The Military-Technical Revolution: A Preliminary Assessment

Andrew F. Krepinevich, Jr.

CSBA Center for Strategic and Budgetary Assessments

1730 Rhode Island Avenue, NW, Suite 912
Washington, DC 20036

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by

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1730 Rhode Island Ave., NW
Suite 912
Washington, DC 20036
(202) 331-7990
http://www.csbaonline.org

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FOREWORD

This net assessment of the military-technical revolution, issued in July of 1992, is perhaps the best-known assessment prepared by the Office of Net Assessment. It has, I believe, held up well over time. The strategic management issues it raised should still be of special interest to top-level Department of Defense officials.

Why was the assessment undertaken in the first place? The history is as follows: During the mid- to late-1970s my office had picked up on the writings and other actions by the Soviet military which suggested that they believed a period of major change in warfare had begun. At that time it was the United States that was laying the groundwork for the revolution, but it was the Soviet military theorists, rather than our own, that were intellectualizing about it, and speculating on the longer-term consequences of the technical and other changes that the American military had initiated. As the Soviets appeared very concerned about these developments, we concluded that it would be useful to intensify those concerns by further investment in the "reconnaissance-strike-complexes" (as the Soviets called them) that were central to their vision of how future warfare would change.

Later, as part of the Commission on Integrated Long-Term Strategy that Fred Iklé and Albert Wohlstetter led during the mid-1980s, Charles Wolf and I co-chaired the "Future Security Environment Working Group" which had been asked to look ahead twenty years and provide an assessment of the geopolitical and technical changes on which United States military planners ought to focus their attention. We recommended three likely changes for special attention. One was that the next twenty years would be a period of major change in warfare.

So it was in late 1990 or perhaps early 1991, shortly after Andrew Krepinevich had joined the office, that I asked him to undertake an assessment to decide still more clearly if we really believed that the Soviet theorists were correct in their belief that technological developments would lead to major changes in warfare. I believed that if we were in such a period, then senior Defense officials would be faced with new, important strategic management issues. The purpose of the assessment, then, was to clarify and highlight what we thought were the most important of these strategic management issues. The assessment raised four:

- How to identify appropriate innovations? (Perhaps, by means of future oriented war games, field exercises, forming experimental units, etc.)

- How to foster innovation? (Perhaps, by changes in career programs—introducing new career paths—military education, protecting and promoting innovative officers, etc.)

- How to change the DoD acquisition process better to support field experimentation? (Perhaps by facilitating procurement of small numbers of new equipment for experimental or prototype units, etc.)

- How to involve our allies? What role would they play? What would be the new division of labor between us?

This assessment is not typical of the assessments produced by the Office of Net Assessment. Nor was the process by which it was conducted like that of other assessments. For example, because of its nature the assessment had very little to do with classified information. It dealt with speculation about the future, and the potential impact of technology and new operational concepts on warfare. Rather than drawing upon a small group or single individual, many panels were formed to discuss the various issues. This process was consciously chosen in the hope that it would produce a shared language and vocabulary for discussing the character of the changes in warfare that might take place in the future. The effort yielded what seemed to be a consensus that we were in a period of major change; in short, that the Russian theorists were right. We also concluded from military history that changes of the scale that we were talking about would involve new concepts of operation, and new organizational structures and processes to execute these concepts.

The assessment draws upon analogies with a previous period of major change in warfare, the 1920s and the 1930s, to specify the scale of the change we anticipated. This period also seemed of special interest because the institutional and other arrangements within the United States military are still reasonably close to those of that period. It was hoped, therefore, that we might learn lessons about successful strategies of innovation from studies of the best performance of United States military organizations.

We live in a period of large scale, rapid technological and, very likely, social change. The pace of technological change is accelerating. We have not fully exploited and adjusted to developments in information and communication technologies; the next wave of change-producing developments is coming out of the biological and human sciences, which are likely to become significant sources of change in military operations and organizations. These developments only reinforce the importance of the strategic management issues that were raised in this assessment.

Andrew W. Marshall

September 2002

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AUTHOR'S INTRODUCTION

On August 1, 1991, Andrew Marshall and I met with a small group of advisors at the Office of Net Assessment at the Pentagon. At the time I was serving as a military assistant to Mr. Marshall. During the meeting Marshall announced his intention to undertake a different kind of net assessment from the Soviet-oriented efforts that had dominated the office's efforts since its establishment in 1973.

Marshall said this assessment would explore whether a major shift in the character of military competitions was under way—what Soviet writers had referred to as a "military-technical revolution." It was not clear to him, however, that such an assessment was possible. The consensus of the group was that the issue was too important not to address, despite the prospective difficulties. Marshall agreed. The task of leading and writing the assessment fell to me.

While this meeting formally initiated the assessment that follows, both Mr. Marshall and I had discussed the issue informally for nearly a year prior. As his Foreword indicates, he had been thinking about the matter for years.

Of particular importance was a meeting on December 19, 1990, during the buildup of US forces in the Persian Gulf prior to Operation Desert Storm. The meeting's purpose was to develop a framework for assessing the post-war security environment. During the meeting Marshall indicated his intention to move beyond the Cold War military balance assessments (even though the Soviet Union still existed). Two days later he met with me and stated his desire to focus the future security environment study more on how military competitions might change. He suspected they might change dramatically. Among the issues he asked me to begin thinking about were how we would define our competition if the Soviet Union's power continued to wane, the growing lethality of conventional war, and how rapid advances in technology might change warfighting concepts.

We met again on January 24, 1991, during the early days of the Gulf War air campaign. Our conversation now focused on issues such as whether or not we were witnessing a fundamental discontinuity in military operations, and how we might identify a new "blitzkrieg" form of warfare if we saw it. Marshall also wanted to know if we might be able identify the magnitude of the shift as well as its form. He noted that the historical record of these transformations in warfare indicated that military organizations were typically surprised by their appearance. We needed to make sure that we were not surprised. Moreover, if possible, we needed to shape the situation in ways favorable to our security interests.

In writing the assessment, I was the beneficiary of numerous one-on-one meetings with Mr. Marshall. I also drew upon the findings of a number of meetings I chaired that brought together experts from within the Defense Department, and from the greater security studies community. Mr. Marshall included me in a number of meetings he convened to explore the issue. Additionally, I expended considerable effort in trying to understand how earlier periods of dramatic change in military competitions had played out.

The assessment was circulated in July 1992, generally to favorable reviews. This surprised us somewhat, given the assessment's strong implication that the military services would likely have to undertake fundamental reforms.

This was the first of two assessments on what was then known as the "military-technical revolution." A second, more comprehensive, assessment was completed a year later, in July 1993. The term "military-technical revolution" was later changed to "Revolution in Military Affairs," primarily as a consequence of the tendency on the part of some to equate the revolution primarily (and, in some cases, exclusively) with advances in technology. Both terms are borrowed from Soviet military writings on the subject. In my subsequent research on the issue I have adopted the term "military revolution," which is more consistent with the scholarly literature, and avoids the baggage of being associated with Soviet usage of the term.

This assessment, and the one that followed a year later, have had a significant effect on the strategic debate over the last decade, leading to calls for a transformation of the American military. Because, as Mr. Marshall notes, this assessment is "perhaps the best known" of those undertaken by the Office of Net Assessment, and because it has "held up well over time," we at CSBA thought its publication would be of value.

Andrew Krepinevich

September 2002

The Military-Technical Revolution
A Preliminary Assessment

By Andrew F. Krepinevich

Prepared for the Office of Net Assessment

July 1992

I. Introduction

Over the next several decades, the systems and operations characteristic of present-day military establishments will probably be superseded by new, far more capable means and methods of warfare. This "military-technical revolution" (MTR) is the subject of this assessment. It is not clear how quickly this change will come about, particularly since the level of competition that spurred military innovation during the Cold War appears unlikely to recur, at least in the near future. Nonetheless, our initial examination of the MTR strongly supports the hypothesis that, sooner or later, leading military powers will exploit available and emerging technologies, making major changes in the way they prepare and conduct operations in war, and realizing dramatic gains in military effectiveness.

The idea of a "military-technical revolution" comes from Russian military writings of the 1980s, and is used there not only to describe likely future developments in military technique, but to identify earlier eras in which such fundamental transformations of warfare took place. Historical examples of past military-technical revolutions make clear that technological change by itself is insufficient to bring about a military-technical revolution. Innovative operational concepts and organizational innovations designed to exploit new technologies are crucial to a military's ability to realize large gains in military effectiveness. This assessment provides some speculation as to the kinds of operational and organizational innovations that may become necessary or appropriate over the next several decades. The intention is to provoke further thought and study of what innovations will prove more advantageous and how they might be fostered in the U.S. military. Given the uncertainties, our suggestions must be very tentative. However, our initial view is that the fullest exploitation of new and emerging technological opportunities will require profound changes in how we plan and conduct military operations, in our organizational structure, and in our systems acquisition process.

This assessment is an initial effort, designed to guide an effort to develop a more comprehensive understanding of the current military-technical revolution. This assessment has four objectives. First, we try to clarify what a military-technical revolution is, and to judge whether one is under way, and its nature. Second, this assessment attempts to ascertain how far along we are in the transition from one "military-technical regime" to another. Third, it endeavors to lay out the parameters of a future long-term military-technical competition, as well as to assess those states or groups that might participate in such a competition, and how. Fourth, it attempts to raise a few selected major strategic management issues that senior defense officials will face over the coming decade.

II. MILITARY-TECHNICAL REVOLUTIONS, PAST AND PRESENT

A Military-Technical Revolution occurs when the application of new technologies into military systems combines with innovative operational concepts and organizational adaptation to alter fundamentally the character and conduct of military operations. Therefore, such revolutions are characterized by:

- Technological Change
- Military Systems Evolution
- Operational Innovation
- Organizational Adaptation

These elements combine to produce a dramatic improvement in military effectiveness and combat potential. The rate of transition into a new military-technical regime will also be influenced by the geopolitical environment, and the nature of the military-technical competition. Our initial work reveals that we are now entering a period that may see military capabilities increase as much as an order of magnitude or more over similar forces that existed over the past 10-20 years.

Due to the many factors involved in bringing such a revolution about, the transition from the Cold War period of warfare to a new military-technical era may take several decades. For example, the revolution from relatively immobile, positional warfare in World War I to mobile, mechanized warfare in World War II took a generation. The emergence of nuclear weapons and doctrine took roughly 10-15 years.

What is revolutionary is not the speed with which the change takes place, but rather the magnitude of the change itself. At some point the cumulative effects of technological advances and military innovation will invalidate former conceptual frameworks by bringing about a fundamental change in the nature of warfare and, thus, in our definitions and measurement of military effectiveness. For example, at various times between 1917 and 1939 many political and military elites realized that the nature of land warfare had changed dramatically, and that an entirely new kind of operation—strategic aerial bombardment—was possible. Many also understood that a new surface naval weapons platform—the aircraft carrier—could effect dramatic changes in naval warfare. Those countries whose leaders realized the possibilities of these changes *and acted upon them* by adapting operationally and organizationally accrued major advantages in the conflict that followed.

Because the current rate of technological change is accelerating, the time intervals between future military-technical revolutions could be progressively shorter for capable states that choose to compete energetically. If this occurs, it will stress competitor states' abilities for operational and organizational innovation. It also will have significant implications for the defense acquisition system: system obsolescence will occur more rapidly, and the importance of timely production of defense systems will increase.

A. Military-Technical Revolutions: An Historical Overview

There appear to have been at least two previous MTRs in this century, and probably two in the 19th century. Between the Napoleonic Wars and the American Civil War, railroads, telegraphs, ironclads, and rifled muskets and artillery dramatically transformed the nature of warfare; i.e., the way in which military forces are organized, equipped, and employed to obtain maximum military effectiveness. Union and confederate generals who were retained the tactics and operations of the Napoleonic era exposed their men to fearful slaughter, as at Fredericksburg, Spotsylvania, and Gettysburg. Both sides did adapt, eventually. The campaigns of 1864 and 1865 were marked by a dramatic increase in entrenchments and field fortifications over what had been the practice only a few years before. Arguably, many of the major battles toward the war's end bore a greater resemblance to operations on the western front in the middle period of World War I than they did to early Civil War battles like Shiloh or First Manassas.

The machine gun, airplane, submarine, and the *Dreadnought* class of ships dramatically altered conflict again between the mid-19th century and the early 20th century. Again, military leaders who ignored technological changes and failed to adapt risked their men and their cause. One recalls here the mutiny of the French army after the futile and bloody Nivelle Offensive, and the destruction wreaked on British shipping by German submarine warfare operations. Toward the war's end, however, new operational concepts were developed to exploit new technologies and military systems. On land, massed frontal assaults preceded by long artillery preparations gave way to infiltration of troops and brief artillery preparation fires. At sea, elaborate convoy operations were established to counter the U-boat threat.

Between 1917 and 1939, internal combustion engines, improved aircraft design, and the exploitation of radio and radar made possible the *blitzkreig*, carrier aviation, and strategic aerial bombardment. After a scant 20 years, the nature of conflict had changed dramatically, and those—like the French—who failed to adapt suffered grievously.

The early years of World War II—in some respects like the Napoleonic revolution—demonstrate what can happen when only one power makes the "correct" choice concerning how advances in technology will change the nature of warfare. In this instance, Germany proved far more adept than France, Britain, and Soviet Russia at operational and organizational innovation on land. At sea, both the United States and Japan saw the potential of carrier aviation forces, and acted upon it. Thus, although the nature of war at sea shifted dramatically, as it did on land, neither the Americans nor the Japanese realized the kind of dominance Germany enjoyed in land warfare from 1939-1942. In the air, Germany's failure to exploit emerging technologies thoroughly left it at a significant disadvantage in strategic aerial bombardment, as, for example, during the Battle of Britain.

Finally, in mid-century, nuclear weapons, especially after their mating with ballistic missiles, brought the prospect of near-instantaneous destruction of a state's economic and political fabric into the strategic equation. Here was a shift in technology so radical it convinced nearly all observers that a fundamental change in the nature of warfare was at hand.

Several observations are suggested by these historical examples:

- First, sometimes the participants in a military-technical competition are slow to observe and exploit the full potential of potentially revolutionary technologies and systems, as occurred in the American Civil War. Neither side gains a major advantage in military effectiveness, although the nature of war is changing.

- Second, there are instances where one competitor realizes and exploits the potential of emerging technologies to gain a decisive military advantage, as occurred with Germany and the *blitzkrieg.*

- Third, it is possible for several competitors to exploit new advanced technologies and systems, adopting new operational concepts and organizational structures, and thereby to realize tremendous gains in military effectiveness. This happened in the U.S.-Japanese naval competition between the two world wars.

- Fourth, as in the case of nuclear weapons, the potential military application of a technology or system may be sufficiently clear and its potential payoff so profound that competition quickly develops among those having a perceived need and the ability to compete. The development of nuclear weapons and, perhaps, the combat potential embodied in the *H.M.S. Dreadnought* are examples of this case.

In summary, to realize fully the possibilities of a military-technical revolution, it is necessary to exploit *all* the elements that characterize such revolutions. Oftentimes, the failure to realize the great increase in military effectiveness was not so much a case of the political and military leadership of a state ignoring technological change, as it was a failure to see and initiate new operational concepts and organizational innovation.

B. Russian Perspectives on the MTR

There are some writings that attempt to describe the military-technical revolution that now appears to be underway. Much of this work was done by the former Soviet General Staff. The Soviets, who accorded great emphasis to military theory, wrote extensively beginning in the late 1970s about a new "revolution in military affairs." And the Russians continue to emphasize the issue. Their focus on the MTR stems, in part, from the anxiety of watching a more technologically advanced United States develop new technologies, and move to incorporate them into new military systems (e.g., the U.S. Assault Breaker defense concept in the 1970s). Consequently, the Soviets began to speculate on how U.S. forces might organize themselves to exploit the military potential of these advanced technologies and systems, and on what kind of operational concepts would emerge.

The Soviets (and now the Russians) assert that advanced technologies, especially those related to informatics and precision-guided weaponry employed at extended ranges, have brought the military art to the point where quality is becoming far more important than quantity, revolutionizing the nature of warfare. They foresee this revolution as the first stage in a two-stage progression, with the second stage witnessing the employment of even more advanced technologies (e.g., lasers, particle beams, robotics, high-powered microwaves, etc.).

They assert that this revolution's first stage will see far greater reliance placed on rapidly acquiring, processing, and moving surveillance and targeting information than during the Cold War era, thereby increasing the value of space-based systems, unmanned systems, and automated detection and engagement. The Russians view the mix of ranged-fire systems, information systems, and the growing ability to exercise automated troop control as dramatically changing the nature of warfare. When integrated, these components form the basis for what they call a reconnaissance-strike complex (RSC). This network of networks (command and control, data acquisition, fusion, and dissemination, and weapon systems) can, theoretically, engage a wide array of critical targets at extended ranges with a high degree of accuracy and lethality.

The growing capability for rapidly executed extended-range engagements employing nonnuclear weapons implies (in the Russian view) that, in crisis or in war, warning time is becoming progressively reduced, and that time will become an increasingly scarce commodity in future conflicts. Entire countries will become the battlefield. The distinction between "front lines" and "rear areas" will be blurred beyond recognition. In future wars, there will only be "targets" and "non-targets." In other words, it is becoming ever more practical to contemplate near-simultaneous operations against the entire array of high-priority enemy targets, a dramatic change from the "traditional" sequential nature of operations. As this occurs, we will see the lines between tactics, operational art, and strategy disappear.

Much of what the Soviets and Russians have written focuses on what we would term air-land operations. However, more recent writings increasingly acknowledge the growing ability—and *necessity*—for forces operating in one environment (e.g., sea) to influence operations in others (i.e., land, air, and space). Thus they see operations becoming increasingly joint in nature. Some recent Soviet and Russian military writings are emphasizing so-called aero-space, or strike, operations. These operations would be conducted by a reconnaissance-strike complex comprised principally, if not solely, of aircraft and missile systems supported by a network of space systems that would provide reconnaissance, surveillance, and target acquisition (RSTA) support. The success of aero-space operations would also be highly dependent upon electronic strikes by friendly air and space systems against enemy defenses.

Based on what the Russians have written on the subject, and what they are telling us in a growing number of personal exchanges, their general observations on the changing nature of warfare include the following:

- The rate of technological change is increasing, placing a greater premium on the ability of military organizations to adapt quickly to remain competitive on the battlefield.

- The ability to move information rapidly—while denying the enemy that capability—is becoming ever more important, perhaps decisive. Space-based communications systems are seen as being extremely important in this process.

- The "electronization" of warfare is proceeding apace, and modern warfare will witness the emergence of a new kind of operation: the "electronic-fire" operation.

- Modern warfare is based on the delivery of extended-range nonnuclear strikes throughout an opponent's entire territory, destroying (or threatening to destroy) an opponent's key political, economic, and military targets.

- Nonnuclear strategic warfare will assume increasing importance, since RSCs are becoming a reality, and because they, rather than nuclear weapons, can potentially provide either a temporary or a final victory in war.

- With the fielding of RSCs comprised of increasingly reliable systems, time will become an increasingly precious resource in future warfare. The defensive side will progressively lose its ability to prevail in war if it begins defensive operations only after the onset of aggression. Consequently, modern defensive operations could well be initiated with preemptive strikes as the only option for blocking aggression or successfully countering a first-strike offensive capability.

- Tactics are becoming increasingly like operational art, in that success at the tactical level now requires the increasing integration of an increasingly heterogeneous mix of systems. Similarly, the operational art is itself becoming progressively more complex, with the mix of systems required for effective operations also increasing substantially.

These writings are thought-provoking. Still, we must think through the MTR phenomenon ourselves before we can say how many of the Russians' premises we are prepared to accept.

C. THE PRESENT MTR

Given the experience of history, and contemporary Soviet/Russian writings on the subject, what can we infer concerning the possibility of a new military-technical revolution emerging?

Where are we on the continuum stretching from one military-technical regime to another (i.e., from the "old" regime to the "new" one)? Our initial work indicates that we are probably in the early stages of a change that could run another one or two decades. We have yet to witness the kind of military event like France in 1940, the Battle of Britain, or the Battle of the Coral Sea that clearly demonstrates a revolution in warfare has taken place.

One could posit that the current revolution probably began on the *technological* level in the 1950s, with the invention of the transistor. The revolution was probably first realized in terms of *military systems* in the 1960s and early 1970s with the arrival of reliable ballistic and cruise missiles, the deployment of a military satellite network, and the arrival of precision-guided munitions, which made their appearance in the Vietnam War. The revolution seems to have arrived *operationally,* at least in part, in the Gulf War in 1991. There various systems and networks began to realize the enormous potential of integrated operations to the point where the reconnaissance-strike complex predicted in Soviet writings may have made its first appearance, albeit as an element of the U.S. expeditionary force. A key breakthrough, however, will occur when we have succeeded in integrating the information networks we have developed for reconnaissance, surveillance, tracking, and target acquisition (RSTA), and battle-damage assessment with the network(s) of weapon systems ("shooters").

As stated earlier, information and simulations capabilities grew dramatically in the 1980s. Their potential, along with that of extended-range precision-guided munitions (PGMs), was dramatically demonstrated in the Gulf War. This leads to the question: Have we reached the "flat of the curve" in this MTR, with little reason to pursue additional gains in military effectiveness? Some, viewing the overwhelming U.S. victory in the Gulf War, might be tempted to answer in the affirmative.

This would be a mistake for, as was noted above, at this point we are probably near the *beginning* of the revolution. The Gulf War revealed much concerning the potential utility of applying technological advances to warfare. Yet it took nearly six months for the United States to achieve a level of systems integration that realized only a *fraction* of their combat potential. Furthermore, there are many unsophisticated steps the Iraqis could have taken to challenge U.S. advantages in information warfare and extended-range precision strikes, and we can anticipate that future competitors will exploit available technologies to degrade our effectiveness further.

It is clear that there is great room for improvement in U.S. capabilities. For example, the Gulf War exposed shortcomings in U.S. command and control arrangements. Battle damage assessment (BDA) capabilities have improved little in the past few decades. There appears to be much room for improvement in terms of systems integration. In the Gulf War the problem was not that the United States had not won the information war; rather, it was that the United States did not come close to its potential to move the most useful information rapidly to those who needed it most. The answers to these problems lie not so much in new technologies or systems, but rather in *system integration and organizational innovation.*

One other fact supports the hypothesis that we are in the early period of this revolution. There has been to date relatively little writing that lays out operational concepts for exploiting the kinds of systems that are emerging—or that could emerge—from the advanced technologies at the root of this military-technical revolution. In the absence of such an operational road map to guide systems development and organizational innovation, progress toward a military-technical revolution will likely be retarded significantly.

Thus the Gulf War showed us a glimpse (perhaps in a way similar to the Battle of Cambrai near the end of World War I) of the potential influence of this revolution on combat effectiveness. To employ an analogy, we may be in the early 1920s with respect to this MTR. The transition process will be dynamic. The Gulf War has already set in motion the hunt for countermeasures to ameliorate the problems created for defenders in a world of rapidly improving information technologies and advanced RSTA and weapon systems.

III. Assessment: MTR Elements

In trying to understand how a fundamental change in the nature of warfare might be underway, it is helpful to examine each of the elements that typically combine to bring about a military-technical revolution. This section addresses these elements, and offers some insights based on initial research on their role in effecting a contemporary MTR.

A. Technological Change

Three central areas of technological progression may be laying the foundation for a military-technical revolution. First, there is the growing ability to gather, process, and disseminate information (especially information concerning potential targets) far more rapidly than ever before. This advantage accrues when the information gained is used to identify, prioritize, and attack effectively the military functions that comprise an enemy's "center of gravity." (Here the term "center of gravity" is defined as that set of targets which, if destroyed, will fatally compromise a state's ability, or will, to block its adversary from achieving its political objectives.) This advantage may be extended by a rapidly growing capability, either through active or passive measures, to deny the enemy information he needs to attack effectively the friendly center of gravity. Thus the potential exists to create an "information gap" between friendly and enemy forces, both in terms of peacetime competition and wartime operations.

In peacetime, it may be possible to use a growing ability to collect information, along with a rapidly expanding simulations potential, to establish detailed profiles of the military and civil functions of potential adversary states. A functional profile is the combination of an identified set of targets and the knowledge of how many of these target links and/or nodes must be damaged or destroyed to prevent that enemy function from being performed effectively for the period of the crisis or conflict. Through simulations and other analytic means, it may be possible to identify more clearly those target sets that must be engaged to satisfy a range of political objectives, depending upon the circumstances that lead to crisis or conflict. These center(s) of gravity may include such diverse targets as a state's leadership (or an individual leader), command and control fusion nodes, energy or communications grids, and key military assets.

A comprehensive understanding of a state as a political, social, economic and military "organism" could prove crucial in defusing a crisis, as well as in achieving war objectives should conflict occur. Indeed, this exploitation of advanced technologies could ameliorate the problem of "searching" for an enemy center of gravity, as occurred during the strategic bombing campaigns against Germany during World War II, and against North Vietnam during the Vietnam War. This is easier said than done. More recently, the United States has been surprised at what it did *not* know about a variety of Iraqi assets (e.g., Scud missiles, nuclear weapon facilities, etc.) that would likely have been included in any pre-war assessment of those targets comprising Iraq's center(s) of gravity. The American military also was somewhat taken aback by the great uncertainties it found in assessing battle damage of enemy targets.

In war, establishing and maintaining information dominance that will allow U.S. forces to engage the enemy's center of gravity while denying him, to the maximum extent possible, knowledge of the location of assets that comprise our center of gravity, will occur in a dynamic environment. Decoys, deception, and maneuver can frustrate current sensors and smart munitions. Prime sensors (e.g., JSTARS) cannot yet see as deeply as we might like into countries and theaters without putting themselves at risk. Our fusion capability is fragile, and much of its potential remains untapped. In the Gulf War our ability to target mobile systems like SCUDs was shown to be limited. Furthermore, potential competitors will learn from the Iraqi experience in the war and employ a variety of means in attempting to degrade our ability to wage information warfare. Things like weather, topography and vegetation also could degrade information systems' effectiveness significantly.

Operation Desert Storm has led many states to begin developing countermeasures to blunt the military effectiveness of new technologies. For some, acquiring nuclear weapons will be seen as an effective countermeasure. Cover and concealment, tunnelling underground, electronic countermeasures (ECM), and mobility could offset to some extent the gains realized through the employment of advanced technologies. Similarly, states employing these advanced technologies will attempt to develop counter-countermeasures to preserve their growing competence in future military operations.

Second, complementing these dramatic increases in information capabilities are the major improvements in the range, accuracy, and lethality of conventional munitions that may allow us to destroy large numbers of targets over the length and breadth of the theater of operations. These munitions are perhaps the most mature representatives of the three areas of technological progress, having made their debut during the later stages of the Vietnam War. Extended-range, advanced conventional munitions (ACMs), when combined with the information revolution, may permit the simultaneous engagement of the enemy throughout the theater of operations, blurring the distinction between tactical, operational, and strategic operations and forces.

The effect could be to drive conventional military operations from sequential engagements toward a single, simultaneous engagement focused directly on the enemy's center of gravity. Combined with the right intelligence on the essential elements of any enemy target base, it may be possible to attack directly those functions the enemy values most, rather than focusing primarily on his forces. Thus future conflicts could witness military forces striking directly at the enemy's "jugular," or "central nervous system," at the outset of a conflict without first having to defeat the bulk of his military forces. Conventional operations could produce relatively prompt "strategic" consequences. But this requires the integration of technologically intensive combat and information systems either globally, or within a theater of operations, to achieve a "critical mass" of military effectiveness.

Third, advanced simulations—from individual system simulators (e.g., flight simulators) to large-scale field exercises (e.g., those at the National Training Center), to distributed node combat simulations (e.g., the Defense Advanced Research Project Agency's

[DARPA's] SIMNET [Simulations Network] system which creates visual images of all players' hardware on a net that may be distributed on a global scale), to computer-assisted design and manufacturing (CAD-CAM)—offer the potential (some of which is already being realized) for employing human and material resources far more efficiently and effectively than ever before. Identifying and gaining a better understanding of one's own center(s) of gravity through simulation and other forms of analysis also could prove extremely important in the event of conflict. In a sense, simulations will help establish a kind of "learning curve dominance," whereby the conditions under which military formations and equipment will have to operate is simulated in advance of the actual operations and, in so doing, the optimum means for achieving objectives can be identified.

Joint operations and network integration at progressively higher levels will probably be central to this MTR. However, due to limitations on time, resources, and training sites, it will be increasingly difficult, if not impossible, to establish proficiency in these areas through traditional field exercises. Simulations can provide a great service by helping to mitigate this problem. For example, aside from improving the capabilities of individuals and small formations though individual simulators, simulations will help train far more people in far larger, more realistic exercises. Consequently, when large forces engage in joint or combined training exercises, or when they go to war, they can achieve the maximum effectiveness with the resources at hand. Short of war, the ultimate test of such simulations is validating their findings through by realistic field training exercises (which are themselves simulations supported by information systems). It should be noted, however, that one can generate and execute more simulations and "excursions" or "variants" of simulations employing computers than can be addressed in a field exercise. Computer simulations offer the user the ability to "weed out" unpromising alternatives while gaining important insights. Field exercises can then be used to validate further the most promising alternatives.

Simulations also are providing us with a greatly improved capability to assess large-scale military operations, to include the effects of command and control, a variety of operational concepts, and new force structures and military systems. Major progress also has been made employing simulations in integrating technology and training to create environments in which individual soldiers and weapons, and combat units (to include provisional formations) can be trained and evaluated against enemy forces in conditions that go beyond field training and approximate reality. The use of electronics, from flight simulators to interactive wargames, is crucial in simulating these environments.

Simulations also can enable us to identify and solve command, control and intelligence problems in advance of actual military operations, improving our capability to adjust plans rapidly while information is "fresh" and the opportunity to exploit it is still present. Perhaps most important, simulations may be the training aid that allows us to develop a mastery of how various systems and networks must be integrated to realize their full potential. They also will help by allowing us to "test" technologies, weapon systems, and operational concepts in a "combat" environment, thereby providing us with insights on how we can adapt our organizations effectively to exploit new technologies, systems, and operational concepts. Furthermore, simulations techniques are being employed in computer-assisted design and manufacturing (CAD-CAM), allowing us to validate certain design elements without building expensive prototypes, and improving the manufacturing process.

While technological progress in these three areas is fueling the current revolution, the overall pace of technological change is much greater now than compared with earlier revolutionary periods. If one examines the MTRs of the past two centuries, the trend toward ever shorter intervals between revolutions is clear. We may be moving away from a time when these revolutions can be described as discrete events, and toward an era of continuous, overlapping military-technical revolution. There are technologies on the horizon—for example, in the areas of biotechnology, robotics, and directed energy—that could intrude on this revolution, or perhaps supersede it far more quickly than this revolution is supplanting the previous military-technical regime. Indeed, the number of technologies experiencing rapid development is increasing. Thus we may tentatively conclude that these phenomena will permit shorter periods between revolutions, or perhaps even overlapping MTRs, if those states who have the capability to pursue an active competition decide to do so.

B. Military Systems

To realize their potential, technologies central to this Military-Technical Revolution must be incorporated into military systems or munitions. Because of the nature of this revolution, the ability to *integrate* military systems into—and across—networks of systems (or system architectures) will be of great importance if they are to achieve a dramatic increase in military effectiveness.

With the advent of the *potential* for systems to perform reconnaissance, surveillance, tracking, and engagement functions at greatly extended ranges in near-real time, several observations obtain. First, establishing information dominance, or an information gap over one's adversary at the strategic and operational level, will be increasingly important to the success of military operations.

Second, warfare will become more of a competition between "hiders" and "finders". Targets that can be identified and tracked (if they are mobile) will run a high risk of being destroyed, not only at or near the forward edge of the battle area (a term which itself may be on the verge of becoming an anachronism), but over the entire breadth and depth of an enemy state or coalition.

Third, as our ability to track the characteristics of other states' societies, leadership, and economies increases, it may be possible to identify a relatively small number of targets that, when successfully engaged (or engaged or a recurring basis), lead to the crippling of an enemy's military effectiveness or capacity to resist. This would open up opportunities for attacking an enemy's critical functions, such as battle management, as opposed to a group of similar facilities.

In exploiting this potential, military forces will ineluctably move to develop the ability to conduct deep-strike operations against the full array of enemy targets. This will involve three elements. First, we will witness the use of space platforms, unmanned air-breathing aircraft, high-speed computers, and a variety of sensors to gather, process, and move huge amounts of relevant information to those that require it. This information would pertain not only to targeting but to other matters like terminal guidance and battle damage assessment as well.

Second, extended-ranged fire systems will be employed to exploit the advantages provided by near-real-time targeting information and long-range precision-guided munitions (PGMs). Third, those competitors attempting to exploit these systems will move toward the coupling or integration of information systems to "shooters." When integrated, these systems would comprise what many Soviet writers have called a reconnaissance-strike complex, or perhaps what we would call a deep-strike attack network. Once this capability is realized, military operations will probably become increasingly simultaneous and less sequential in their execution. Of course, integrating information systems with extended-range PGMs will also be employed for defensive purposes; for example, in strategic or theater defense architectures.

At the same time that the "finders" are gaining an advantage through the exploitation of advanced technologies, the "hiders" will seek to negate that advantage as best they can. Thus the struggle to establish information dominance in an environment where to be seen is to run a high risk of being destroyed. The "sunrise systems" in this revolutionary period—those systems that are likely to increase significantly the military effectiveness of the force structure—will differ from Cold War-era systems in that they will tend to:

- Be smaller to avoid detection and destruction.
- Rely more heavily on low-observable and stealth technologies.
- Rely increasingly on electronic warfare and passive deception measures to gain and maintain information dominance.
- Trade reduced physical protection to gain increased mobility.
- Be designed to increasingly rely for their effectiveness on being integrated into ever more sophisticated networks of systems.
- Become more open-ended in their architecture, enabling them to incorporate quickly improvements in military capabilities, and also allowing them to be readily integrated within a network of weapon and information systems.
- Rely increasingly on automated operations to gain/maintain information dominance by minimizing the expenditure of time.

- Employ non-line-of-sight fires to exploit the advantages of having achieved information dominance at their level of operation.

- Emphasize the non-lethal disabling of enemy capabilities, thereby increasing the range of political and strategic options for the use of force in achieving national objectives.

Does the United States need to scrap its present inventory of "sunset systems" and move to field a military force that is heavily oriented on "sunrise systems" in the immediate future? Probably not, for several reasons. First, at present the United States has the luxury of having no peer competitor; i.e., a state having the advanced "enabling" technologies of this MTR, having the ability to develop and integrate systems based on these technologies, and who is actively attempting to do so. Second, the United States retains a large "capital stock" of weapon systems that currently compare very favorably against the Cold War-era forces of near-term potential adversaries.

Third, as will be discussed in the section on operational concepts, it should be possible to operate effectively in the emerging conflict environment with a force that comprises a "high-low" mix of defense systems. To provide analogies with earlier revolutions, not every division in the *Wehrmacht* had to be a panzer division to execute the *blitzkrieg* doctrine; nor did every naval task force have to be a carrier task force to exercise sea control, or to conduct power-projection operations. Fourth, the accelerating rate of technological change will make it imprudent for the United States to field a "high-tech" force, only to have to replace it in relatively short order as the next technology "wave" arrives.

What systems comprise the "sunset systems" of this revolution? That is to say, what systems could be either dramatically or significantly less effective as advanced technologies are exploited to their fullest potential? Given the trends cited above, it may be possible to suggest such a list of "sunset systems;" e.g., platforms that:

- Are highly specialized and inflexible; i.e., that cannot be integrated quickly and effectively into networks of systems, and that are incapable of quickly and effectively incorporating new technologies.

- Are not highly mobile, both tactically and strategically.

- Do not incorporate low-observable or stealth technologies.

- Require a large, vulnerable logistics support system to operate effectively (e.g., those that are lift, fuel, munitions, or manpower intensive), and therefore which can be relatively easily neutralized by attacks on this support system.

Given these characteristics, the following types of systems will likely become progressively less central to military operations:

Tanks and other heavily armored combatants. One might question whether, as the capability for extended-range engagements grows, it will be desirable to "close with" the enemy to destroy him. It may be more advantageous to create an "information gap" between ourselves and our enemy, and employ extended-range munitions to accomplish the required levels of destruction. Direct-fire engagements are thus avoided, since by allowing them to develop, the enemy can reduce partially (and perhaps significantly) the information gap we have spent time and resources to create.

Ground forces may be increasingly centered around formations of highly mobile extended-range non-line-of-sight (LOS) systems, rather than tank-heavy forces. This is not to say that armored forces will become irrelevant; rather, they will assume less of a central and more of a supporting role. For example, even if ground operations come to emphasize ranged fires, direct fire systems will continue to provide an important capability, for several reasons. First, it can be argued that such forces may eventually have to close with the enemy, to take and hold terrain. Having a mechanized vehicle that offers protection against residual enemy capabilities seems to make good sense. Second, it may not always be possible to fight at extended ranges. For example, the Israelis cannot afford to trade space on the Golan Heights in attempting to develop ranged-fire engagements. Nor can United States forces engage in such a practice along the DMZ in Korea.

Third, one must expect adversaries to offset their disadvantages in deep-strike capabilities by trying to "hug" these forces as close as possible (perhaps emphasizing infiltration tactics), thereby making direct-fire engagements unavoidable, if not predominant. The end result may be a redefinition of the nature and the role of tanks and other heavily armored combatants. Adversaries would also attempt to make successful ranged-fire engagements more difficult through countermeasures like increased hardening, mobility, and deception. This problem could be addressed by developing counter-countermeasures, or by reliance on direct-fire forces acting as "screening" forces or, more likely, by a mix of both measures.

Manned aircraft. It is not clear that achieving information dominance during conflicts in future wars will require the kind of emphasis on manned air systems characteristic of the 1940-1990 period. Nor is it clear that manned aircraft will be required to engage targets—especially fixed targets—or do battle damage assessments to the degree they are at present. We are only beginning to tap the potential of long-range munitions (e.g., cruise missiles), unmanned aerial vehicles (UAVs), and their linkage to space systems in what may be a new form of military operation: the aerospace operation. It may be that unmanned systems and standoff munitions, perhaps coupled with U.S.-based strategic stealth aircraft, will constitute the "tip of the spear" in future conflicts. These systems could disable the enemy's ability to resist attacks by more "traditional" manned systems. We could have a transition period in which sunrise systems are introduced while the large capital stock of Cold War systems is gradually phased out or mothballed. A similar transition would occur with space, land, and naval forces. As with heavily armored systems, one issue concerns how much emphasis to place on systems whose utility may well be in relative decline, to the neglect of developing those sunrise systems that have the potential to boost military efficiency substantially over comparable military formations that were fielded during the Cold War era.

Large surface combatants. Any system that presents a large signature will be increasingly vulnerable to detection and destruction. This applies to large surface combatants. Consequently, in looking at surface naval forces, it might be possible to de-emphasize substantially the role of carrier and other surface battlegroups in maritime operations. As missiles, UAVs, and space-based platforms come to substitute increasingly for missions executed by aircraft, the role of carriers (and their many escorts) could diminish. Just as bombers are becoming relatively less important than the ordnance they carry, so too might surface warships, which could evolve to become "barges" (with some perhaps operating below the surface) for advanced conventional munitions that can strike pre-designated targets at extended ranges.

Over time, one would expect that the information revolution will allow us to reprogram rapidly cruise missiles guidance systems, and to provide them with in-flight target updates from UAVs and satellite systems, and with terminal guidance as well. Battle management functions could gradually shift from the fleet to CONUS-based elements linked to the force through the satellite communications network.

Again, the question arises: given a large capital stock of Cold War-era systems, to what extent should we continue to support and operate them at the expense of developing our ability to exploit the potential of sunrise systems? It is somewhat analogous to asking the question in the interwar period of what relative emphasis was to be placed on battleships at the expense of developing carrier aviation.

Large satellites. With the migration of many information (and perhaps some engagement) functions to space-based systems, it may be that the relatively large, very soft satellites that we now deploy will comprise a space "Sunset System" as we progress beyond the mid-tem future and into the long term. This is because as satellites become increasingly important to the effective conduct of military operations, they also will become very lucrative targets, encouraging potential adversaries to develop ASAT systems to threaten our network of space systems. To offset the risk to a key element of our information network, our space-based assets may have to emulate terrestrial-based military systems by becoming more survivable through a variety of means that include electronic warfare, stealth, miniaturization, and proliferation. This last element may require a rapid replacement satellite launch capability.

We have examined ways in which systems might evolve to exploit advances in technology. It also is important to identify how such systems are to be integrated into the operational concept that will shape of the nature of future warfare.

C. Operational Innovation

Having advanced technological capability and military systems does not guarantee success for those states seeking to realize a military-technical revolution. The manner in which these capabilities are employed also will determine whether their full combat potential is realized.

Dramatically different operational concepts, to include doctrine and tactics, must be developed to derive the full military potential from advances in technology. In a sense, when a military-technical revolution occurs, the "rules of the game" are fundamentally altered. For example, naval operations that focused on the battleline and "crossing the T" of the enemy fleet, and which were highly appropriate at the Battle of Jutland in 1916, were wholly irrelevant at the Battle of Midway in 1942. The operational "rules" had been changed. Similarly, the elaborate field fortifications and massed infantry assaults supported by massed artillery that characterized the static warfare during World War I proved, for the most part, irrelevant to countering the operational concept of *blitzkreig*.

Both the Germans and the French possessed planes, tanks, and radios in 1940. However, it was the manner in which the Germans integrated these systems within a new operational concept that led to their shockingly quick victory over the French. Layering new systems on old doctrine merely allows you to become more effective at the margins within the old operational paradigm of conflict. In 1940 the French were prepared to use their aircraft, armor, and radio communications gear to wage World War I more effectively.

As noted above, operational innovation interacts closely with technological development. Technological advances feed forward potential improvements in combat potential to those in the field. Just as there is a "technological push" from the laboratory to forces in the field, there is also a "conceptual pull": operational concepts emerge that cannot be implemented with existing technologies. However, operational concepts have seldom predated technological breakthroughs. Thus, a simultaneous "push-pull" relationship should be sought. Over the mid- and long-term future systems development can be heavily influenced by operational concepts. An effective approach to realizing a military-technical revolution, therefore, requires constant interaction between those developing military technology and systems, and those engaged in planning the operational concepts that will exploit the combat potential of these emerging technologies and systems.

There is probably more than one way in which sunrise systems can be exploited to bring about a revolutionary change in the nature of warfare. One thinks here of the developments during the 1917-1939 period, which saw revolutionary developments in land (or air-land) warfare (the *blitzkreig*), and war at sea (carrier air operations and modern amphibious assault operations). There also emerged an entirely new military operation in a relatively new medium; i.e., strategic aerial bombardment.

Our initial work indicates that operations in the emerging military-technical regime will likely be characterized by:

- An increasingly greater reliance on information (and electronic warfare) systems as an element of military effectiveness and combat potential Given the considerable potential that exists for the United States and other competitors to improve their military effectiveness, as time progresses we will likely see a dynamic competition centered on creating or denying an information advantage (or "gap") though a variety of means. This will include pre-war activities like establishing in advance very specific target sets/packages that comprise an adversary's center of gravity to be destroyed as quickly as possible at the onset of hostilities.

- The ability to integrate at ever higher levels of sophistication. Full exploitation of advanced systems' potential will require integrating technologies into systems, systems into networks, and across network architectures themselves to execute operational concepts. In fact, this capability is the foundation of the reconnaissance-strike complex described by the Soviets as being at the heart of this MTR.

- A continuing (and perhaps accelerating) trend toward simultaneous, vice sequential, military operations; i.e., where an enemy's center of gravity can be disabled promptly, without having to engage in the intermediate operations that characterized military operations in all earlier MTRs, save the nuclear revolution.

- Increased emphasis on "campaign planning" involving the joint and combined application of force over a time-phased, sequenced plan of events that is intended to achieve political and military objectives through discriminating attacks on enemy centers of gravity.

- The progressive blurring of the distinction between—and the increasing fusion of—space air, land, and maritime operations, to the point where most operations become multidimensional in nature.

- The relative growth in importance of so-called nonlethal and electronic neutralization of targets in lieu of their destruction by fires. This could lead to a capability to disable an enemy's combat potential with great discretion.

- The growing importance of space as a major medium for conducting and supporting military operations.

- The emergence of aerospace operations; i.e., the linking of space systems with extended-range air systems (e.g., UAVs, cruise missiles) and a variety of sensors in an entirely new type of military operation.

- The increase in non-LOS fires relative to LOS fires. As discussed earlier, direct contact will generally be avoided by those who have achieved information dominance and who possess the means to exploit it.

How should we order and evaluate the new operational concepts that could be employed to optimize military effectiveness in future conflicts? The traditional examinations of ground, sea, and air campaigns appear more anachronistic now than they did even during the Cold War era. For example, as technology provides us with the ability to gather intelligence at extended ranges, and to strike targets at great distances, it becomes increasingly inappropriate to speak of "maritime" or even "air-land" operations. Space-based systems exert increasing influence on land, sea, and air operations. Land-based aircraft and ballistic missiles are exerting an increasing influence on maritime operations. Strategic bombardment now encompass sea-launched strikes of aircraft and cruise missiles, and deep-strike land-based systems as well. In sum, the trend toward greater sophistication of combined arms operations at ever lower levels of combat seems both clear and likely to continue through this MTR, blurring the old geographic-based distinctions between land, air, and maritime operations.

Warfighting doctrines will likely move away from an emphasis on the physical occupation of key terrestrial areas toward a far greater emphasis on maneuver by fires. The growing potential of extended-range weapons combined with RSTA systems will act as force multipliers by quickly providing, or augmenting, the combat power required to hold key terrain. New concepts of operations to exploit this shift will almost certainly be necessary. As will be discussed, a shift in emphasis toward the employment of integrated ranged fires also will require organizing military forces in ways significantly different from their current configurations. For example, it may be best to organize our forces around major functional capabilities (e.g., space control, air superiority, sea control, forced entry, etc.) than along traditional Service lines. Joint and combined operational doctrine would then be developed to execute the missions characteristic of these functional areas. Indeed, one would expect Service doctrine to be progressively supplanted by joint doctrine as the shift through this revolution reached maturity.

Given the trends elaborated above, how might we evaluate operational concepts for a new era of warfare? One method that appears promising is first, to order the discussion around mission requirements. A list of missions might comprise the following:

Information Dominance

Space Control

Air Control

Sea Control

Sustained Land Operations

Forcible Entry

Strategic Strikes (on Centers of Gravity)

Strategic and Theater Defense

Strategic Mobility

Unconventional Warfare

In most instances these functional requirements will entail joint and combined operations. Many will be "full-dimensional" operations in the sense that they involve forces operating in all four elements (air, ground, sea, and space). In war, our armed forces may be required to meet one, some, or all these requirements. Depending upon the contingency, these operations may be executed sequentially or simultaneously. For example, information superiority, space control, air control, and strategic strike operations may be executed in a nearly simultaneous manner. On the other hand, occupation of a hostile state may require both simultaneous and sequential operations (e.g., establishing information superiority, sea and space control, and conducting strategic strikes; followed by strategic mobility, followed by air control and forcible entry operations; followed by sustained land operations).

How will military forces employ advanced technologies and the systems employing these technologies within new operational concepts to revolutionize the nature of warfare? Will operational concepts differ appreciably in waging wars against peer competitors, as opposed to wars against lesser competitors who lack the means to realize the full benefits afforded by access to, and exploitation of, advanced technologies? At this point, we can at best provide only a notional sketch of the operational concepts that might be appropriate for these mission areas. This is partly due to the fact that we are in the early phases of this military-technical sea change, and also because it is difficult to identify how competitor states will approach the competition. It also is due to the relative lack of emphasis accorded this issue in professional military circles, with few exceptions.

Information Dominance

Establishing information dominance could well be the *sine qua non* for effective military operations in future conflicts. Information dominance, as used here, is defined as a superior understanding of a (potential) adversary's military, political, social, and economic structures, to include their strengths, weaknesses, locations, and degrees of interdependence, while denying an adversary similar information on friendly assets. Information dominance is relevant to all levels of conflict, from the grand strategic to the tactical. Ideally, it is established in peacetime and sustained in pre-crisis and crisis periods, and in war. At the strategic level, information dominance is concerned principally with providing continuing data on the location of targets comprising the enemy center(s) of gravity, as well as of those targets that might threaten friendly assets that can maintain or widen the information "gap."

In pre-crisis and crisis situations, it may be possible to deter a potential adversary state from taking a threatening course of action if that state realizes that it cannot compete for information dominance, or even information denial. Achieving information dominance in war will likely require a full-dimensional operation, with a key element involving establishing and maintaining space control (see below). Strategic strikes (to include so-called "electronic strikes" and special operations forces strikes) against an adversary's terrestrial information networks would ideally be carried out simultaneously with space control operations.

For military forces organized, trained, and equipped to take complete, or nearly full, advantage of advanced information systems and networks (we will call them "peer competitors"), establishing information dominance will likely be considerably easier against non-peer competitor states (i.e., those states that can take advantage of only a fraction of the potential offered by advanced technologies) Several factors argue for this conclusion. First, peer competitors will almost certainly have an information advantage over non-peer competitors prior to hostilities. Thus a peer competitor will seek to widen an information gap that already exists. Second, peer competitors should have an advantage in ranged-fire systems. Thus the instruments to widen the information gap are available. The non-peer competitor's prospects for redressing this unfavorable situation are likely to derive from striking first (recall the Russian observations on pre-emptive defense), and from mission asymmetries; i.e., the possible willingness of non-peer competitors to accept a state of information denial for both sides as opposed to seeking information dominance.

In conflicts between peer competitors, the absence of a significant information gap will probably make both sides anxious to strike first, especially if it is believed that an adversary's information network, or subelements thereof, do not degrade gracefully. Active and passive defensive measures (e.g., stealth, electronic warfare, deception, cover and concealment, mobility, air and missile defenses, etc.) employed to protect friendly information systems will likely play an important role in widening or narrowing the information "gap" and in facilitating mission accomplishment.

In summary, since establishing information superiority could be *the decisive operation* in future conflicts, and since this objective could be achieved early in the war, we should expect that increasing emphasis will be placed on achieving surprise. As this revolution matures, the day may come when the forces of peer competitor states evolve to a "hair-trigger" posture, characterized by a trend toward automated engagements with forces ready to fire on little warning. To adopt a less threatening posture could be seen as inviting a pre-emptive attack against friendly information networks, allowing the enemy to establish information dominance, which would quickly lead to the progressive inability of friendly forces to execute the highly integrated, information-intensive military operations that will be crucial to success in war.

Space Control

Space is becoming inextricably linked to war on land, in the air, and at sea. It is possible to imagine the continued migration of C3I functions into space, with many downlinking functions being performed by airborne platforms, especially unmanned aerial vehicles (UAVs). As space assets become more valuable, especially in establishing information dominance, they will inevitably become lucrative targets for destruction. This will be especially true for satellites in low-earth orbits, and possibly for space-based strategic defense assets as well. Today's large, "soft" satellites will likely become increasingly vulnerable to attacks from both peer and non-peer competitors. While peer competitors will likely seek to control space as part of their operation to establish information dominance, non-peer competitors will probably set space denial as their objective, much in the manner in which inferior naval powers have traditionally sought sea denial as opposed to sea control.

Peer competitors could employ both active and passive (or so-called "non-lethal") means to disable an enemy's space assets, while protecting their own. These means would probably include terrestrial-based and space-based strategic defenses that could double as antisatellite (ASAT) systems, and electronic countermeasures. The struggle for space control between peer competitors will be dynamic in nature. Countermeasures could witness the miniaturization of satellites, the incorporation of stealth technologies into satellite design, mobility, deception, and the increased use of electronic warfare to protect satellites and to disable them. As satellites become smaller and launch costs decrease (and as satellites become increasingly important to military operations), the option of crisis or wartime rapid replacement launches could emerge as an increasingly attractive option.

Commercial satellites or the satellites of neutral powers could acquire special significance in a battle to establish control over space. Warring powers may have to face hard choices with respect to waging "unrestricted space warfare" in a manner similar to that faced by Germany in the two world wars with respect to the issue of unrestricted submarine warfare.

Non-peer competitors will likely settle for a condition of space denial. This objective may also apply to peer competitors who have lost the battle for control of space. Employing electromagnetic pulse (EMP) attacks against an adversary may be an attractive option for these belligerents, especially if EMP strikes can be employed discriminately.

Air Control

Establishing air control will probably rely heavily on the creation of a favorable information gap. In a situation where peer competitors oppose one another, the combination of establishing information dominance and employing ranged-fires using PGMs, ASATs, and strategic and theater defenses could, if employed quickly and effectively, fracture an opponent's information, deep-strike, and air defense networks. This, combined with the preservation of friendly active and passive air defenses, would assure air control. Mastering control of the air is thus based on three factors: first, establishing information dominance; second, exploiting it through the employment of ranged fires to disable enemy offensive and defensive air networks; and third, possessing active and passive defenses adequate to protect friendly air assets.

In the case of conflict between two peer competitors, and in the absence of dramatic improvements in active and passive defenses that outstrip improvements made in offensive capabilities, a great advantage will probably go to the side that strikes first. This will especially hold true if the strike corresponds to simultaneous operations that lead to establishing or preserving information dominance.

Electronic warfare, deception, cover and concealment, mobility and hardening of key assets will be employed by peer competitor and non-peer competitor states to minimize their vulnerability to detection and destruction. Peer competitors also can be expected to employ stealth technology to this end. These countermeasures will receive relatively greater emphasis from non-peer competitors because of their inability to compete for information dominance, and also because of their limited ability to employ nonnuclear ranged fires to significant effect. Peer competitors, on the other hand, will likely put considerable effort into developing an assured "second-strike" capability.

Once air control is achieved it could be possible for peer competitors to populate the skies with additional information platforms, ranging from UAVs to sunset systems like JSTARS and AWACS, and with so-called brilliant conventional munitions that can loiter on station until cued by RSTA systems to engage a target. The result will be a widening information gap and increasing leverage for friendly ranged-fire systems.

Sea Control

World War II saw the intrusion of aircraft on military engagements at sea. The Cold War saw the range of aircraft extended and the deployment of large numbers of anti-ship missiles. Future conflicts could well see a considerable increase in PGMs and overhead information processing added to this mix. The result will likely be a major increase in the vulnerability of surface ships to attack and destruction by ranged-fire attacks. Just as maritime forces are threatened from forces on land, at sea, in the air, and in space, establishing sea control will require the integration of forces from each of these dimensions.

In a conflict between peer competitors, targets at sea could be identified and tracked by space systems and UAVs, and engaged by naval forces, or by extended-range land systems, or by intercontinental nonnuclear strikes. As with forces based on land, naval forces will likely have to become smaller and more mobile to survive, also relying on other active and passive defensive measures as well. Just as some force elements on land will find themselves burrowing underground to enhance their survival, new underwater platforms will probably be among the sunrise systems in this MTR. The structure of surface force elements may evolve to comprise a number of small support ships, operating as far as possible from an adversary's engagement envelope, each sustaining a handful of smaller highly mobile surface effects ships (SES). Both the SESs and underwater platforms would be modular in nature, and could be reconfigured with various "packages" to perform a variety of missions (e.g., sea-launched cruise missile/UAV launches, special operation forces' insertion, heliborne raids, minelaying and minesweeping, non-LOS fire support, etc.).

In addition to surface and subsurface operations, it may be possible to seed areas with sensors to establish passive barriers or *cordon sanitaires.* These barrier regions could be activated by the emplacement (perhaps remotely by ranged-fire weapons)—of smart mine fields that could impair mobility or restrict access to key straits or coastal regions (e.g., the Persian Gulf). These sea-denial zones could be monitored and enforced, not only (or even primarily) by surface or subsurface fleet elements, but by space-based and land-based systems, to include aircraft, and extended-range ballistic and cruise missiles.

The placement of sensor and mine barriers covered by ranged-fire systems will probably become an increasingly attractive option for non-peer competitor belligerents that are attempting to enforce sea denial in coastal waters, or perhaps in strategic straits located in their region. In establishing sea control in these areas, peer competitor states would likely rely primarily on their advantages in RSTA, ranged-fire systems, missile and air defenses, and electronic warfare to provide cover for mine/senor countermeasure operations.

Sustained Land Operations

The recent land operations that occurred in the Gulf War relied heavily upon strategic strikes, air control (superiority), air support, and space- and sea-based assets for their success. The growing effectiveness of extended-range strikes by air and maritime forces (e.g., with advanced cruise missiles) will likely increase the role of these forces in land operations. Thus land forces and operations will probably have to change significantly to maximize their military effectiveness in future wars.

In a conflict between peer competitors, there likely will be a strong incentive to shoot first to support efforts to gain information dominance, primarily on the tactical and operational level. Success in this effort would make the accomplishment of subsequent objectives significantly more manageable. If a favorable information gap is created, ground forces would likely have strong incentives to abandon their traditional role of closing with and destroying the enemy in favor of employing ranged fires as the decisive element in combat. Line-of-sight (LOS) weapon systems—principally armored forces and helicopters—would be employed in the traditional role of cavalry. They would screen enemy forces that, having lost the information assets necessary to employ deep strikes (at least against most friendly mobile targets), would have to rely on direct-fire engagements in conducting ground combat operations.

Thus peer competitor land forces will likely place significantly more reliance on a combination of space-based systems, UAVs, extended-range precision-guided missiles, and special operations forces (SOF), and far less emphasis on armored systems. Furthermore, to minimize reliance on large, vulnerable logistics bases which could be subjected to enemy deep-strike attacks, and to enhance mobility, the importance of PGMs, advanced highly fuel-efficient engines, and lightweight composite protective materials will increase further.

In summary, a future land campaign might involve ground forces initially supporting information dominance operations, and conducting ranged-fire strikes on enemy center-of-gravity targets while screening enemy LOS systems. Only after this preparation of the battlefield occurred would friendly land forces begin sustained offensive operations, conducted in conjunction with forces operating in the other dimensions of conflict, to eliminate residual enemy resistance. On the other hand, a peer competitor facing either a peer competitor that has lost the battle for information dominance, or a non-peer competitor, may encounter an adversary that will attempt to redress the imbalance through some innovative operational concepts for land operations. One such concept will be discussed presently.

Strategic Strikes

It was observed that advanced technologies may provide the means for fielding an integrated group of networked systems (or architectures) that could execute conventional "strategic" strikes against an adversary. There has been some discussion, particularly in the Soviet/Russian literature, that this could occur through the employment of so-called aerospace operations, whereby airborne and space information (and perhaps weapon) platforms provide real-time targeting information to long-range precision-guided advanced conventional munitions, which may be land-, air-, or sea-based. If a sufficient information gap can be created , it may be possible to strike the entire range of enemy strategic targets comprising their center of gravity in a relatively short period of time, without first having to defeat the bulk of an enemy's military forces. Thus, strategic strikes would be expected to either coincide with, or follow on the heels of, operations to achieve information dominance, and perhaps air and space control as well. Strategic strikes would focus on a relatively small set of enemy targets—those comprising its center of gravity—i.e., those targets that, when disabled, will deny an enemy state the ability or the will to block an opponent from achieving its military objectives.

Furthermore, at some point in this revolution it may be possible, through the use of advanced simulations, to "test strike" a small subset of a target base, observe the effects—perhaps even matching the data obtained with simulations—and then deciding whether (and how) to continue eliminating the entire class of targets designated for destruction, or to identify more promising alternatives. There are two potential advantages to employing test strikes. First, they may allow a peer competitor to preserve time and resources critical to achieving its military objectives. The intent would be to avoid the situation the United States found itself in during previous strategic bombardment campaigns in World War II and the Vietnam War. In the former case, in the European theater the United States focused on several target sets (e.g., air frames) before finding Germany's weak point. During the Rolling Thunder campaign against North Vietnam, a progression of target sets was attacked (e.g., transportation, oil, electrical) without achieving the desired results. The importance of time and the high cost of advanced conventional munitions places a high premium on "getting it right the first time" in extracting the desired results from a chosen target set. Second, such an approach allows a peer competitor to avoid creating undesirable damage to the enemy state. Such unwanted damage may complicate war prosecution (one thinks here of the effect on domestic and world public opinion), war termination (will such damage stiffen the resolve of the target regime or its people?), and postwar plans (e.g., reconstruction).

In a war between peer competitors it seems clear that, unless an assured second-strike capability is established, the side that can execute its strategic strike operations first stands to benefit most, assuming that it retains sufficient information on the enemy target base, and overcomes active and passive defenses, to conduct its strikes effectively. This is an important point, since it is not yet clear that forces engaged in strategic strikes will have the requisite level of RSTA and battle-damage assessment (BDA) data, or that they will be able to negotiate successfully all enemy countermeasures. Therefore, in a war between peer competitors, it may not be possible to execute decisive strategic strikes, especially if the defender retains a sufficient level of its information structure intact to enable it to conduct an integrated, coordinated defense.

As for nuclear weapons, they may become significantly more discriminate. Micronuclear weapons might be able to destroy targets with little collateral damage that conventional systems could not eliminate at an acceptable cost. While their employment may be useful in a purely military sense, there are obviously strong political factors and precedents for not employing nuclear weapons, save in extremis. However, nuclear weapons in the hands of radical regimes that possess ballistic or cruise missiles could emerge as the "poor man's" counter against peer competitor states.

Strategic and Theater Defense

Another mission area requiring attention concerns strategic and theater defense, which comprises defense against ballistic missiles and air-breathing systems, like cruise missiles and attack aircraft. As states exploit the advanced technologies that appear likely to move the world into the new military-technical regime, strategic and theater defenses will not only have to contend with weapons of mass destruction, but with extended-range precision strikes employing nonnuclear munitions as well. The latter defense requirement will be the most likely, and will almost certainly focus on the protection of point targets (e.g., satellite networks, data fusion centers, key military industries, senior political and military leaders, etc.). A symbiotic relationship will exist between the strategic defense systems network and the information systems network.

Establishing information dominance will likely be as crucial to conduct of effective strategic defensive operations as it is to supporting other military operations. At the same time, the ability to maintain information dominance in the face of enemy attempts to fracture friendly information networks will probably depend, to a significant extent, on the ability of strategic and theater defenses to protect those networks. This dynamic reinforces the earlier discussion on the importance of creating an information gap between friendly and enemy forces, and the incentive to strike first—especially in a war between peer competitors—before the friendly information network comes under attack. It also reinforces the incentives for peer competitors to develop an assured second-strike capability, of which strategic and theater defenses could be a major component.

Early in the next decade much of the early and middle Cold War era military technology will have diffused to those non-competitor Third World states that have the means and the desire to acquire it. These states could well have military forces equipped with such "late-model" technologies as nuclear weapons, ballistic missiles, cruise missiles, and satellites. In sum, they may have dramatically increased their ability to identify and destroy targets at extended ranges. For many Third World states, this will be a military-technical revolution in the sense that they are entering the Cold War era MTR. Ten to fifteen years from now, or perhaps sooner, a peer competitor having to project its power to protect its interests may find that the nature of the threat it faces has probably changed dramatically from the late Cold War and early post-Cold War era. Unless a peer competitor has moved to a higher military-technical plain—unless it preconstitutes to exploit the potential of the current revolution, it is unlikely that it will be able to prevail as quickly and antiseptically as, for example, the United States did in the Gulf War. A more extended discussion of this challenge is found in the section dealing with the competition.

To deter and, if necessary, conduct effective military operations against this kind of emerging Third World threat, a peer competitor will have to develop the means to neutralize this threat. One possible option involves some form of strategic and theater defenses. These defenses will probably offer protection for the homeland, and also for forward-deployed forces and coalition partners that lie within the range of an enemy state's conventional weapons and its weapons of mass destruction.

The required level of strategic defense proficiency will depend on several factors, to include the military capabilities of enemy, the nature of friendly forces, the circumstances or contingency under which the defenses are stressed, and the strategic posture adopted by the two sides. With respect to this latter point, several options are open to a peer competitor opposed by a non-peer competitor, all of which were debated in the early days of the Cold War when the emerging nuclear power was the Soviet Union. It was true then, and is today, that a strategy of preventive war and, perhaps, pre-emptive war as well, places less stress on strategic and theater defenses than a strategy of deterrence and a willingness to accept the first blow in war. Or it may be that an "optimum mix" of simultaneous operations comprising information superiority, air superiority, strategic strikes, and strategic defense will be the most likely initial phase of future conflict. If a peer competitor fails to come to grips with the issue of strategic defenses, it may find itself deterred from exercising military power against a non-peer competitor, even though the peer competitor may have dramatically improved its combat potential as a consequence of the military-technical revolution.

Forcible Entry

As peer competitors become increasingly proficient in exploiting advanced technologies and developing sunrise systems, and as many Third World states acquire more destructive, extended-range weaponry, the conduct of forcible-entry operations will likely change dramatically. For peer competitor states operating against non-peer competitor states, the threat environment could require that forcible entry operations be initiated at extended ranges (although they may be supported by covertly inserted special operations forces). For peer competitors, the ever-increasing engagement envelopes of non-competitor states, combined with the post-Cold War reduction in forward-based assets, will likely require peer competitors to project a higher proportion of their military power—although not necessarily a greater absolute amount of tonnage—than was the case during the Cold War.

Using the United States as an example, in many forced-entry operations, whether against peer or non-peer competitors, once information dominance is established the focus will probably turn to space, air, and sea control operations. These would be coupled with strategic strikes, probably by CONUS-based and, perhaps, sea-based systems, all supported in part from space. Their objective would be to take out those capabilities constituting the enemy's center of gravity, and they would employ conventional munitions. If these strikes proved successful, the need for forcible entry and follow-on operations might be reduced or eliminated. These strikes would be followed by combined strikes against forces that might oppose the forced entry. This could establish the conditions for forcible entry operations and follow-on sustained land operations, if required.

These deep-strike forces would be the "tip of the spear;" the high end of a high-low mix of sunrise and sunset forces. Their strikes would open the way for the application of more "traditional" forms of military power. Of course, the entire force would be integrated into the military's information network structure. To employ an historical analogy, the "spear tip" of a peer competitor would be akin to the German panzer corps and tactical air arm in the *blitzkreig*—the force that breaks through the enemy's main line of resistance, thereby allowing more traditional forces (the infantry and artillery) to operate with greater effectiveness.

Strategic Mobility

Gaining information dominance, and air and sea control can facilitate the movement of force to areas where it is needed. By combining advanced technologies with innovative applications, peer competitors could develop the ability to move relatively large amounts of combat potential per unit of weight compared with Cold War era capabilities. There are several reasons for this. First, many C3I functions could migrate into space. Second, the increased employment of PGMs should reduce ammunition tonnage requirements. Third, as systems become smaller and lighter (hopefully benefiting from advanced composites and improvements in fuel efficiency), lift requirements will be further reduced. Fourth, the increased use of strategic strikes to disrupt and fragment enemy plans and military effectiveness should result in a reduced combat burden for those forces projected into the theater of operations. Conversely, reliance on forward-based assets will likely be reduced, both for geopolitical reasons as well as military-technical necessity. The former speaks to the changing international environment: now that the Cold War is over, the overseas base structure of many states will almost certainly shrink significantly. The latter speaks to the dangers of placing forces within range of adversaries whose ability to conduct pre-emptive attacks at extended ranges will likely increase significantly in the mid- to long-term future.

The information revolution, combined with business practices that rely heavily on information technologies, also can be used to minimize the drain on logistics—and to allow logistics centers to be as small (and mobile, or hardened) as possible, to escape detection, targeting, and destruction. These centers also may be increasingly "remote"—

out of harm's way—as the reliance on stand-off munitions and ranged-fire engagements increases.

Computer-assisted design and manufacturing, and computer-supported simulations will be essential elements of research and development (R&D) efforts designed to produce highly efficient engines, and to develop light-weight ceramics and stealthy designs to provide a new generation of systems that will employ a variety of countermeasures to dilute the effectiveness of peer competitor forces. Progress in these areas could dramatically reduce the demand on logistics support for fuel (and on strategic lift requirements as well). Computer-aided management principles can be used to minimize stockage levels and insure the logistics system provides quality support (as demonstrated by the "just in time" business practices currently in vogue). Finally, as was recently demonstrated in the Gulf War, information technologies can help establish a more efficient organization for the movement of large military forces and their associated logistics as part of a major power-projection operation, thereby maximizing combat power for a given amount of logistics expended.

Unconventional Warfare

Non-competitor states—those states that can only realize a fraction of the potential of advanced technologies and systems to change the nature of warfare, will likely attempt to make up for their technological inferiority by devising unconventional operational concepts. For example, during the period 1940-1990, technically sophisticated military forces were frustrated on several occasions by unconventional operations. Examples include the Soviet use of scorched earth warfare against Germany in World War II, the Vietnamese Communists' use of People's War against the United States in the Vietnam War, and Islamic fundamentalists' employment of terrorist operations against the multinational force in Lebanon in the early 1980s.

Low-intensity warfare, comprising primarily but not exclusively insurgency, terrorism, and subversion, has been the most prevalent form of conflict in the post-World War II era. It seems likely that these conflicts, which are characterized by unconventional operational concepts, will continue as a dominant form of warfare in the post-Cold War era. It also is highly probable that non-peer competitors will engage in low-intensity warfare, employing the unconventional operational concepts characteristic of those kinds of conflicts, albeit modified somewhat by the infusion of more advanced military systems, as a means of frustrating peer competitor adversaries. Time is often as precious in this kind of conflict as it is in the kinds of operations that may characterize the emerging MTR. In the case of unconventional warfare, however, the objective typically is not so much to beat the enemy to the punch; rather, it is to protract the conflict while employing an indirect approach to weaken that portion of the enemy's center of gravity that rests on the will to resist. Thus unconventional operational concepts can be considered a "countermeasure" to those operations described above that will likely become increasingly possible for peer competitors.

With the continued movement toward a global economy and the rapid breakdown in the barriers impeding the flow of information, peer competitor states will probably have to address the more subtle, but important, implications of these phenomena on military operations, in crisis and in war. This issue is elaborated upon in some detail in the section addressing the U.S. competitive posture over the next 10-20 years. Unfortunately, a more detailed examination of this issue—including an assessment of peer competitor countermeasures—was outside the scope of this initial effort.

In summary, it seems very likely that, as peer competitors identify the best methods for employing the products of advanced technologies and the military systems they are making possible, and as both peer and non-peer competitors react to this phenomenon, that military operations will likely experience a revolutionary change in nature. For peer competitors, they will almost certainly be increasingly dominated by the need to establish information dominance as a prerequisite to effective execution of other operations. Furthermore, these operations will typically involve a myriad of forces; i.e., they will be joint, combined, and/or full-dimensional operations. Operations by peer competitor forces will probably be increasingly characterized by the application of force at extended ranges to exploit the advantages of information dominance. Integrated with advanced information systems, the forces conducting these operations will closely approximate what the Russians have described as "reconnaissance-strike complexes," or what we might call "deep-strike task forces." The key operative term here is "integrated," and the key variable is time. The peer competitor will almost certainly look to integrate quickly the various information and strike systems that together will be employed to establish information dominance and accomplish national military objectives.

There are probably considerable gains in military effectiveness to be derived from translating technological advances into operational concepts, and in modifying military structures to execute these concepts effectively. From the above discussion, this clearly implies the likely need for a major restructuring of a peer competitor's armed forces (and acquisition system), if such a state desires either to dominate the competition or remain a major competitor.

D. Organizational Innovation

We are likely at the beginning of a period of revolutionary change in warfare. This change will probably occur over an extended period of time, perhaps 10-20 years, or longer. A major factor in determining the length of this transition period will be how adept competitors are at fostering and nurturing innovation. For those states that intend to develop the capability to wage war effectively in a new era of conflict, it is important that they begin to think through how they will organize themselves to promote the innovations—in terms of technologies, systems, and operational concepts—that will be required for a successful transition. In short, possessing potentially revolutionary technologies and associated military systems, and a blueprint for an innovative operational concept to best exploit those assets, is *not* sufficient to effect a military-technical revolution.

Innovation in the Interwar Period

The British clearly demonstrated this point during the interwar period. Then, despite having been on the cutting edge of mechanized warfare in World War I, despite the input of British strategists like Fuller, Hart, Stuart, and Broad, despite the strong desire to avoid the carnage of static, positional warfare characteristic of the Western Front, and despite the need to develop a more mobile form of ground warfare for potential operations in areas like North Africa, the British could not effect the organizational change necessary to create a *blitzkreig* capability of their own. Thus it is possible to have cutting-edge technologies, systems that exploit these technologies, brilliant innovative concepts for their application, and still fail to realize the potentially revolutionary gains in combat potential and military effectiveness that they promise. Evidence indicates that, if a "market" cannot be created among a state's civilian and military leadership for organizational adaptation and innovation, then that state probably will not succeed in its attempts to promote such innovation.

One also, however, cannot discount the influence of other factors on these trends. The British, for example, after their losses in World War I, were determined to avoid a grinding war of attrition by not fielding ground forces for deployment on the Continent. Although they did establish an independent tank corps to test and develop operational concepts, it was overshadowed by an overall effort to escape the horrors of World War I.

The Germans, victims of a war of attrition, also saw the need to avoid that kind of war. However, they could not realistically consider the option of opting out of the next major war on the Continent. They therefore looked for a way to win quickly and avoid a stalemate, so as to avoid losing a war of attrition as they had in 1918. Furthermore, the Treaty of Versailles, having limited the German Army to 100,000 men, led to an increased focus on mobile operations for defense, as opposed to the static defenses that characterized World War I. Finally, stripped of their planes and tanks by the treaty, the German military could think more freely about what types of weapon systems would best be suited for future conflicts. It was not burdened by a large capital stock of defense equipment. Since the Germans could not, in many instances, actively train, they also had a greater opportunity to think through how they would approach future conflicts. The result was that the Germans developed the capability to wage a war of maneuver that offered them the prospect of winning quickly, before France and England could fully mobilize their war potential and before a naval blockade could strangle Germany.

Another example of organizational rigidity frustrating a peer competitor is the concentration of the British air assets in the Royal Air Force, which led to the anomalous result of RAF aircraft existing as "tenants" on Royal Navy aircraft carriers. The retardation of British carrier air operations development followed. Again, however, in the case of the British fleet air arm, other factors like geography come into play as well. The British seeing their island as a huge aircraft carrier off the Continent, did not feel the need to develop the carrier's power-projection potential as strongly as did the United States and Japan.

The United States, on the other hand, did see a need to project power across the entire Pacific, a mission that would require projecting power and seizing advance bases. An innovative cadre of U.S. naval officers appreciated the role carrier-based aircraft could play in meeting these requirements. They oriented the U.S. Navy's performance objectives around the ability to maximize the number of aircraft sorties it could generate. Their British counterparts, on the other hand, focused on detection and warning for British battleships, sailing and navigation as determinants of carrier proficiency. The U.S. Navy's use of carriers to "extend the battle space," and support forward offensive operations in austere environments paid big dividends in World War II, while British carriers played a relatively minor role.

Resources can be constrained, but that need not impose an insurmountable barrier to innovation. Revolutionary changes occurred between 1919 and 1939 in an era of severe resource constraints for most military organizations, especially in the United States. Yet the U.S. Navy was able to develop the concept of carrier task forces, the U.S. Marines modern amphibious operations, and the U.S. Army Air Corps the foundations for strategic aerial bombardment, all remarkable accomplishments.

However, one must also acknowledge that the interwar period was also different in significant ways from the situation in which we currently find ourselves. For example, during this time some sectors, notably aviation, benefited from dramatic industrial growth and a supportive public policy. During the interwar period over eighteen aviation companies were formed, including most of our major aviation corporations now in existence. Moreover, despite limited resources, government development and acquisition management supported the development and flight-testing of over ten medium and heavy bombers and more than two dozen fighter and trainer aircraft each. Thus, despite significant resource constraints, the United States successfully preconstituted for World War II. During the interwar period, however, there was considerable overlap between the technologies associated with commercial aviation and the automotive industry, and those required for military systems. The extent to which this kind of relationship exists today between the commercial and the defense sectors could influence significantly a competitor's ability to innovate.

Another challenge in effecting organizational innovation is that frequently, when new weapons and organizational structures are tested, the results do not compare favorably with existing methods of waging war. This is because there often are technical "bugs" that need to be worked out in new weapons, and the integration of the various players in a new concept of operation often proceeds in fits and starts. This, combined with the heavy weight of bureaucratic inertia in organizations, is often sufficient to frustrate innovation. The use of simulations may be a way out of this problem, permitting a variety of organizational structures to be examined and tested before they are actually put into place. But simulations can be, and have been, "rigged" to produce the desired answers.

Innovation and the Emerging MTR

Innovation is critical to the success of any attempt to compete effectively in a new era of warfare. In the Cold War era, U.S. decisions about forces hinged to a considerable extent on the threat posed by the Soviet Union, and the need for organizations that could focus on adapting or innovating for the mid- or long-term potential threat took a back seat to the need to focus on the threat at hand. In the emerging geopolitical and military-technical environment great uncertainty surrounds both the identity and nature of the mid- and long-term threats to U.S. security, and the nature of future warfare. In this environment the ability to innovate and adapt quickly would logically assume a much greater priority than it enjoyed during the Cold War. The fate of military enterprises, and of nations and coalitions, may well depend on military and acquisitional structures that are able to innovate faster than their competitors, or their enemies. Much of the need for organizational innovation will stem from the information revolution.

To take but one example, a major problem of the Gulf War was moving the right amount and the right type of the enormous quantities of information collected to the people who needed that information to fight the war. Commanders frequently were overwhelmed by the amount of information at hand, much of it irrelevant to their needs. In addressing this problem over the years, we have tended to increase the size of our staffs, hoping that they would be better able to manage the incoming flow of information, fusing it into information packets, which are then sent on to those who need it. In practice, this has not worked.

What has worked, especially in the business world, is the streamlining of organizations by eliminating unnecessary organizational levels. This has had the effect of removing information bottlenecks by allowing more people direct access to the information they need. This is made possible by the information revolution, in which huge quantities of information can be quickly and deftly manipulated and organized in a manner tailored to the needs of its individual users. It is in this area—systems integration and information fusion—that we are only beginning to scrape the surface of the potential gains in military effectiveness. To put it bluntly: we have state-of-the-art information systems harnessed to antiquated military organizations. (Ironically, the corporate structure that emerged with the industrial age in the 19th century emulated the hierarchical military organizational structure; now it may return the favor by providing a model for military organizational change.)

Changing existing organizations to better exploit the benefits of the information revolution proved difficult in the business world. It will likely prove even more difficult in military organizations, given what the considerable body of knowledge on large-scale organizational change has to say on the matter. In this instance, we are talking about taking away a major element of the hierarchy's power: its authority to withhold or distribute information to subordinate organizations. The integration of information systems to better exploit the information revolution and establish information dominance in warfare may require fundamentally different command relationships than what we have traditionally come to expect.

Although the information revolution is responsible for much of the need for organizational innovation, this same revolution can also help organizations to make the required innovations as efficiently and effectively as possible. As noted earlier, organizational change is one area where the dramatic advances in simulations capability may prove highly useful. It could well be possible to examine the potential effectiveness of new organizational arrangements through a hierarchy of simulations.

The simulations could begin with a consideration of first-order organizational issues by a relatively small group of individuals. If the initial analysis proves feasible, further organizational "prototyping" could be accomplished through more elaborate simulations and, eventually, field simulations or exercises. Simulations can be employed to test the sensitivity of current organizations to changes in the geopolitical or military-technical environment. In this way the "feed forward—feed back" interaction mentioned earlier can be extended to organizational innovation as well. Simulations can assist in evaluating organizational change in wartime, as well as in peacetime. During war the "feedback" from real-world experience would, in most cases, provide better inputs to simulations examining the efficacy of organizational restructuring options.

There may also be a cultural disposition toward innovation (sometimes referred to in the United States as "Yankee ingenuity"). During the Gulf War, the ability of U.S. forces to innovate (e.g., to devise ad hoc solutions to problems relating to their inability to move the information at hand), was a key factor in the United States' success. This innovation ran the gamut, from the most basic to the most sophisticated information systems. For example, literally tons of maps were sent to the war zone, yet most didn't filter down to the level where they were needed. There were instances where commanders and their staffs were operating with rough grids sketched out on paper serving as maps. The U.S. forces also had to jerry-rig their linkages with the Global Positioning System (GPS) satellites. The technical literacy and initiative of American human resources will likely be a great advantage in U.S. efforts at establishing information dominance. Conversely, we would expect hierarchical societies to be at a disadvantage in attempting to adapt to the new military-technical regime.

The potential for peer competitor states to conduct highly effective, nonnuclear strikes to the depths of a theater of operations, and to disrupt or destroy C3I networks will likely produce a chaotic battle zone, and not only at the "front lines." Military operations will likely have to become highly decentralized, while unencumbered (i.e., rapid) access to needed information grows by leaps and bounds. The need to reorganize the command structure to function in this manner is clear. At the same time, lower-level commanders and their subordinates will have to remain informed of their role as part of a highly integrated (i.e., joint) military campaign. The result will probably be neither a horizontal nor vertical organizational structure, but a hybrid of sorts.

Indeed, to execute the kind of operational concepts that could dominate a new military-technical era—those emphasizing both the importance of acting quickly, yet within ever-higher levels of complexity—organizations will likely have to emphasize decentralized execution and centralized control. Junior commanders will need to know how their operations support the senior commander's overall plan, how to integrate their operations within various elements of a full-dimensional concept of operations, and how to react quickly, and often independently, to a rapidly changing conflict environment. The latter two requirements will likely necessitate a "flatter," less hierarchical, organizational structure, with junior commanders and their staffs having direct access to information that was formerly "rationed" out by higher headquarters.

Effecting Organizational Innovation

Having stated that innovation is a key element in realizing the full potential of military forces in a period of revolutionary change, the question must be posed: how is organizational innovation fostered and nurtured to a successful conclusion? Our initial research indicates that the most difficult part of the transition will come in the area of organizational innovation. Large-scale organizations—especially military organizations (including perhaps their requirements and acquisition components, and industrial base as well), with their high regard for tradition and the limited availability of feedback—are often highly resistant to change.

Typically a major military innovation comes about in peacetime only when two conditions are met. First, there must exist military leaders who recognize the need for innovation, and who support its implementation. In examining cases of U.S. military innovation in this century, it was discovered that senior military leaders in the Services played the crucial roles. Second, these leaders must be able to institutionalize the innovation. The latter requirement is accomplished primarily by attracting talented young officers to the cause. However, these officers are unlikely to risk their careers supporting innovation unless their mentors are able to protect and promote them. The redirection and institutionalization of *human* resources appears to be the crucial element in effecting peacetime military innovation.

The United States may find the process of innovation a difficult one. "High-level political overrides" imposed from above rarely occur, for the simple reason that the tenure of the senior DoD leadership is so brief, and its attention diffused. The United States (like France and Britain after World War I) has emerged victorious from its most recent war. Defense resources are being cut dramatically. The response thus far, however, has primarily been to cling to the sunset systems and forces that characterized the Cold War era, and the requirements, acquisition, and intelligence structures whose focus is on specific, near-term problems rather than on the general longer-term competition.

In fact, this preliminary study finds little evidence that the United States defense establishment is preparing for or even considering large-scale innovation. For example, our acquisition system is structured to respond to specific guidance on requirements provided early in the acquisition process. This may have been appropriate during an era in which their was a clearly defined threat and a well-defined international order. But this is no longer the case. What is needed now—especially in a period of declining resources—is a requirements system that looks much further into the future, that explores a variety of alternatives (again, simulations can play a major role here), and that works with the acquisition system through the feed-forward and feed-back process described earlier to identify—not only sunrise systems—but sunrise network architectures as well. Finally, we need an acquisition system that is highly agile and flexible; that can react quickly to an emerging threat that, at present, remains unknown, and that is already positioning itself to compete successfully in the next military-technical revolution.

Given the importance of systems and network integration, and the growing role of "all-dimensional" operations that require the *interservice integration* of a variety of systems and networks, it is unlikely that a single Service's senior leadership will be able to effect significant innovations by itself. Before a Service can innovate successfully, its leadership may also have to convince its counterparts in the other Services of the merits of innovation. This brings up the issue of whether the United States requires a professional joint, or general, staff with the authority to deal with these matters on a continuing basis with a significantly higher degree of expertise than is currently available.

IV. The Competition

If history is any guide, we can expect a competition to arise among states, organizations (e.g., the European Union), and loose coalitions to realize the enormous potential gains in military effectiveness that characterize military-technical revolutions. At present, the United States is the clear leader in this competition, having benefited from the efforts made during its long-term military-technical competition with the Soviet Union.

Although defense budgets are declining in most major states, as the interwar period demonstrates there are still opportunities for exploiting advanced technology, experimenting with new systems, and testing of innovative operational concepts and organizational structures. Several states of groups of states—the United States, Japan, and Germany/EU—have the technological base and necessary resources to participate fully in this competition. Others—like France, Russia, and China—may emerge to full competition over the next twenty years. Furthermore, many states have learned from the Gulf War and, regardless of their ability to compete at a high level, they are already looking for countermeasures to frustrate possible peer competitor advanced operational concepts.

A. U.S. Objectives

What are our goals in this MTR? We are the *de facto* leader in the competition at this point. It may be possible in the short-, or even mid-term future, to extend the U.S. near monopoly in military capabilities for advanced warfare by dissuading potential competitors. Still, maintaining a long-term monopoly on this type of capability would seem impractical. Other advanced industrial nations now have, or could soon have, the technologies required to compete. Over the long run a realistic U.S. objective probably would be to dominate key sectors of the competition, much as a large corporation might seek to dominate key markets or business sectors, while actively examining ways to move on to the first military-technical revolution of the 21st century.

Or perhaps our goal will be more modest: to merely remain competitive or, perhaps, to await events and react to the competition. If we desire to remain the dominant player, however, we must consider ways to shape the competition and to deter potential competitors from entering the field, or to compete effectively against them if deterrence fails. We also cannot fail to consider those who cannot compete, but who will attempt to degrade our effectiveness through innovative uses of widely available advanced technologies, or by employing innovative operational concepts.

We find ourselves in a position somewhat analogous to the one we occupied in the late 1940s. Then, as now, the United States was the only country in the world that possessed the capability to conduct a dramatically different kind of war. One difference between the immediate post-World War II era and the immediate post-Cold War era is that there is no hostile major power competitor to the United States. We do not now face an obvious equivalent to the Soviet challenge that existed in the late 1940s. We may therefore be blessed with a "window of opportunity" that will allow us to think carefully about what our goals should be. In summary, there are three possible courses of action available to the United States for competing in the military-technical revolution: 1) dominance in virtually all areas; 2) dominance in certain key areas; and 3) awaiting events and reacting to the competition as it emerges. The second course is probably the most prudent. It acknowledges both the constraints on the nation's resources, as well as the demands of its security requirements.

B. Technologies and Systems Acquisition

As noted above, the United States has a lead in a significant number of advanced military technologies, and often an even greater lead in their application to military systems. The "barriers to entry" into full competition—technological sophistication, a substantial economic base, and the political will to compete—are likely to be substantial for most states. Advanced data-processing systems, sophisticated space platforms, advanced sensors, and low-observable/stealth platforms are a sampling of the sophisticated high-technology assets that will likely be required for full participation in the military-technical revolution. Most of these technologies are beyond the near- and mid-term capabilities of most states. The technologies underwriting these systems may be relatively easy to buy, but they are very expensive to integrate, both in terms of financial and human technical resources.

The advanced technologies of interest to competitors will increasingly be developed first in the commercial sector, vice the military-industrial sector, of national economies, for three reasons. First, because many of the technologies associated with the MTR have their origins in the commercial sector. Second, because the end of the Cold War has weakened international controls on military and dual-use technologies. Third, defense R&D is declining relative to commercial R&D, and there are no indicators that this trend will abate in the foreseeable future.

Given the requirements imposed by the emerging geopolitical and military-technical environments, two observations can be made concerning military systems developed to exploit advanced technologies in what will likely be a rapidly changing conflict environment. First, they must be produced in numbers sufficient to permit the validation of operational concepts, to cover immediate contingencies, and to train the force structure in their use. The Germans could not have wrought the *blitzkreig* with one *panzer* division, nor the U.S. Navy the revolution in naval warfare with one carrier.

Second, given the changing and uncertain geostrategic environment, it must be possible to produce, on relatively short notice, sufficient numbers of key sunrise systems to cope with a major contingency. The "Iraqi Equivalent" state we face in ten years will almost certainly be more formidable than the threat posed by Iraq in 1990. It will likely possess many "late-model" Cold War era systems and munitions (e.g., ballistic and cruise missiles, access to space platforms, smart munitions, etc.), and have mastered the nuclear revolution. As noted earlier, such a threat probably will have developed countermeasures to minimize its vulnerability to sunrise systems and the kinds of operations that would likely characterize this latest military-technical revolution. If it is to retain the ability to concentrate overwhelming military force against such states, the United States will have to stay at least one "revolution" ahead of them.

As noted above, the systems we produce also must be flexible enough (through incorporation of open-ended architectures) to incorporate new munitions or subsystems, and to facilitate systems integration. This implies the need for major organizational changes in the manner in which defense systems are developed and produced. Just as a competitor seeks to get inside an adversary's decision or information cycle, he also must be able to operate inside an opponent's production and innovation cycles. Maintaining U.S. dominance in system design simulation (i.e., the employment of computer-assisted design and manufacturing—CAD-CAM) may be a crucial element in this area of the competition.

An adaptive, flexible, and innovative acquisition system will become increasingly important as the rate of technological change increases. The ability to produce a critical mass of systems that can be employed for operational concept validation and training is needed to save time in the event of crises or conflicts. The ability of the defense industrial base to transition into production—or to adapt and prototype systems based on rapidly changing technologies—will also be crucial in winning the race for time and establishing information dominance.

Furthermore, it may become increasingly necessary to view the acquisition process in terms of "packages" or integrated sets of key sunrise systems. Just as effective operations in warfare increasingly require us to conduct joint operations, so too will we have to do a better job of integrating a series of systems and munitions together to operate effectively within a very different military-technical regime. The process described here can best be termed *preconstitution*, rather than reconstitution, reflecting a commitment to preparing for conflict in a new military-technical regime, against potential adversaries who are themselves moving ahead and mastering Cold War era technologies and systems. In this way we can retain an ability to exercise overwhelming force against those states who are still developing the potential of Cold War era technologies and systems, and we also can position ourselves to discourage potential peer competitors from actively participating in this MTR.

We cannot discount the importance of civilian systems to successful competition. Just as the Military Airlift Command relied on the Civil Reserve Air Fleet, so too will we and our competitors likely come to rely on priority access to commercial satellites and other components of the MTR in the event of crisis or war. A key issue for consideration concerns our ability to exercise this kind of coupling in peacetime to obtain maximum effectiveness from it in crisis or in war.

Nor can we discount the potential importance of relying on off-shore components. As technological and financial interdependence increases, our ability to employ a force capable of executing operations under the emerging revolution may be constrained by the policies of others. For example, an erstwhile ally may have the potential to place us in a position analogous to that which Great Britain occupied in the 1956 Suez Crisis; i.e., we may find ourselves risking, or incurring, a "technological veto" by a third party supplier state. To what extent should we rely on off-shore technologies and systems to support our efforts to transition to a higher military-technical regime? Will such dependence push us in the direction of having to adopt a short-war posture to avoid being leveraged by potential technology and system embargoes?

C. The Long-Term Competition

Ought we to look forward to a spirited competition for dominance in the new form of warfare? Probably, if history is any guide. But as noted above there are ways in which the United States could shape the competition, or dissuade or deter competitors. First, the United States could offer to extend security guarantees to those friendly states that eschew competition. Second, we might consider offering to "loan-out" selected elements of the MTR. For example, we could employ satellites, UAVs, information fusion centers, etc., to give a friendly state key advantages over its enemies in a conflict, as was done to some degree during the recent Falklands and Iran-Iraq wars.

Third, the United States could deter potential competitors as a result of the high entry price into the MTR competition. A state that has access to the relevant technology and skilled manpower base may still not choose to compete because of the formidable costs involved in developing both an MTR infrastructure and a "critical mass" of MTR systems that allow for a dramatic shift in military operations.

A crucial element of the technological competition for the United States may be the ability to reverse the erosion in competitive advantage by positioning itself to leap ahead to a higher level of competition. For example, the Soviets spoke of a "second phase" portion of the MTR. Thus it may be possible for the United States to dissuade competitors in the military-technical sense the same way businesses do in the commercial sector, by being one product line ahead of the competition.

As observed earlier, the scramble for competitive advantage will almost certainly be dynamic in nature. There will be a continuing search for countermeasures and counter-countermeasures. This phenomenon is, of course, not unique to this MTR, as can be seen from the Battle of the Atlantic during World War II. It also is possible that commercial high-technologies could allow marginal competitors to degrade significantly the advantages accrued by full competitors.

It will be important for the United States to determine those advanced technologies it should develop in the defense sector, those it can rely upon domestic civilian firms to provide, and those in which it is willing to cede dominance to other states. Although the importance of commercial technologies to the MTR is likely to grow, there will probably be some technologies and applications (e.g., data fusion and battle management) that remain primarily in the defense sector. Furthermore, it will be the *integration* of a variety of technologies and systems (with human technical expertise serving as the "glue") into network architectures that ties together the systems that create and exploit the "information gap."

The advantages that accrue to "followers" as opposed to "leaders" in identifying and developing key advanced technologies warrant an examination. Being ahead can confer certain advantages. In some instances, for example, long lag times occur before others can emulate the technological breakthrough. In other instances, however, it may be that the leader incurs high costs to penetrate technological barriers that can then be quickly and cheaply penetrated by competitors.

An important element of consideration will be the competitiveness of our defense acquisition process and industrial base. Given the dramatic changes in the geopolitical as well as the military-technical environment, they will probably have to undergo a revolution of their own. If the United States adopts a goal of competitive dominance, it will probably require much greater DoD emphasis on research and development of key technologies and sunrise systems than is currently the case. To compete effectively we also will likely have to be able to procure advanced systems quickly (inside a competitor's "acquisition cycle") when needed, or adopt a short-war posture (with all its inherent dangers). Capabilities for preconstitution and prototyping will likely assume an increased saliency. Innovation will be more easily accomplished with weapon systems that are inherently flexible. Products of this approach would include systems that incorporate open-ended architectural designs to accept follow-on electronics or weapons suites.

We will have to invest significant resources in the defense industrial base to maintain its future viability. This investment may be covered, in part, through reconstitution efforts. However, maintaining an industrial base capable of *preconstituting* for future conflicts will require substantial additional funding to encourage support for experimentation and innovation.

On a more positive note, the dramatic pace of technological change—especially in the area of information technologies—is also influencing dramatically the business operations of those firms that comprise the defense (and commercial) industrial base. The technological and operational revolution these businesses are experiencing may offer some solutions to the problem of retaining a healthy defense industrial base that can support preconstitution and innovation in a new military-technical era. It is a proposition worth exploring.

There are three additional interesting aspects of this competition. The first concerns the requirement for a "technologically literate" manpower base to exploit fully the fruits of the MTR. This is almost certainly the case now; however, this requirement may erode somewhat in the future if technological advances can create highly "user friendly" and "maintenance friendly" weapon systems. There are advantages to developing systems that are very simple to use (e.g., the Stinger missiles employed by Afghan resistance forces). In so doing, however, we run the risk of ceding our advantage in human technical resources. Simply put, many potential competitors could find it relatively difficult to operate and integrate the kinds of systems characteristic of this revolution. This may be a "barrier to entry" we want to preserve by limiting the "user friendly" levels of MTR systems. However, a major component of this revolution involves the ability to integrate systems and networks at ever higher levels of sophistication. Given this, the issue of how "user friendly" a given system is may be of only marginal import.

Thus, while potential competitors might be able to duplicate or acquire a specific technology or a specific weapon, this may not endanger our long-term competitive advantage if we recognize and protect our core competency in managing and integrating multiple technologies, systems, and networks. (The issue of core competencies will be addressed presently.) The most difficult capabilities for a competitor to emulate are almost certainly those that depend upon this kind of inter-network integration, which itself is also a function of organizational adaptability, human technical competency, and training. Correspondingly, advantages that rest solely on a single technology are likely to be ephemeral.

Second, will advanced technologies allow us to maintain an equivalent level of combat potential with significantly fewer systems and people? If so, does this make competition more manageable by lowering the manpower entry price since the force structure's "critical mass" is much reduced from Cold War era levels? How does this influence the target base that we or our potential adversaries present in the event of a conflict? These issues warrant close examination.

The third point relates to the asymmetry that will likely exist in terms of competitor goals and objectives. If we retain our Cold War era objective of being a global power, we will find that the military-technical needs of many competitors, whose ambitions are regional, are likely to be far lower than ours Many such competitors will probably have the far less ambitious (and far less demanding) goal of information, space, sea, and air *denial,* as opposed to seeking control or domination. Thus national objectives will help define a competitor's requirements, and its level of success as well.

D. Identifying Core Competencies

If the United States intends to dominate key sectors of the competition as its goal, how does it pursue that goal? As noted above, while we would like to be able to control the pace and the evolution of potential threats to U.S. security, it will be very difficult, if not impossible, to accomplish this by regulating access to technologies. We also noted the possibility of providing states with incentives and disincentives for not competing.

Another way to examine the question of dominance is by identifying what "core competencies" the United States will want to maintain in this competition. This involves identifying those functional, or mission areas it can divest itself of without incurring unacceptable risks to its security. A core competency comprises a complex combination of technology, manufacturing base, skilled manpower, training, organizational adaptivity, and operational experience that permits a military organization to do something of strategic importance better than its competitors or adversaries. By "something of strategic importance" is meant a capability that is seen by opponents as being crucial in determining the outcome of competitions or confrontations with the United States, a capability in which America is either preeminent or has the capability to be preeminent. By "core" is meant a capability that applies to a number of different missions and that permits the competitor to adapt its missions and capabilities to the changing security environment more rapidly than its potential adversaries. Implied in the definition is that, if a core competency were lost, it would be extremely difficult to regenerate. Examples of U.S. core competencies during the Cold War are carrier air operations and nuclear force operations.

To dominate the key aspects of the military-technical revolution, the United States will likely have to establish or maintain core competencies in reconnaissance, surveillance, tracking and acquisition of targets (to include space surveillance, information fusion, electronic warfare, and communications security), ranged-fire operations, simulations, and in the prompt, efficient production of related sunrise systems. In other words, the United States must maintain a dominant capability to create an "information gap" between itself and a competitor, and to exploit that gap through the use of advanced extended-range munitions. The United States also must be able to bring these capabilities to bear wherever they are required around the globe. Finally, protecting these assets, their ability to project U.S. power, and avoiding the prospect of being self-deterred will likely require that the United States also be dominant in strategic and theater defenses. In Soviet parlance, this is the capability to task organize reconnaissance-strike complexes with a global reach.

Examples of sectors of the defense "business" that the United States may wish to consider de-emphasizing are large, mechanized/armor land operations, large forward-presence surface naval operations, the primacy of manned aircraft systems, and nuclear operations. Note that the term "de-emphasize" does not imply abandonment; rather, it suggests a significantly reduced focus. Examples of sectors of the defense "business" that the United States may want to dominate are space operations, strategic defense operations, extended-range fires/reconnaissance-strike complex operations, and innovative power-projection operations (perhaps as part of an emerging "aerospace operation").

E. Assessing the Competition

Competitors can be grouped into three general categories. Category I comprises those states that have the necessary resources—human, economic, and technological—to compete now if they choose to do so. One would probably place Germany and Japan in this group, with other possible members being France (in alliance with another power), and Russia. The European Union (EU) is probably the only supranational organization that can claim membership in this group.

Category II would comprise MTR "wanna be" competitors; i.e., those states that could acquire some of the technological trappings of the MTR, and whose human resource base is somewhat competitive, but who currently lack the ability to compete on a qualitatively equal basis with the Category I states discussed above. These states might begin competing in significant ways in the mid-term future (i.e., in 10 years or so). Possible Category II members would include Britain, France, and Russia. Other states that would almost certainly be in this category would be China, India, Israel, and perhaps Brazil, South Africa, South Korea, and Ukraine, among others.

Category III is made up of those states that cannot hope to compete to any significant degree in the technical dimension of the MTR over the next twenty years, but who will compete by looking to adopt strategies that negate the effectiveness of Category I and II participants. We have encountered these kinds of competitors in the past. Countries like North Vietnam and Iran sought to prosecute their conflict with the United States in ways that denied us the ability to employ our "strong suits" against them. Such strategies might make selective use of "off-the-shelf" advanced technologies. They also would exploit geography (avoiding desert terrain, for example, while concentrating assets in jungles or in urban areas), and weather. These states might well tend to view the possession of nuclear weapons as a "poor-man's" substitute for an inability to compete in the current revolution. Of course, innovative concepts designed to frustrate our exploitation of the MTR will not be the exclusive province of Category III competitors.

Aside from their capabilities, how do we evaluate the intentions of potential competitors? How do we know when they are moving to enter the competition? We should develop a list of "warning indicators" that can be used to identify a state's intentions with respect the competition. We probably ought to use these benchmark indicators to help guide the collection and analysis efforts of our intelligence community. There also may be considerable overlap between developing warning indicators and the notion of "pre-targeting" potential competitors or adversaries.

Once a potential competitor becomes an active competitor, how should the United States pursue that competition? What core technical competences will be emphasized? How will they be applied in the form of political objectives, operational concepts, and force structure? Finally, how can we deter the competitor from taking actions inimical to U.S. interests, and how would we defend these interests if deterrence failed?

F. One Possible Threat

Although it will have to take into account the possible emergence of peer competitors, arguably the most formidable threat the United States will face over the next 10-20 years as this MTR develops more fully will be a Third World competitor that combines some of the sophisticated technologies of the Cold War era with the unconventional strategies and operational concepts of a Category III state. Technologically speaking, this state might have nuclear weapons ("old" technology originally developed in the 1940s), cruise and ballistic missile systems (again, relatively old technology), advanced guidance systems for cruise missiles, and advanced conventional munitions (e.g., laser- and optically guided bombs), access to commercial satellite communications networks, chemical and biological munitions, and late-generation "traditional" systems (e.g., tanks, aircraft, surface warships). Assume also that this state is energized by an ideology hostile to our values, or by a radical theocratic leadership. This combination might produce a "streetfighter" state: a state willing to accept a disproportionate amount of punishment (to include collateral and environmental damage) if necessary to accomplish its strategic objectives.

Such a threat, while pursuing objectives hostile to U.S. interests, would not want to confront the United States. Rather, it would have every incentive to learn from the lessons of the recent past, avoiding the direct approach practiced by Iraq in the Gulf War, while exploiting the successful, indirect, "unconventional" approaches followed by Iran since the late 1970s, and by North Vietnam in the Second Indochina War.

A "Streetfighter State" would pursue its plans for aggression by emphasizing the social dimensions of strategy. That is to say, the aggressor would attempt to exploit those aspects of the U.S. social culture that would inhibit the effective application of American military power. Specifically, acts of aggression would be low-intensity in nature and ambiguous in execution, with emphasis on terrorism, subversion, and insurgency. The objective would be to commit acts of aggression in such a way that they fall beneath the threshold that would trigger a U.S. military response. If the Streetfighter State does not have the patience or the time to conduct a protracted war of ambiguous aggression, it may be forced into a fall-back "smash-and-grab" campaign, analogous to Iraq's conquest of neighboring Kuwait in the Gulf War. This kind of aggression, of course, would be far more likely to trigger a U.S. response. If forced to confront the United States directly, the Streetfighter State would probably try to make the war as sanguinary and as protracted as possible, again focusing on the social dimension of strategy.

In either case, to reduce the prospect of a U.S. response the aggressor would initiate propaganda warfare against potential opponents and appeal to "world opinion" prior to and during the act of aggression. A primary target would be the U.S. public's respect for legal and moral norms. The Streetfighter State would attempt to place the burden of proof for establishing the case of aggression on the United States, especially in instances where ambiguous aggression is being practiced. The aggressor would encourage negotiations through various international fora while aggression continues, or while gains are consolidated. The Streetfighter State's objective here becomes one of protracted litigation through a host of supranational organizations, to include the United Nations, World Court, and relevant regional associations (e.g., Arab League, Organization of African Unity, etc.).

The revolution in commercial information systems will allow an aggressor state to take its case directly to the people of all democratic states. An important goal will be to fracture any budding coalition of states that might be forming to conduct military operations against the aggressor. Furthermore, threats of direct aggression (e.g., terrorism, ASAT strikes) or the use or propaganda may enable the Streetfighter State to deter key states (or blocs, or organizations) from joining or supporting a U.S.-led coalition. If states like Japan are deterred in this manner, the United States could encounter significant problems (e.g., with access to commercial space systems, or to off-shore defense components) crucial to the success of its operations.

Still, there is no guarantee that either the practice of ambiguous aggression or the consolidation of gains through protracted litigation will prove successful. The Streetfighter State may find itself opposed by a U.S.-led coalition prepared to take military action. In this instance, asymmetric mission requirements could make an aggressor with Category II levels of technology and an early Cold War era integration capability a formidable adversary. The Streetfighter State would not seek information dominance, but readily accept an "information neutral" environment. Its missions would involve denying United States' military forces control of space, the air, and the sea, rather than attempting to control those media itself. This could be accomplished by launching primitive ASATs, and by detonating nuclear weapons in space or the upper atmosphere, thereby generating electromagnetic pulses that would work far more to the disadvantage of U.S. information and weapon systems than to those of the aggressor.

Still, let us assume that U.S. forces manage to avoid these active and passive defenses. American forces prepare for deep-strike operations on key enemy targets. It is discovered, however, that these targets may have become exceptionally difficult to strike, even with advanced conventional munitions and near-real-time intelligence. There might be several reasons for this. First, many key targets have been provided with a human shield of hostages (ideally American or coalition, but perhaps including indigenous "enemies of the regime" as well). Second, key elements of the enemy military force could have been positioned in densely populated areas. In some instances, these elements would be co-located alongside nuclear reactors or power plants, or industrial plants that utilize significant quantities of highly toxic chemicals as part of their manufacturing process (i.e., "Bhopals in waiting"). Can the United States risk attacking these forces, even with precision ACMs?

The United States also would face the prospect that, even if the attacks are successful, there is a strong likelihood that the enemy will destroy several of these "dirty" targets himself, while accusing the United States of causing the catastrophe. The overall aim would be to prevail by employing a superior strategy capable of defeating a technologically superior force, even at a cost in human and material resources that would be unacceptable when viewed from the value system of advanced western industrial states. Once these targets are self-detonated, the enemy would either retaliate in kind or attempt to exploit the social dimension of strategy by appealing to the U.S. and international opinion to stop the war. If the former course is chosen, attacks by mobile ballistic missile or cruise missile systems, or by sabotage teams, could be conducted against targets in the region or even in the West.

Let us further assume that the United States overcomes this obstacle as well, and conducts successful forced entry operations that are preceded by extended-range strikes that neutralize most enemy long-range systems and their corresponding C3I network. If U.S. forces must conduct sustained ground operations to physically control the country, their problems could well continue. First, the enemy might initiate unconventional warfare operations against American forces. These operations might include environmental warfare (e.g., destroying water supplies, detonating industrial plants that employ toxic chemicals, detonating oil wells, burning large tracts of forest in a literal "scorched earth" campaign, etc.), insurgency, terrorism, and subversion. The likely objectives of such operations would be to raise the costs to U.S. forces, especially in time and blood. To this end, the enemy might also establish sanctuaries, either in remote areas of the country or in neighboring states that are willing to act as benevolent neutrals. From these locations the enemy could support unconventional operations, and could also stockpile weapons like cruise missiles that are difficult to find, but which can strike effectively at long ranges.

The above is probably a worst-case scenario for U.S. employment of MTR-capable forces. It assumes a number of things about the Category II/III Streetfighter State aggressor that may or may not be realized, such as its leadership's ability to exploit U.S. weaknesses by executing an innovative strategy, a people wholly committed to the regime and opposed to the United States, and the regime's ability to coordinate the strategy through the people in a very chaotic environment. What also has not been addressed, but must be, is the potential of Category I competitors to refine their operational concepts, introducing counter-countermeasures to offset the Streetfighter State's innovative attempts to counter their operations. For example, to what extent can the Streetfighter's strategy of aggression be offset by a satellite rapid replacement launch capability, or by strategic and theater defenses, or by special operations forces covert operations in "advance" of the U.S. military response?

V. ISSUES

A. INTRODUCTION

A strong consensus exists that a military-technical revolution is underway. This revolution is being driven primarily by advances in microelectronic technologies that vastly increase our ability to gather, process, and disseminate information; support the development and employment of advanced precision-guided conventional munitions; and permit major advances in simulations techniques. But while new technologies are the ultimate cause of a military-technical revolution, they are not themselves the revolution. The revolution is fully realized only when innovative operational concepts are perfected to exploit systems based on new technologies, and when organizations are created to execute the new operations effectively. Such a revolution creates new military capabilities that dominate previous modes of warfare.

We are probably in the early stages of a transition to a new era of warfare. Our prospect now resembles our situation in the early 1920s. Then we were in the early stages of a military-technical revolution, but with no clear enemy, low defense budgets, and with no clear idea of how (or when) the revolution would be fully developed.

Despite the prospect of low budgets, our position is now very favorable. Our capabilities in some of the major areas of warfare, while far from what we think the military technical revolution will make the new state of the art, nonetheless give us a commanding qualitative advantage over all other countries today. And there is no immediate prospect that this advantage will be challenged. Our technologically advanced allies lack the incentive to press a military-technical competition; the Russian military is more inclined to compete but will for perhaps a decade at least lack the resources to do so. In the long run, however, even if the world's military technological leaders remain allied or friendly with each other, they are likely progressively to adopt new military systems and techniques to maximize their advantages over third parties from whom they do perceive threats.

Accordingly, our assessment does not imply a need for major near term changes in defense policy. The Department's highest near term priorities will be downsizing without demoralizing the force and reorienting it toward the regional strategy. But it is important also to use the next few years making preparations for the period of major change that lies ahead. We have, and should use, time to refine our assessment of how major areas of warfare will change, to consider our goals and strategy for the military-technical revolution, and to determine what kind of institutional changes may best foster the process of innovation that we will need. The clearest near-term goal for U.S. efforts to exploit new military technologies is to improve capabilities that permit us to dominate lesser opponents in limited contingencies. A second aim of our strategy might be to hedge against, or even to try actively to discourage, the emergence of a first-rate military technological competitor. If we pursue these goals, many questions arise about the best political and military means of doing so. What follows is a brief discussion of a few selected major strategic management issues that senior defense officials will face.

B. Issue I: Identifying Appropriate Innovations

A military-technical revolution implies that new technologies are not simply used to conduct military operations more effectively, but that they are used to conduct more effective kinds of military operations. Rather than existing forces harnessing new technology in the service of existing concepts of operations, new concepts are devised and new forces are organized that can use the new technology to best advantage. Past military technical revolutions have seen the creation of new formations—the carrier battle group—and the extinction of old formations—the horse cavalry. What are the operational concepts and force structures appropriate to today's new and emerging technologies? It appears that most thought devoted to that question in the United States has centered on the case of a large air-land theater of operation. Yet it is plausible that for other areas—war at sea, war in space, power projection/forcible entry, and strategic strike—revolutionary changes are also possible in how these activities are conducted, or even whether they are conducted. Information warfare, a new warfare area, has not been defined as such or received much attention until very recently.

One comes away from this first assessment of the MTR with the impression that we need to explore how technological developments could change all warfare areas, and identify the kinds of operational concepts and formations that will be suited to the period before us. How can a broader search for the full implications of these new technologies be stimulated and coordinated over the next two to three years?

C. Issue II: Promoting the Process of Innovation

In addition to the intellectual task of identifying and understanding new ways of warfare, there is the practical task of getting military organizations to adopt those new ways, and even to adapt themselves to those new ways. Although the innovative operational concepts that became known as the *blitzkreig* were first described by British strategists J.F.C. Fuller and Basil Liddell-Hart, it was the Germans who were willing to adapt their military force structure to execute those concepts.

In the 1920s there was no overarching structure guiding innovation in U.S. forces; rather, it took place within the Services. The innovations were not driven by specific threats, but by perceived changes in the security environment and by technological developments. Innovation flowed from specific new requirements, e.g., the need to acquire advance bases in wartime to support naval operations in the western Pacific. Military leaders recognized the need for innovation, and institutionalized innovations by attracting talented young officers to new combat arms through a variety of incentives, including the creation of new lines of promotion to the most senior positions in the Services.

There may be special problems with innovation in this military-technical revolution since much of the innovation may have to cut across Service boundaries. Future military operations will be increasingly joint in nature (and at progressively lower levels of command), and "full dimensional" (i.e., involving forces operating simultaneously on land, at sea, in the air, and in space). Thus it would appear that the Joint Staff and the staffs of the various CINCs will have to play a greater role in fostering innovation than has been true in the past.

Encouraging innovation is not simply a matter of implementing "reforms" or arranging for the "execution" of a set of innovative plans. Military innovations of the kind we foresee will take place over a period of decades, and the key issue is how to foster a continuing process of experimentation, learning, and organizational adaptation. Senior managers in the Department should consider how they can nurture the long-term process of innovation within and across the Services.

D. ISSUE III: THE DEFENSE ACQUISITION PROCESS

So much time and effort has been expended in recent years to make the Defense acquisition system more efficient and effective, that we are reluctant to suggest still another look at it. Yet if we believe that we are in a period of military-technical revolution, then we need a system that allows experimentation and innovation. Our concepts of operation will be evolving as part of an extended learning process involved in the exploration of a variety of alternatives. Part of this exploration should be possible through the right kind of simulation and wargaming. But from time to time moderate numbers of new weapons and other systems will have to be purchased to allow for experiments with new concepts of operation and novel force organizations, and for our forces to feel confident of their weapons. Even the Department's new emphasis on "prototyping" does not escape the dominant role played in the acquisition process by the careful specification of military requirements. But with concepts of operation in flux, there will be great uncertainty about what is truly "required"—perhaps more uncertainty than the existing acquisition system can tolerate. The danger is that lower budgets will only increase the emphasis on making sure we have the right requirements, at a time when, faced with greater uncertainties than we have witnessed since the 1920s, this emphasis is misplaced.

Black programs and the Skunkworks operations show what can be done in at least some cases. We are not at all certain what should be done. Our concern is whether the existing acquisition process fits the needs of the dramatically changed geopolitical and military-technical period we are entering. It is possible that same set of technological developments that lead to new modes of warfare will also permit new modes of weapons design and innovative production methods. These methods could help the defense industrial base achieve the required flexibility to preconstitute in an uncertain security environment. The Department's senior managers should consider whether they want to undertake an effort to explore how best to modify or change the acquisition process to facilitate the process of experimentation and innovation that characterizes periods of military-technical revolution.

E. Issue IV: The Role of U.S. Allies

Among the many issues connected with developing an overall U.S. strategy for the military technical revolution, one that deserves particular attention is the role of our friends and allies in that strategy. Do we wish to develop the next generation military capabilities jointly with our allies, or do we hope to maintain some margin of advantage over all other countries? Do we envision coalition warfare in which our friends are as capable as ourselves? Or in which we provide certain kinds of military services or functions that our friends lack? Do we attempt to discourage first-rate military technical competitors by sharing capabilities and winning trust, "lending" capabilities and building dependence, or maintaining superior capabilities and building entry barriers? Will "natural," economic limitations on what our allies can do make these issues moot (by making some advanced capabilities unaffordable to them) or make these issues more delicate (by making their capabilities more clearly dependent on our willingness to share?) Should our policies in these matters differ across different warfare missions? The recent, somewhat abstract controversy over the question of the U.S. as a "sole superpower" may take more concrete form in relation to this issue.