiles. See "China's Military Seeks Great Leap Forward," Aviation Week And Space Technology, May 12, 1997, Vol 146, #20, p. 70. Assuming the Chinese--or somebody else--build and widely deploy such systems, we must expect such missiles to pose a militarily significant--and possibly very dangerous--threat.

17. A key requirement for the effectiveness of such surveillance aircraft is that they be employed as far forward as possible, since the curve of the earth limits their look-down range. This forward employment will, of course, increase their vulnerability. Even if they are not destroyed, systematic efforts against them might force them farther back into friendly airspace, which is likely to degrade their usefulness. While an alternate approach will be to hold them in a rear area and surge them forward under heavy escort, this will yield only intermittent coverage. Past information indicates the Soviets developed several missiles for an anti-AWACS role, including a variant of the Kh-31 air-launched missile and the SA-5e version of the SA-5 GAMMON, which could eventually show up on the world market. For information on the anti-AWACS KH-31, see John W. R. Taylor, "Gallery of Russian Aerospace Weapons." Air Force, Vol 79, #3, March 1996, P. 76. For information on the SA-5e, see "2000 GAMMONS Still In Service," Jane's Defense Weekly, Vol 11, #15, April 15, 1989, P. 654. More recently, the People's Republic of China has been advertising a surface to air missile, the FT-2000, as an anti-AWACS missile, although the exact production status of the missile is uncertain. See "China Displays New (Old?) Attack Fighter," Aviation Week and Space Technology, V. 149, #21, November 23, 1998, P.23. Ground receivers could be attacked by special operations forces, terrorists, or by air and helicopter units. There are likely to be far fewer surveillance platforms than downlink reception sites (a Joint STARS deployment in support of the Bosnia operation included two aircraft and 13 ground stations) so targeting the platforms is likely to be the more effective strategy.

18. Considering the reported expense--and therefore the small numbers--of satellite reconnaissance systems, the loss of such systems will be hard to replace and therefore extremely disruptive. While in the future this vulnerability may be reduced through use of the high-resolution civilian imaging satellites that are starting to come on line, these satellites will be equally vulnerable, but available in larger numbers. This author is inclined to expect an antisatellite (ASAT) system to be a ground-based directed energy weapon, since such a system would be easier to hide and harden than a missile-launched ASAT system, which would need at least one missile for each satellite targeted--a pretty substantial deployment if the total number of imaging systems gets into double digits. In addition, depending on the technology, laser systems might be mobile, and would be more tactically flexible and responsive. In any case, such a

capability is not likely to be easy to build, and if it is in a fixed location it is likely to be a priority target for attack. For a useful study of the requirements for such a system, see Federation Of American Scientists, Laser ASAT Test Restriction (Washington, DC, Federation Of American Scientists, 1991).

19. As a more precise definition, this article defines deep attack as the use of conventional firepower, primarily but not necessarily airpower, to influence the ground battle at the operational level of war by doing some or all of the following: isolating and shaping the ground battlefield, weakening the combat power of enemy ground forces not yet in contact with friendly forces, weakening enemy offensive air and operational-level surface-to-surface missile capability, and interfering with the enemy scheme of maneuver. Whether deep attack is undertaken to support the scheme of maneuver of friendly ground forces or whether the ground campaign will be a supplement to the air campaign will need to be determined by the circumstances and characteristics of the theater in question. This definition blends a variety of missions, including the concepts of tactical interdiction, offensive counter air, the emerging concept that, for lack of a better term can be referred to as offensive counter missile, and deep close air support. This definition draws heavily from Ian Lesser, Interdiction And Conventional Strategy Prevailing Perceptions (Santa Monica, RAND Note N-3097-AF, June 1990)

20. AH-64 Apache attack helicopters can hit targets at ranges traditionally associated with interdiction missions, as noted in LtCol Thomas Runge USAF, Firepower And Follow-On Forces Attack: Making Every Round Count (Maxwell, AL, Air University Press, 1991) P.XII.

21. For a typical report, see "Russians Aim For US Lead in Exports," Defense News, Vol 12, #6, February 10-16, 1997, P.4.

22. The potential threat from such weapons was revealed during the bombing of North Vietnam, and the danger they present continues even if we have achieved air superiority or supremacy. During the 1991 Persian Gulf War, US aircraft generally bombed from medium altitude (10,000 feet or higher) to minimize the risk from light AAA and SAMs, which degraded accuracy considerably. The potential danger from netting such weapons with sensors and C3 is discussed in Mark Hemish, "New Sensors And Processing Boost Short-Range Air Defense", International Defense Review, Vol. 19, #2, 2/1986.

23. The People's Republic of China is reportedly offering a blinding laser for export. The USSR reportedly deployed blinding lasers throughout their air defense system in the 1980s. See "Chinese Laser "Blinder" Weapon For Export", Jane's Defense Weekly, Vol 23, #21, 27 May 95, P. 3.

24. Fuel-air explosives are a potent but little-noticed aspect of modern weapons technology. They are weapons that release an aerosol that detonates when thoroughly mixed with air, producing a large explosion. See Louis Lavoir, "Fuel-Air Explosives, Weapons and Effects," Military Technology, 9/1989, 64-70.

25. See "Secret US Warhead Nearer To Fielding," Aviation Week And Space Technology, Vol. 142, #14, P. 62. Carbon fibers work by shorting out electrical and electronic components. This would destroy the equipment without killing anybody.

26. One of the pictures on the wall at the US Air Force Gulf War Air Power Survey during 1992 was a picture of an airfield full of F15s, unrevetted, unsheltered, and parked nearly wingtip to wingtip. Undoubtedly intended as an illustration of the USAF Global Reach, Global Power concept, it should also remind students of World War II of how Hickam Field, Hawaii, looked on December 6, 1941. For more detailed and not necessarily dated information on the vulnerability of air bases to attack, see "In 1991, Air Force Will Learn Whether It Has A Home", Washington Times, 12 Jan 89, P.1, and "Getting the Jump On Base Defense", Insight, 6 February 1989, 34-36.

27. The Iraqis did this to a degree, but much of the area of concentrated ground combat contained very little civilian population. Thus, we could establish numerous "kill boxes" in DESERT STORM--designated areas where our aircraft were told to kill any vehicle in the area--with the expectation that there would be nobody there except Iraqi soldiers and vehicles. What will happen if in the next war the enemy runs his operations and supply lines through inhabited areas with considerable numbers of civilian vehicles?

28. Possible advanced communications technologies include spread-spectrum radios, which spread their transmissions over a wide band of frequencies . This makes them harder to detect, intercept, and triangulate. Other possible advanced communications technologies include extremely high frequency (EHF) radios and laser communications, which operate at frequencies high enough to make point-to-point communications literally just that. However, they are evidently subject to significant degradation from environmental factors.

29. Moldable 'stealth' materials can be produced, which presumably means it is possible to produce plates which can be fitted or retrofitted on armored vehicles. See Jane's Defense Weekly, 30 April 88, P. 855. Also, radar-absorbing material can be applied as a paint. See "B-2 Radar Signature Hitch May Lie With RAM Fit," Jane's Defense Weekly, Vol. 16, #13, 28 September 1991, P. 562. Of course, such coatings are likely to be subject to rapid degradation once in the field, as they get damaged by or scraped off on the surrounding landscape and vegetation. Dirt on the coating also evidently degrades its RAM properties.

30. See, for instance, "Army Takes Page From Navy Playbook, Begins Work on Point Defense System," National Defense, Volume LXXXI, #520, September 1996, P. 29 on US efforts to develop a terminal defense for armor.

31. One of the little-noted discoveries of the war with Iraq was that up to that point the tanks had at least held their own, if not won, the tank-antitank race.

32. For one of the worst examples, see Barnaby, The Automated Battlefield. Dr Barnaby embraced precision guided munitions with the enthusiasm of a contractor trying to make a sale. Unfortunately, he compared the PGMs of 2000+ with the targets of 1960, thereby grossly underestimating both the survivability of modern weapons and the potential of countermeasures.

For a more detailed critique, see Thomas R. McCabe, "The Myth Of The Bulls-Eye War", unpublished paper, summer 1988.

33. For a detailed study, see General Accounting Office, Antitank Weapons: Current And Future Capabilities (Washington DC, Government Printing Office, 1987). Somewhat dated, but the facts haven't changed.

34. Assuming that the US and its allies have not established air supremacy or fully suppressed air defenses, attacking aircraft will presumably be flying at high speed and very low altitude (which increases survivability but provides little time and a very limited range for target acquisition) over probably unfamiliar terrain (worse if it is hilly or mountainous), probably with numerous inhabited areas, possibly with a good many power lines about. He may well be doing this at night and/or in foggy, cloudy, or bad weather. Depending on the closeness of the Forward Edge of the Battle Area (FEBA) and/or the degree of intermingling of hostile and friendly forces, he must expect to face intense hostile (and quite possibly friendly) antiaircraft fire, blinding lasers, degraded radar and sensors from countermeasures, hostile and friendly artillery fire in the same airspace, hostile interceptors and attack helicopters, and a great deal of smoke, dust, and general confusion. Individual targets are likely to be camouflaged, and, as in DESERT STORM, it may be hard to differentiate between present targets and past targets that have been previously killed. The problem will be even more difficult for single-seat aircraft such as the F/A-18 or the F-16, since the jobs of flying the aircraft and aiming the weapons will both fall on a single man, obviously increasing the potential for task saturation. Finally, if the attacking aircraft is not equipped with a laser designation system, it will need the support of an air or ground platform or unit that is, and these must work together as an integrated team. For a review of the difficulties this presents, see William B. Scott, "Revived Killer-Scout Tactics Leverage PGMs," and "Flight Underscores Demands Of Killer-Scout Mission," Aviation Week And Space Technology, V. 145, # 17, October 21, 1996, pps 48-53. Under these conditions target acquisition by the attacking aircraft is likely to be extremely difficult and dangerous.

35. For example, the sensor mechanism for the submunition of the US SADARM--Search And Destroy Armor--has a search radius of 100 meters at a look angle of 15 degrees. See Joseph Antoniotti, "PGMs--Semi-Active Laser Versus Millimeter Wave Guidance," International Defense Review, Vol. X, #9, September 1986, P 1272. More recent versions have evidently enlarged the search radius somewhat.

36. Combat Identification was formerly called Identification Friend or Foe: IFF. See Commander George Cornelius, USN (Ret), "Big Bucks For Weapons-Small Change For Lifesavers,' Naval Institute Proceedings , Vol 122, #1116, February 1996, P.70.

37. For information on US efforts in combat identification, see Commander George Cornelius, "Big Bucks...". Also see Commander Austin Boyd, USN, "Space Provides Real-Time Combat Identification, " Naval Institute Proceedings, Vol. 122, #1115, January 1996, 75-76, and John Mintz, "Hill Presses Army to Deploy New System," Washington Post, July 27, 1996, P. 8.

38. For a useful overview, see Capt Kenneth R. Bergman, "Laser-Guided Systems: An Overview," Marine Corps Gazette , Vol. 74, #8, August 1990, 53-56.

39. A central part of intelligence dominance consists of attempting to automate the intelligence process. This speeds up the processing and distribution of data, at the risk of reducing or removing the human sanity checks from the system. It remains very much to be seen if, in processing the raw intelligence data, we will be able to screen out errors and deception. The ultimate problem here may still be GIGO--garbage in, garbage out. An equally critical question that is seldom addressed is whether increased access to information will necessarily lead to improved decisions. For an outstanding article that warns that this is not necessarily the case, see Major John F. Schmitt, USMCR, and Gary A. Klein, "Fighting In The Fog: Dealing With Battlefield Uncertainty," Marine Corps Gazette, Vol 80, #8, August 1996, Pgs 62-69. There is the additional problem of information overload: "trying to drink from a fire hose." See "Information Glut Hampered US Troops In Bosnia, Pentagon Says," Washington Post, April 3, 1997, P. 22.

40. The Admiral Yamamoto of 20XX will have carefully analyzed opposing information systems, mapped them with as much precision as possible, and precisely targeted their weaknesses. The Admiral Kimmel of 20XX, on the other hand, will be trying to protect his information systems--or get them back on line and organize a counterattack--while the bombs--both logic bombs and real bombs--go off around him.

41. "Army Trying Out Electrons To See If It Can Get Smaller and Faster," Washington Post, March 31, 1997, P. A4. However, it should be noted that the leeway permitted the opposing force was limited: they were not allowed to use any type of electronic countermeasures "...lest they end the experiment before it began." See "Army Puts Computer-Based Technology to Battlefield Test," Los Angeles Times (Washington Edition), March 25, 1997, P.7.

42. See "Wired For War: Digital Soldiers Will Make The Army Smarter and Deadlier--If The Computers Will Just Stop Crashing," Time, March 31, 1997, P. 72.

43. For an excellent article on this subject, see Williamson Murray, "Clausewitz Out, Computers In," The National Interest, #48, Summer 1997, Pgs. 57-64.

44. Or, as noted by Frederick W. Kagan, "...to expect the god of technology to save us from the drudgery of war is folly." See Kagan's part of "High-Tech: The Future Face of War? A Debate" in Commentary, Vol 105, #1, Jan. 1998, P.34. For an interesting and potentially relevant study, see Samuel W. Mitcham, Jr., The Desert Fox In Normandy (Praeger, Westport, Conn., 1997). The German units there were war-weary, massively outnumbered and outgunned, operationally paralyzed by a combination of Hitler’s orders and Allied airpower, and it still took over a month to dig them out of Normandy.

45. We should remember that in Kuwait the Coalition had what were actually unusually favorable circumstances. In particular, there was a highly developed infrastructure in Saudi Arabia and the neighboring Gulf kingdoms available for use; key regional allies, especially the Saudis, were generally equipped with air, ground, and support equipment that was at least interoperable with our own. Further, local militaries had largely been trained by American and British instructors, and English was the functional international language. Finally, we had several months to prepare. Compare this with a hypothetical situation in eastern Europe some time in the

future, where the local forces will be, at best, only partially organized or trained along Western lines; their equipment and support infrastructure will be only partially interoperable with ours; their readiness will be extremely low; their infrastructure will be thin and/or badly maintained; English will not be the international language, and we need to fight a come-as-you-are war in a war that will probably have already started before we get there. This is likely to be a much grimmer war with a far more uncertain outcome. See my draft article "Airpower Beyond The Next War," January 1999.

46. This would primarily be reactive armor--plates of metal-encased explosive placed on the outside of armored vehicles. These explode when hit by the gas jet of a detonating shaped-charge warhead before that jet can cut through the main armor of the vehicle: the intention is to disrupt the shaped charge gas jet before it penetrates. The reference to the bags of marbles is from Steven Canby, "Operational Limits of Emerging Technology", International Defense Review, Vol. IX, #6, June 1985, P. 880.