



RAND Arroyo Center
ARMY RESEARCH DIVISION

Annual Report 2001

Contents

Message from the Director

This year's Arroyo Center annual report could not go to press without acknowledging the tragic events of September 11, 2001. The Army is involved in all aspects of the war on terrorism, in ways that go far beyond the impressive performance of Army Special Forces teams on the ground in Afghanistan. Yet neither can this report ignore the wide range of missions that confronted the Army before that terrible day, all of which continue to challenge the Army even as it tackles the war on terrorism. This report reflects that blend. It recounts research that, even though initiated long before September 11, relates directly to the war on terrorism. But it also contains research on other, enduring missions the Army must carry out.

Thomas L. McNaugher
Vice President, Army Research Division
Director, Arroyo Center

Countering terrorists or other aggressors requires responsive forces, and the first article in this report describes our research on the contribution that rapidly deploying ground forces can make to the early phases of a campaign. Our results show that aircraft operating alone can rarely deny the enemy his objective. This conforms to the nation's experience in the Balkans in 1999, where aircraft had little effect on Serb forces engaged in ethnic cleansing in Kosovo. Conversely, rapidly deploying ground forces improve the effectiveness of airpower—as we have seen recently in the war in Afghanistan—while of course adding combat power of their own on the ground. The best way to deliver combat power, the analysis strongly suggests, is jointly.

Responding to terrorism and, indeed, other threats will require agile and capable forces. Much of the bulk of Army forces resides in the logistical tail, and the Army has been working diligently to shrink the size of the logistical elements that accompany its combat forces. Our analysis shows how a new inventory policy can shrink the logistics tail of combat forces while actually enhancing their readiness.

The requirement for agility extends beyond combat forces. To respond to its rapidly changing needs, the Army needs agile business processes to acquire systems and materiel and to operate a sprawling infrastructure efficiently. With an information-driven force, the Army has to find ways to take advantage of the rapid advances that continually occur in information technology. Traditional acquisition procedures are too cumbersome. Furthermore, the Army finds itself the steward of an enormous infrastructure that has shrunk much more slowly than the resources required to maintain it. The article on alternative ways to collaborate with industry offers ideas for addressing both problems.

The Army has long recognized that information can make a crucial difference in the outcome of battles. Indeed, much of the Army's transformation plan hinges on exploiting the advantages of superior information. However, Army models and simulations do not have a good way to reflect the value of information. The article on measuring the effect of information describes proof-of-principle research that demonstrates the feasibility of developing Information-Age measures of

effectiveness that can gauge the effect of information not only in combat but also in stability operations.

The September 11 attacks brought home in the starkest possible fashion the message that the United States is no longer a haven against conventional attacks. Two oceans and arguably the most effective combat forces in the world cannot guarantee the security of the homeland when terrorists make the civilian populace their explicit target. The Arroyo Center has been examining the demands of homeland security for several years, and the article on defending the homeland reports on our most recent effort. It offers a quantitative analysis of what homeland security might demand of the Army and suggests ways the Army might respond to what will surely be greater demands to secure the homeland.

The final article takes a searching look at the possibilities offered by distance learning. The results of the analysis suggest that the Army can derive considerable benefit from distance learning but that it has to take advantage of it in the right way, exploiting its ability to deliver instruction where and when needed. Used wisely, distance learning can enhance personnel readiness in a variety of ways. However, gaining full benefit will require some policy changes.

September 11 announced a new era for the Army, but it did not eliminate the challenges of the old one. The Arroyo Center is proud to be the Army's partner as it seeks ways to meet and overcome both the new and the long-standing dangers that face our nation. ★

About the Arroyo Center and RAND

The Arroyo Center is the U.S. Army's only federally funded research and development center (FFRDC) for studies and analysis. Founded in 1982 as part of the Jet Propulsion Laboratory in Pasadena, California (and located on Arroyo Drive—hence the name), the Arroyo Center moved to RAND in 1984 at the request of the Army's Chief of Staff. The Arroyo Center shares with RAND a commitment to objective, empirical research and analysis of major policy issues. In Arroyo's case, this means a focus on mid- to long-term issues affecting the Army's efficiency and effectiveness, with special attention to projects whose content spans the Army's many subdivisions and agencies. On the basis of extended investment in these issues, Arroyo Center analysts can respond to the near-term needs of Army leaders with immediate help on urgent problems. They can also provide a sounding board for Army officials as they consider policy alternatives. The Arroyo Center represents a repository of continuously deepening and expanding understanding of key Army issues. Its goal is to help make a better U.S. Army.

The Arroyo Center's FFRDC status promotes objectivity and a long-term perspective. Funding via a renewable, five-year contract provides a stable environment in which Army officials and Arroyo Center analysts can work together to build continuity of expertise on issues of enduring interest to the Army's leadership. The continuity of the long-term contract also helps RAND and the Arroyo Center attract and retain high-quality analysts, and it allows them to develop institutional capabilities—databases, simulation capabilities, and the like—that serve the Army's needs. The way Congress provides most of the funding separates the reactions of Army sponsors to Arroyo's findings from funding decisions, enhancing the Arroyo Center's independence.

Arroyo Center projects analyze major problems confronting the Army, recommending solutions and courses of action and often supporting their implementation. Arroyo Center research projects largely group into the following four categories.

- The global security environment, including what changes in it imply for the Army's future roles, structure, and doctrine and ways the Army might respond.
- New technology and operational concepts and how they can improve the Army's ability to carry out its mission, and how better business practices can improve the way the Army acquires equipment and operates its installations.
- Supporting and providing resources for Army combat units, the logistics system, and the sustaining base. This area includes developing sustainment metrics for the next set of weapon systems and analyzing the effects of age on equipment.
- Recruiting and retention, force management and future manning, leader development, training and unit readiness, and Army medical practice.

The Arroyo Center's research agenda is shaped through near-continuous interaction between senior Arroyo analysts and senior Army leaders; indeed, "quality engagement" with senior leaders is an important part of Arroyo's vision of itself. Each year's slate of projects is approved by the Arroyo Center Policy Committee (ACPC)—in effect, Arroyo's board of directors—whose membership, shown below, comprises the full breadth of the Army's senior leaders. The ACPC meets twice annually, once to review key findings of recent Arroyo research, and once to approve the next fiscal year's research agenda.

About RAND

In choosing to lodge the Arroyo Center within RAND, the Army linked itself to one of the nation's oldest federally funded research institutes, with a well-earned reputation for objective and innovative empirical research. RAND's origins trace back to just after the end of World War II, when the Army Air Corps lodged a small group of analysts within the Douglas Aircraft Company in Santa Monica, California, with the mission of improving air operations in war. So successful was that undertaking that the Air Corps leadership kept the group in operation even as the military services demobilized after the war. When it became clear that the group could not be housed in an aircraft firm without creating a perception of conflict of interest, RAND (for Research And Development) was established in 1948 as an independent nonprofit corporation based in Santa Monica and dedicated to analysis of policy issues for the newly formed U.S. Air Force. Throughout the 1950s, RAND proved to be a fertile ground for innovative thinking on strategic issues—especially nuclear strategy—and defense management.

RAND continues to work for the U.S. Air Force, but today Project AIR FORCE is but one of many divisions of what has become a diversified research institution working on a remarkably wide range of policy issues, including education, criminal and civil justice, labor and population, health, education, and science and technology. RAND also has its own graduate school, now called the RAND Graduate School for Policy Studies, the nation's largest fully accredited school offering a Ph.D. in policy analysis. Today RAND occupies offices in Santa Monica, Washington, D.C., Pittsburgh, and Europe.

All of RAND's divisions draw on the corporation's chief asset—its staff of nearly 700 professional analysts, supported by some 500 additional staff. RAND's people belong to the firm rather than to individual subdivisions, giving each division access to skills it alone would not need full time. The benefit here is substantial; the Arroyo Center's work on Army medicine has always drawn in large part on experts who work mainly for the RAND Health division, while its manpower work often employs demographers and statisticians who work mainly for other parts of the firm. All divisions benefit from the energy and intelligence of RAND's graduate students, who perform on-the-job training across the corporation.

Like RAND's other divisions and all FFRDCs, the Arroyo Center makes its research results available to the public, consistent with security considerations and after appropriate review by the Army. In this way the Arroyo Center helps create a broader understanding of Army issues across the wider policy community, while also informing future generations of Army leaders. ★

The Arroyo Center Policy Committee

The Arroyo Center benefits from the oversight and guidance of an important group of senior Army leaders, known officially as the Arroyo Center Policy Committee (ACPC). Its guidance transcends the individual projects that address issues of immediate concern to the Army to focus on the development of major lines of research critical to the Army's long-term effectiveness. The ACPC plays an indispensable role in motivating the Army and the Arroyo Center to initiate research on the fundamental policy questions that cut across jurisdictional boundaries within the Army and the overall defense community. Its membership is made up of the following individuals.

General John M. Keane (Co-chair)
Vice Chief of Staff, U.S. Army

Mr. Claude M. Bolton, Jr. (Co-chair)
Assistant Secretary of the Army (Acquisition, Logistics and Technology)

Mr. Reginald J. Brown
Assistant Secretary of the Army (Manpower and Reserve Affairs)

Mr. John W. McDonald
Deputy Under Secretary of the Army

Mr. Walter W. Hollis
Deputy Under Secretary of the Army (Operations Research)

General John N. Abrams
Commanding General, U.S. Army Training and Doctrine Command

General Larry R. Ellis
Commanding General, U.S. Army Forces Command

General Paul J. Kern
Commanding General, U.S. Army Materiel Command

Lieutenant General Bryan D. Brown
Commanding General, U.S. Army Special Operations Command

Lieutenant General Peter M. Cuviello
Chief, Information Officer/Director of Information Systems for Command, Control, Communications and Computers, U.S. Army

Lieutenant General Benjamin S. Griffin
G-8, U.S. Army

Lieutenant General John M. Le Moyne
G-1, U.S. Army

Lieutenant General Charles S. Mahan, Jr.
G-4, U.S. Army

Lieutenant General David D. McKiernan
G-3, U.S. Army

Lieutenant General Robert W. Noonan, Jr.
G-2, U.S. Army

Lieutenant General James B. Peake
Commanding General, U.S. Army Medical Command/ The Surgeon General

Executive Agent for the Arroyo Center
Major General A. J. Madora
Director, Program Analysis and Evaluation, Office of the G-8, U.S. Army

Getting Forces There and Stopping the Enemy

Numerous official and unofficial histories have chronicled the success of U.S. forces in the Gulf War. What has drawn less attention is the enormous advantage those forces enjoyed: six months to deploy and prepare. This advantage has not escaped the notice of potential adversaries, and any future conflicts are unlikely to play out in a similar fashion. Thus, the initial phase of conflict is liable to be the most demanding one. A key question for the regional Commander-in-Chief (CINC) will be how to allocate scarce airlift among many claimants. The decision will be driven by what types of forces could make the greatest contribution early in the operation. Recent RAND Arroyo Center research explored two types of operations—a major theater war and a smaller-scale contingency—with an eye to assessing what Army forces could do in the early phase of a conflict and the value of attack aircraft to halting an enemy advance.

How We Went About the Analysis

To explore these questions, Arroyo Center researchers posited two scenarios in 2008—one in Southwest Asia and one in Kosovo. Each had several variants. Researchers used two complementary models for the analysis: RAND's Joint Integrated Contingency Model (JICM) and RAND's version of the high-resolution Janus model. JICM provides broad, campaign-level assessments. It can replicate deployment, logistics, and combat operations of air, sea, and land forces. Janus supplies detailed results of battles, typically at brigade level and below. It can model the activities of about 1,500 entities per side (vehicles, weapons systems, etc.) in short time steps (minutes), providing a wealth of detail about tactical engagements. Together the models produce valuable insights into what capabilities are particularly useful in the early stages of a campaign.

The scenarios varied substantially. The Southwest Asia scenario involved open terrain where large forces can maneuver easily. Open terrain also made it relatively easy to locate targets. The theater had substantial friendly forces in place. The Kosovo scenario, in contrast, had broken and hilly terrain with large forests and villages. No friendly forces were present at the outset of the conflict, and the forces involved were much smaller than those in the Southwest Asia scenario.

A key question for the regional Commander-in-Chief will be how to allocate scarce airlift among many claimants. The decision will be driven by what types of forces could make the greatest contribution early in the operation.

The research team made a number of assumptions. First, it assumed that airlift would be limited and thus that tradeoffs would have to occur. The study assumed that 104 C-5 and 112 C-17 cargo aircraft would be available and that no more than 55 percent would be allocated to move Army forces. The team also assumed that the Interim Brigade Combat Team (IBCT) would be available by 2008 and that it would take about 300 C-17 sorties to deploy.[1] The team judged that a wing of F-15C fighters would require about 50 such sorties and that an Apache attack helicopter battalion along with a Multiple Launch Rocket System (MLRS) battery would take roughly 65. The F-15Cs can deploy themselves to the theater, but their support (e.g., maintenance) requires airlift. These airlift sortie

[1] The IBCT assumed here had about 3,500 people. Its major organizations included three medium infantry battalions, an anti-tank company, and an artillery battalion. It also had intelligence, reconnaissance, engineer, and support units.

estimates assume that ammunition has been prestocked in the theater for aircraft and rocket launchers.

Southwest Asia Scenario and Excursions

The general scenario for Southwest Asia posits an Iraqi force attacking south on three axes through Kuwait and into Saudi Arabia. The goal of coalition forces is to stop the Iraqi attack as far north as possible, ideally before much of Kuwait has fallen. The criteria for success are the destruction of half the armored fighting vehicles of the Republican Guards or the loss of half of all the Iraqi force's armored vehicles. Stopping Iraqi forces from reaching their objectives or from threatening ports and airfields with indirect-fire systems is also judged as success.

Researchers explored nine variants of the Southwest Asia scenario, and these appear in Table 1.

Table 1: Variants for Southwest Asia Case

Case	Description
A	Base case. Current prepositioned forces and deployment plans.
B	No Army forces prepositioned in region.
C	Army reinforced with 24 Apaches and MLRS; 72 fighters cut.
D	Same as C, except Army unit is IBCT.
E	IBCT deploys from Germany. 48 C-130s available. Apaches and MLRS present.
F	IBCT deploys from continental United States. Apaches and MLRS present.
G	Like C, but no land-based Tacair; 12 more fighters per carrier.
H	Like F but 30 C-17s added to airlift pool.
I	Like C, but 4 more Hellfires fired per mission, plus 500 ATACMS-BAT.

NOTE: Attack aircraft included 144 F-15C and 100 F/A-18 based on two carriers unless otherwise indicated, e.g., Case C.

Southwest Asia Results

The modeling showed that results are disastrous without U.S. ground forces present early in the campaign. Air forces alone or in conjunction with only coalition forces do not stop the enemy from seizing his objective. This occurs because once attacked from the air, he employs countermeasures. Our scenarios assumed that the Air Force and Navy aircraft employed a Joint Standoff Weapon, a weapon that is released some distance from the target and glides to a precise set of global positioning coordinates, where it dispenses a submunition with an infrared seeker that locates individual targets. The ability to loft the weapon from a distance means that an aircraft can attack from outside the enemy's air defense umbrella. But the standoff also means a long time of flight, assumed here to be seven minutes. The initial sorties catch the enemy by surprise and are quite effective. Once attacked, however, the enemy begins to zigzag, which means that vehicles may not be in the target area by the time the weapon arrives, and effectiveness falls off sharply (from 0.63 kills per weapon to 0.36 kills). With U.S. ground forces present, the enemy must not only cope with the air-delivered weapons but also fight through a ground force.

In the base case, the Iraqi forces seize most of Kuwait and advance into northern Saudi Arabia before being stopped. Army forces play a key role in halting the advance around D+7 (seven days after the attack begins). Results are significantly worse when no U.S. Army ground forces are present when the fighting starts (Case B). Coalition ground forces and coalition and U.S. air forces remained the same in Case B. By D+10, Iraqi forces are still advancing, and important locations such as King Khalid Military City have fallen. Trading some air power for ground augmentation (Case C) produces better results than does the base case. Adding Apaches and the MLRS armed with 100 Army Tactical Missile Systems (ATACMS) and the Brilliant Anti-tank (BAT)[2] submunition results in the destruction of several hundred more armored vehicles, and the Iraqi advance is stopped shorter than in the base case.

Adding an IBCT to reinforce coalition ground forces in the defense (Case D) curbs the enemy penetration somewhat over the base case. However, casualties also increase, reflecting

[2] Launched by the ATACMS, the BAT submunition is designed to destroy armored vehicles. The munition modeled here uses two sensors, acoustic and millimeter wave, to find and attack targets.

the increased role of U.S. ground forces and the relative capabilities of an IBCT in a defensive role in desert terrain against an attacking armored force. Deploying the IBCT from Germany (Case E) produces similar results. Of interest is the fact that C-130 aircraft cannot deploy the interim armored vehicles from Germany without several refueling stops. Therefore, they deployed other equipment while C-5s and C-17s carried the armored vehicles. Deploying the IBCT from CONUS (Case F) delays the IBCT until about D+4 (vis-à-vis D-day for Case D and D+2 for Case E) and forces the CINC to defer land-based fighters and other critical assets (e.g., Patriot batteries) to provide enough airlift to move the IBCT.

One excursion explored the ramifications of increasing the number of Navy tactical fighters by adding 12 fighters to each of the two carriers in the scenario. This occurred in conjunction with shifting airlift from moving the support elements for land-based fighters so that the Apache helicopters and MLRS rocket battery could be brought in. The thinking in this case was that the CINC might not be willing to forgo significant amounts of land-based fighters to gain an IBCT. The results of this excursion compare favorably with Case C. Another case added airlift—30 C-17s. As a result, more forces could deploy, and the results were generally similar to those cases where Apaches were available early in the campaign. A final excursion boosted the numbers of ATACMS (+500) and increased from six to ten the number of Hellfire missiles each Apache fired on each mission. This excursion produced the best overall results, with over 4,000 enemy systems destroyed, and it highlights the importance of providing adequate ammunition resupply rates to optimize the contribution of key systems like Apache and MLRS. Figure 1 displays the results of each case, showing the contributions of Tacair, Apaches, and ATACMS. The best result occurs in Case I (far right of chart), where over 4,000 enemy systems are destroyed or disabled. The worst case occurs with no prepositioned Army forces present; just over 2,400 enemy systems are lost.

In addition to using JICM, researchers used Janus to carry out detailed analysis of air attacks and ground combat. The analysis considered an Iraqi division moving to contact. It had to move 120 kilometers at a speed of approximately 25 kilometers per hour, with 100–150 meters between vehicles. One excursion considered an air-only attack, with F-16 and F/A-18 aircraft armed with the Joint Standoff Weapon with sensor-fuzed weapons (JSOW/SFW). About 12 aircraft attack the division each hour over a five-hour period with 144 JSOW. The initial surprise attack by 12 aircraft results in 0.63 systems killed per JSOW/SFW. But after the first attack, the enemy columns begin to zigzag, and the kills per weapon fall off. The enemy division loses 65 vehicles but seizes its objective.

Researchers next explored how an Army heavy brigade would fare against the division. Several variations of the brigade were played, beginning with an armored brigade task force with only its normal support, i.e., an artillery battalion in direct support but no Apache or MLRS. Subsequent excursions added various combinations of supporting elements including a company of Apaches, a battery of MLRS firing different types of munitions (e.g., MSTAR), and both attack helicopters and MLRS.

In all cases, the brigade destroyed the enemy armored force. Figure 2 shows the loss-exchange ratio (i.e., ratio of enemy to friendly losses) of the excursions. It varied from 6.8

Figure 1: JICM Excursions for Southwest Asia Scenario

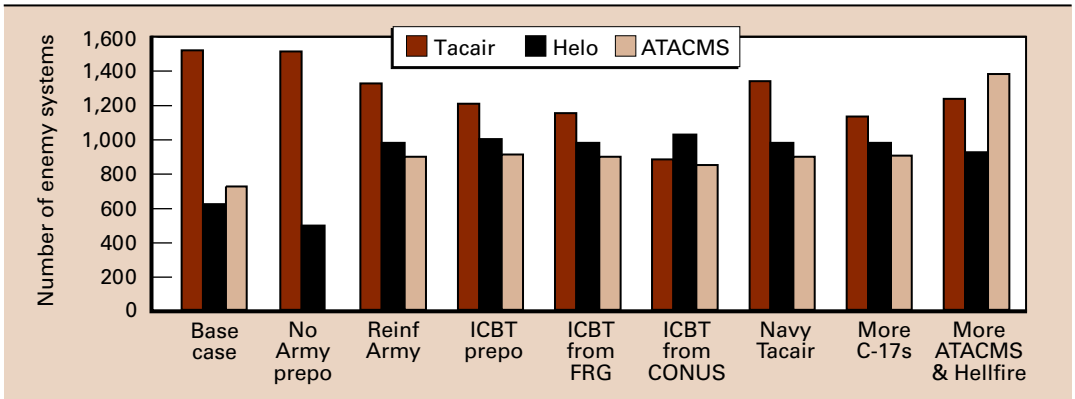
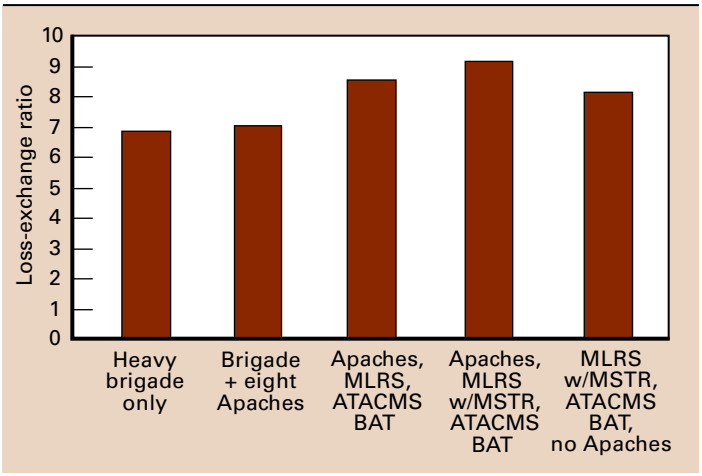


Figure 2: Janus Results in Southwest Asia Scenario



in the case of the unreinforced brigade to a high of 9.1 when a company of Apaches and MLRS with precision munitions were added.

Kosovo Results

The Kosovo scenario involved a smaller force, which enabled it to be modeled in Janus. The analysis considered seven cases, beginning with an air-only excursion. Next examined was an unreinforced IBCT, followed by various combinations of the IBCT, Apaches, and MLRS equipped with a range of munitions. The enemy force consisted of three brigades, two mechanized and one armored, a force made up of almost 800 vehicles including trucks, artillery, and air defense weapons. Its goal was to seize Kosovo quickly and stop NATO ground forces from entering.

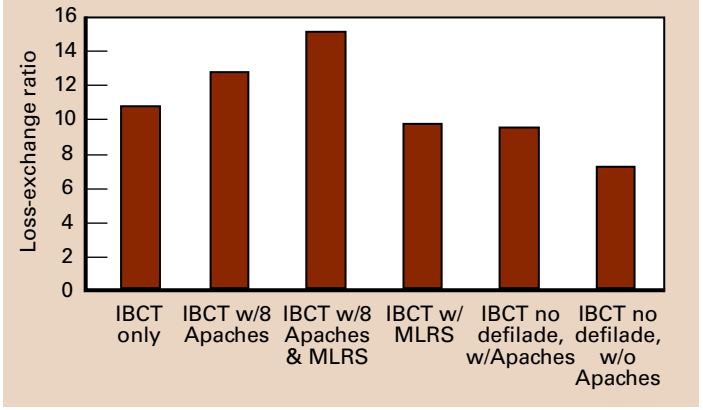
The deployment analysis showed how much the Army gains in responsiveness when it can move units already positioned overseas. This case considered IBCTs moving from the United States and from Germany. Researchers assumed that an IBCT could deploy on C-17s and C-5s either from Germany or CONUS and that two airfields would be available, one in Albania and one in Kosovo. They also considered two arrival rates of either 20 or 40 landings per day. Deploying the brigade from CONUS takes between 11 and 12 days and consumes 40–50 percent of the C-5/C-17 fleet.[3] Deploying from Germany, the brigade closes in 7 days with 20 landings per day and in 4 days with 40 landings. It requires 16 and 22 percent of the C-5/C-17 fleet respectively.

The air-only phase, consisting of waves of Air Force and Navy fighters attacking the enemy armored columns, did not stop the enemy from reaching his objectives. Over four hours, U.S. aircraft fired 160 JSOW/SFW weapons, killing 36 enemy vehicles. But enemy brigades still reached their objectives in five to six hours. The heavily forested terrain of Kosovo made it difficult for the aircraft to locate their targets. Also, the enemy units minimized their vulnerability by speeding up as they crossed open areas.

Employing an IBCT in conjunction with attack aircraft thwarted the enemy. The IBCT took up a hasty defensive position between the advancing enemy columns and their objectives. This means that the infantrymen were dug in under tree cover, some small obstacles and minefields had been emplaced, and the armor was in a "hull-down" or protected position. It took the brigade between 8 and 12 hours to establish this level of defense. Two cases assumed that the IBCT did not have time to set up a defense and instead fought a meeting engagement with the Yugoslav forces.

Figure 3 shows the loss-exchange rates for the six scenarios involving an IBCT. In all cases, the IBCT stopped the enemy short of his objectives. As the figure shows, the loss-exchange ratio favored the IBCT, ranging from more than seven to fifteen. Even in the case where the IBCT does not have time to establish defensive positions and has no attachments,

Figure 3: Janus Results in Kosovo Scenario



[3] Researchers analyzed only the 20-landing-per-day option because the flight time from CONUS is so long that more landings are infeasible.

the brigade destroys more than seven enemy systems for every one it loses. As in the Southwest Asia scenario, the Apaches and the MLRS with its complement of advanced munitions proved themselves potent additions.

Conclusions

The analysis leads to some important and, in some cases, surprising conclusions. Attack aircraft acting alone do not stop advancing armored columns. Given their widely publicized success in the Gulf War and, more recently, in Afghanistan, how can that be? The answer is relatively straightforward: the enemy adapts. The history of war is replete with examples of adaptations to offset an enemy strength. Knowing that long armored columns in open terrain invite disaster, any foe the United States is likely to face will avoid them. They will maneuver when in open terrain, seek cover when they can, and dash across open areas to minimize their exposure. As the models employed in this research show, such tactics can minimize the effect of attack aircraft.

Equally interesting is the fact that attack helicopters are very effective. The reason is that the tactics used to avoid high-speed attack aircraft do not work as well against attack helicopters. Zigzagging is effective against weapons that depend on a long time of flight, but Apache attack helicopters have much shorter times of flight and their weapons, once fired, lock on the target. Nor is dashing across open areas much more effective against Apaches. Helicopters, of course, are vulnerable to low-altitude air defenses.

The analysis also shows that the Army's new IBCT can mount a formidable defense. Operating in complex terrain, it can deal handily with enemy armored formations, especially if it has time to take up positions in hilly, wooded terrain. It can also do well on open ground. A drawback is that it takes a substantial amount of airlift to deploy the brigade from the United States. Positioning units forward in Europe and Asia helps them get to the fight significantly faster.

The analysis showed that when key terrain has to be held or when stopping the enemy short of key objectives is critical, Army forces are an indispensable part of the joint force mix.

Perhaps the main conclusion of the research is a familiar one: joint operations work best. They do so because they foreclose the enemy's options. If he tries to minimize his vulnerability to air attack by dispersing or hiding, he increases his vulnerability to ground forces. The tactics that work against air power, e.g., zigzagging, offer no particular advantage when dealing with a ground force. Effective air defenses do not threaten ground forces, and, indeed, ground forces can be instrumental in neutralizing the air defense threat to friendly aircraft. Confronting an enemy with a joint force multiplies the number of problems that he has to solve, and unless he too is capable of a joint response, he is unlikely to solve them all. The analysis showed that when key terrain has to be held or when stopping the enemy short of key objectives is critical, Army forces are an indispensable part of the joint force mix. ★

Task Force Hawk: The Importance of Being Joint

By many key measures, Operation Allied Force was a major success for the NATO alliance. It forced the Yugoslavs to end the violence against the Kosovars, withdraw their forces from Kosovo, accept an international military presence in the province, and permit the unconditional return of hundreds of thousands of refugees. Arguably, it compromised Slobodan Milosevic's ability to hold power and ultimately resulted in his ouster.

Yet the conflict also prompted a number of controversies. While many of them were at the level of strategic political-military policy, some involved the use of U.S. forces. Task Force Hawk, the Army element sent to Albania to provide a deep-strike element using Apache helicopters, was the most visible case of the various problems encountered. This article first briefly reviews the background of the decision to deploy TF Hawk and examines the deployment itself. It then looks at the operations undertaken by the task force and some of the joint difficulties encountered. Last, it makes some observations about joint force planning and force integration.[4]

Task Force Hawk: Origins and Concept

NATO planning for an air campaign against Yugoslavia started in the summer of 1998. A primary influence shaping the planning was the fact that none of the NATO countries had overriding interests in the outcome. True, conflict in the Balkans could spin out of control and create important problems for European nations, but national survival was not at stake. The absence of a vital interest fostered a cautious and incremental approach intended to minimize casualties and any other event that might make it difficult to walk away from the conflict. This desire underpinned the decision to use only aircraft and to impose restrictive operational guidelines.

The Commander-in-Chief, Europe, General Wesley Clark, regarded Yugoslav ground forces as a "center of gravity" for Yugoslav president Milosevic, who could ill afford to see them seriously damaged.[5] General Clark's view was that destroying these forces would help persuade the Yugoslav leaders to end the conflict. From early on, all recognized that it would be hard to locate and hit Yugoslav ground forces inside Kosovo from the air. Yugoslav Army (abbreviated VJ) units were employed in small (company and small battalion-sized) combined arms "battle groups" to spread forces throughout the province and to facilitate their ability to support police forces (abbreviated MUP) that might encounter resistance. Combined with the hilly, forested terrain, these tactics produced a dispersed, nearly invisible enemy force with months of experience in small-unit, combined-arms operations.

In searching for ways to hit Yugoslav forces in Kosovo, General Clark determined that a task force built around Apache helicopters would provide one way to do it. Army planners in Europe first learned that he was considering the

[4] The observations offered in this article are dealt with in more depth in a forthcoming RAND Arroyo Center report entitled *Disjointed War: Military Operations in Kosovo, 1999.*

[5] General Wesley K. Clark, *Waging Modern War*, New York: Public Affairs, 2001, pp. 241–242.

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use of attack helicopters in Kosovo on March 20, 1999, four days before the NATO air attacks began. Initial guidance directed the staff of the Army's Germany-based V Corps to plan for a force of roughly 1,700 to deploy to Macedonia, from where it would launch deep-attack helicopter operations against VJ and MUP forces inside Kosovo.

The CINC's request for TF Hawk sparked an immediate controversy in Washington. Where Clark saw benefits, the Joint Staff saw risks. The formal request for an attack helicopter task force came to the Joint Chiefs on March 26 and met with objections from the Joint Staff and the services. Issues such as possible VJ attacks against the Albanian base, the effectiveness of low-altitude air defenses inside Kosovo, and the dispersed nature of the targets in Kosovo were cited as obstacles to the use of attack helicopters.[6] Faced with sharp disagreements from generals on either side of the Atlantic, President Bill Clinton decided on April 3 to deploy, but not yet *employ*, TF Hawk.

Task Force Hawk Deployment

One of the most controversial aspects of TF Hawk was the time required to deploy it. Initially planned as a force of 1,700 operating out of Macedonia, it shifted to one of 5,100 located in Albania. The risk in Albania was deemed greater than in Macedonia, and more self-defense capability was added: tanks, Bradley fighting vehicles, and a Patriot battery. The increased size affected the deployment time. But an even greater influence was the Rinas airstrip in Albania and the priority given to the humanitarian relief mission based there. Due to the restricted size of Rinas airport, the ongoing humanitarian flights that were landing, and the limited means to offload equipment, the deployment was limited to roughly 20 C-17s per day. Deploying TF Hawk was never General Clark's top priority.

Deployment took 30 days. Initial elements left Ramstein Air Force Base, Germany, on April 8, and the task force was declared fully ready on May 7. TF Hawk's helicopters left Germany on April 14, and by April 18 all arrived in Pisa, Italy, where they waited several days while concrete landing pads were constructed at Rinas. The limited ramp space at Rinas (required by the cargo aircraft) and the torrential rains that had turned the area around the airfield into a virtual sea of mud dictated the need for landing pads. On April 21 the first 11 Apaches and 20 support helicopters arrived at Rinas. By April 26 the last of the 24 Apaches had arrived. Lieutenant General John W. Hendrix, the TF Hawk commander, declared initial operational capability that day, by which time the Apaches had conducted several exercises to prepare for the mission. On May 7, TF Hawk was declared fully ready for deep operations and was placed under the operational control of Joint Task Force Noble Anvil, led by Admiral James Ellis, who commanded forces in NATO's southern region.

How does this deployment time compare to the expectations of key U.S. and NATO commanders? Despite the public perception that TF Hawk was slow to deploy, the unit met the goals set for it. The National Security Council set a goal of mission capability in the April 23–24 period, in part due to the upcoming NATO 50th Anniversary conference in Washington. General Clark had set April 23 as the target date for an initial operational capability. On that date, 11 mission-ready Apaches were at Rinas, and several readiness exercises had been conducted. In fact, the deployment of TF Hawk had gone well from the viewpoint of the Air Force and the Army.

But that was not the public's perception. This was shaped by a press statement by the Department of Defense on April 4 by Mr. Kenneth Bacon, the Assistant Secretary of Defense, Public Affairs. Responding to a question from the press, Bacon said, "You're probably talking, when you consider the transportation challenges, probably talking about a week or so, maybe seven to ten days, I would guess." A formal Department of Defense press release that same day stated that it "will take up to ten days to deploy the units."[7] This statement implied closure on April 14, well before General Clark's or the

[6] The many concerns raised by the Joint Chiefs are detailed in a press account by Dana Priest, "Risks and Restraint: Why the Apaches Never Flew in Kosovo," *The Washington Post*, December 29, 1999, p. A1.

[7] DoD Defense Link, DoD News Briefing, April 4, 1999, and "U.S. Attack Helicopters and Multiple Launch Rocket Systems to Deploy in Support of Operation Allied Force," DoD Press Release No. 145-99, April 4, 1999; DoD News Briefing, April 4, 1999, Mr. Kenneth H. Bacon, Assistant Secretary of Defense for Public Affairs.

NSC's target dates.[8] This established in the minds of the media and the interested parties a false expectation of the deployment time.

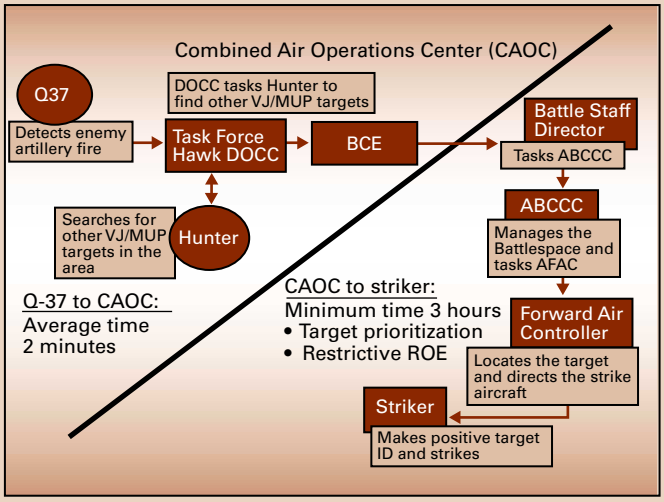
Task Force Hawk Operations

As with the deployment, TF Hawk faced a variety of operational challenges once in Kosovo. The plan called for TF Hawk's attack helicopters to strike VJ and MUP units operating in central and western Kosovo. The targets were dispersed, platoon-sized MUP and VJ elements. Targets were developed by various means, including joint reconnaissance systems, Army counterfire radars that were observing VJ artillery and mortar units firing against the Kosovo Liberation Army (KLA) in western Kosovo, and unmanned aerial vehicles that flew from Macedonia.

All missions were planned as night attacks by groups of four to six Apaches, supported by fixed-wing aircraft strikes and rescue helicopters on standby. Extensive deception missions and suppressive fires against known and suspected VJ air defense sites were prepared. The main Army means to provide lethal suppressive fires came from the rocket and cannon artillery units in Albania.

Planning and control of the helicopter strikes centered on V Corps Deep Operations Coordination Center (DOCC), which had deployed to Albania. It worked in the following way. The DOCC developed targets for attack helicopter strikes and passed them to the Combined Air Operations Center (CAOC) at Vicenza, Italy. TF Hawk's key interface at the CAOC was the Battlefield Coordination Element (BCE), a small Army detachment whose role was to coordinate the details of proposed helicopter missions. As plans were developed to strike VJ and MUP forces, the BCE communicated those plans to the CAOC to coordinate airspace, negotiate fixed-wing air support, and work out critical timing issues. Every day TF Hawk submitted mission proposals, in the hope that authorization to conduct operations would come. While the task force was preparing for strike operations, it was also developing VJ and MUP targets that were passed to the CAOC for possible strike by fixed-wing aircraft. However, due to the lack of joint procedures for passing data on emerging targets and responding to that information, most targets either were not attacked or were struck hours later. Restrictive rules of engagement were a major contributing factor as well, limiting the effectiveness of sensor-to-shooter links. The requirement for "eyes on target" to minimize risks to civilians frequently negated the utility of rapid targeting data such as that provided by Hawk's Q-37 firefinder radars. Figure 4 illustrates the limitations of the joint targeting process.

Figure 4: Joint Targeting Process



NOTE: "Hunter" refers to the Army's Unmanned Aerial Vehicle, "ABCCC" to the Airborne Battlefield Command and Control Center.

Authorization to employ the force directly never came. Among the most salient reasons were the following:

- The risks outweighed the rewards. Targets in western Kosovo consisted of small, dispersed enemy units, usually hidden under the trees and in villages. Low-flying helicopters would have been exposed to small arms fire, anti-aircraft guns, and shoulder-fired missiles. The fact that the Apaches would have been limited to several

[8] Arroyo Center research never identified the source of the 7–10 day figure. General Clark himself reports in his memoirs that "We had a number of Apache crews and controllers based in Germany, and we estimated that once we were given the go-ahead it might take a week or ten days to get them into the theater of operations." Clark, *Waging Modern War*, p. 198. But this statement refers to his estimate when the task force was still slated for Macedonia and to consist of about 1,700 troops. Possibly the Pentagon Office of Public Affairs used this initial estimate, despite the substantial change in conditions and associated timelines with the later shift to Albania.

mountain passes leading from Albania into Kosovo heightened the risk. They could not fly over the mountains fully loaded. Therefore, the VJ could concentrate its defenses on a few key ingress and egress routes.

- Decisionmakers believed NATO fighters were having some effect on the enemy ground forces from safer medium-altitude operations. Although postconflict analysis shows that the VJ and MUP suffered minimal losses from NATO air attack, at the time it was thought that NATO was having a greater effect on the enemy than was actually the case. Fighter operations at medium altitude were seen as much less risky than Apaches attempting to penetrate into Kosovo at low altitude. Indeed, the VJ shot down only two NATO fighters during the entire 78-day air operation.
- The rules of engagement sharply limited lethal suppressive fires. There was great concern for the safety of the refugees who were forced from their homes by VJ and MUP "ethnic cleansing." NATO pilots were required to see their targets before releasing ordnance to ensure that no civilians were in the target area. Every time civilian casualties did occur, the rules tightened further. Extensive lethal suppressive fires would have been required to support the helicopter attacks, since VJ low-altitude air defense weapons (e.g., AA guns and shoulder-fired missiles) did not need emitting radars to engage targets and were therefore very hard to locate.
- Washington's support for Apache operations seems to have eroded as a result of the crash of two Apaches in Albania during training missions. Both crewmembers died in the second accident.

Despite the fact that TF Hawk's Apaches were not employed in Kosovo, the unit contributed to the overall success of Operation Allied Force. The leadership in Belgrade probably viewed TF Hawk and the NATO ground forces in Macedonia as the nucleus of an eventual NATO ground attack into Kosovo.[9] Additionally, the presence of TF Hawk also likely reassured the government of Albania that NATO was committed to its defense during a period of extreme crisis when tens of thousands of refugees were flooding into that nation from Kosovo. Task Force Hawk's target location and reconnaissance systems also helped locate VJ and MUP forces in Kosovo.

Despite the fact that TF Hawk's Apaches were not employed in Kosovo, the unit contributed to the overall success of Operation Allied Force.

The Value of Jointness

Operation Allied Force provides many lessons for future joint operations. This alliance operation had strictly limited objectives and significant political constraints. Future joint operations will very likely present similar challenges for U.S. forces; as General Clark has said, these are likely to be enduring characteristics of "modern war." Consequently, it is possible that a future operation will be "air-only"—even where air-land synergies would be clearly preferable to single-dimension operations. A better joint approach is needed to respond to similar types of contingencies, even if a ground element is not present. Below are some of the more important insights gained from this research.

Operation Allied Force was a major success: NATO won the conflict using air power alone and did so with no combat fatalities. Still, better joint procedures would have assisted the operation. No land component commander was ever designated. This precluded ground force planning in the event that a ground offensive was required. It also complicated the process of establishing clean lines of command for the Joint Task Force commander.

Similarly, joint procedures for target coordination evolved slowly. They need to be worked out in advance. There

[9] General Clark states that Task Force Hawk "conveyed a powerful image of a ground threat, and would have been its lead component." Clark, *Waging Modern War*, p. 425. Other RAND research argues that the threat of a ground invasion was one of several contributors to Milosevic's eventual willingness to settle with NATO. It cites Yugoslav precautionary measures such as strengthening defensive positions along possible invasion routes and the positioning of some 80,000 mines along the Kosovo border with Albania as evidence of Milosevic's concern. See Stephen Hosmer, *Why Milosevic Decided to Settle When He Did*, Santa Monica, CA: RAND, MR-1351-AF, 2001, pp. 109–114.

It became clear that there was a general lack of understanding about how to employ attack helicopters in conjunction with what was primarily an air operation.

was a general lack of familiarity among the components about how to integrate and coordinate target requests. The Army BCE located at the CAOC did not normally work with corps-level Army headquarters, and the Air Force and Navy personnel in the CAOC were unfamiliar with Army procedures. Additionally, land component intelligence personnel tend to be experts in enemy land force tactics. This kind of expertise would benefit those responsible for conducting air operations targeting enemy ground forces.

There is also a need for better joint procedures to integrate Army attack helicopters with an air operation. It became clear that there was a general lack of understanding about how to employ attack helicopters in conjunction with what was primarily an air operation. Army attack helicopters and missiles could again participate in an "air-only" campaign or the initial phase of a joint campaign before the employment of ground forces. Therefore, better joint procedures should be developed to facilitate their early integration.

As part of this effort to improve joint synergies, the Army needs to expand the range of available ground force options. The U.S. Army of 1999 had essentially two types of ground units available for operations in Kosovo. Light forces, exemplified by light and airborne divisions, would have been easier to deploy to Albania than heavy mechanized units. However, given the limited firepower, ground mobility, and protection of these units, casualty-averse decisionmakers would probably have been loath to employ them even had they been willing to conduct a ground operation into Kosovo. On the other hand, the Army's heavy forces armed with M-1 Abrams main battle tanks and Bradley infantry fighting vehicles would have been severely constrained in the terrain of Albania and Kosovo. Indeed, Army engineers in Albania who surveyed the routes that heavy units could have taken from Albanian ports to the Kosovo border concluded that weeks of engineering work would have been required to shore up bridges, repair roads, and make other improvements necessary for a "heavy" force to operate. The Army's current plan to introduce "medium" units into its force structure, as represented by the Interim Brigade Combat Teams and later the Objective Force, is an appropriate move given the experience in this operation.

Allied Force demonstrated the strategic deficiencies of not taking a joint air-land approach to military operations. The political impediments to such an approach were real enough, but so too were the consequences of a lesser strategy. Key combat synergies derived from joint air-ground operations and the compelling force they can exert on adversaries were not realized in this conflict. Joint air-land operations derive much of their effectiveness from the fact that they foreclose an opponent's options. Dispersing forces to keep them from becoming a lucrative target for air strikes leaves an opponent more vulnerable to piecemeal defeat on the ground. Concentrating combat units to increase their effectiveness in ground operations increases their vulnerability to air attack. NATO's early decision for an air-only operation, which mirrored U.S. statements and sentiment, essentially ceded the initiative to Milosevic.

While U.S. and NATO forces can be justifiably proud of the ultimate success of Allied Force, this should not obscure the problems encountered. Allied Force was a combined air campaign that never had the benefit of a truly "joint" command. Establishing such a command from the outset would have helped the overall effort. Ground intelligence analysts would have brought their special expertise to the identification of targets in Kosovo, possibly improving the effectiveness of the air campaign against Yugoslav-fielded forces. Above all, a fully joint headquarters would have been better able to integrate TF Hawk, not to mention more ambitious ground operations had they been called for, into Allied Force. In many respects, therefore, TF Hawk exemplifies the larger joint challenges that still lie ahead when operating in complex political-military contingencies. ✯

Measuring the Effect of Information

The 1990s have witnessed the dawn of what future historians will doubtless label the Information Age. Clearly the ability to acquire, retrieve, manipulate, and share information has had and will continue to have a profound effect on a host of human activities. Warfare is no exception.

Though it is clear that information will have far-reaching effects on military operations, how to measure that effect is far from well understood. Most models and simulations focus on firepower, not information. But understanding how information influences combat is important to the Army, particularly when it is spending a considerable amount of its scarce investment capital on establishing Information-Age links across its forces (the so-called digitization of the Army). The Army needs Information-Age analytic tools to help it make the best choices possible.

Chief among the analytic tools required are good measures of effectiveness (MOEs) that can demonstrate the value of information to military outcomes. The current set of measures, such as force loss-exchange ratios, will continue to be useful, but they do not give much visibility to the growing contributions of information. Moreover, they are often calculated with simplistic head-to-head attrition models that ignore important processes in which information plays a big role.

Recently published RAND Arroyo Center research takes a step toward addressing this issue. In a proof-of-principle demonstration, researchers developed a limited set of Information-Age MOEs.[10] The hope is that this demonstration will spark development of many more such measures, which will be needed to quantify the value of information in military operations, including combat. *Joint Vision 2010*, a document published by the Joint Staff that lays out its vision of future combat, posits a series of new concepts for the future battlefield: dominant maneuver, precision engagement, full-dimensional protection, and focused logistics. Although these concepts also reflect current operations, *Joint Vision 2010* contends that in the Information Age they become much more powerful—so much so that they, in effect, become new concepts. We draw on these concepts to frame our exploration of the value of information or, more specifically, the information superiority that the Army says, in *Army Vision 2010*, it seeks to achieve. The Arroyo Center work characterizes information as "knowledge." Knowledge differs from information in that it takes into account two key attributes of information, quality and value. That is, information becomes knowledge if and only if it is relevant and useful.

Information has always been an integral part of military operations, and commanders have devoted considerable resources to improving intelligence, reconnaissance, and surveillance techniques in a quest for more and better information. The assumption is that the more the commander knows about the situation on the battlefield—and particularly

Knowledge differs from information in that it takes into account two key attributes of information, quality and value. That is, information becomes knowledge if and only if it is relevant and useful.

[10] Richard Darilek et al., *Measures of Effectiveness for the Information-Age Army*, Santa Monica, CA: RAND, MR-1155-A, 2001.

The assumption is that the more the commander knows about the situation on the battlefield—and particularly what he knows about enemy forces—the better he is able to employ his forces and thus win.

what he knows about enemy forces—the better he is able to employ his forces and thus win. History is replete with examples in which the commander with better knowledge was able to prevail, often against superior forces. More recently, Arroyo Center research found a high correlation between good reconnaissance operations and successful battle outcomes at the National Training Center.[11] The reverse is also true: poor reconnaissance operations lead to unsuccessful outcomes.

Developing the Metrics

In finding ways to demonstrate the value of information, researchers faced two challenges. The first was to demonstrate that information could be modeled mathematically. If it could, the second challenge was to show that the value of information could be reflected in analytical tools.

To meet the first challenge, researchers constructed a probability model of knowledge by employing a relatively uncomplicated equation, borrowed from information theory, that calculates a ratio of knowledge between two opposing forces. Both commanders employ their sensors and intelligence assets to collect information on the opposing force. The resulting reduction in uncertainty is then mathematically related to the increase in knowledge. A ratio is calculated that reflects the relative knowledge of the two sides. From this, it is possible to determine if Red knows more than Blue, less than Blue, or the same. Depending on the outcome, Blue or Red has information superiority, or neither side has an information advantage. If the ratio is sufficiently great in the favor of one side, then that side moves from information superiority to information dominance, a goal of *Joint Vision 2010*.

[11] Martin Goldsmith and James Hodges, *Applying the National Training Center Experience: Tactical Reconnaissance*, Santa Monica, CA: RAND, N-2628-A, 1987.

Information superiority is more than a matter of the numerical ratio. For example, if Blue's knowledge has a value of 0.01 (that is, Blue knows only 1 percent of the enemy force disposition) and Red's a value of 0.005, the formula yields a ratio of 2. But the relative difference of the two sides is qualitatively different than if the respective figures are 0.8 and 0.4, which also yield a ratio of 2. Furthermore, the two sides may have relative differences in information needs, with Blue needing a lot of information and Red not needing much (think of what the Viet Cong needed to know compared with U.S. forces). This problem was addressed by establishing mathematical thresholds.

With this model serving as the theoretical basis, researchers then confronted the second challenge: determining whether the value of information can be reflected in analytic tools. They employed the traditional analytic techniques of game theory and Lanchester equations to assess the value of information superiority, including the possibility of information dominance, i.e., information superiority so complete that it even affects what an opponent knows. If it is possible to reflect the value of information to outcomes in these traditional tools, it should also be possible to reflect it in the various suites of models used in Army analysis.

Game Theory

Game theory has been used widely to analyze the effects of selecting alternative strategies to achieve a military objective. In two-sided, zero-sum games (i.e., a win for one side is a loss for the other), both sides have several strategies they can pursue, and, although each knows the strategies the other can select, neither knows which one the opponent will choose. The effect of knowing what strategy an opponent will select makes game theory an excellent place to begin analyzing the effect of information on outcomes.

The researchers ran a series of two-sided games in which they varied the amount of information and the number of strategies available. For example, in one game each side had equal information and five possible strategies. In another, one side had vastly superior information, including which strategy the other side would choose.

The results of the game theory analysis showed that information makes an overwhelming contribution to the military outcome when one side achieves information dominance, defined as follows: one side (and not the other) knows the values of the strategic choices available to both sides, and that side also knows which strategy the other will choose.

Lanchester Equations

The Lanchester laws also provide another insightful way of gauging the contribution of information. While these equations are little used in modern military analysis, they make a good test case to determine whether the effect of information on combat outcomes can be modeled. A Lanchester equation assumes that everything that affects the combat outcome—force ratios, weapons effectiveness, intelligence, etc.—is embodied in the loss rate coefficient. If researchers can, in effect, extract the information component from the coefficient and demonstrate an effect on outcome, then it can be modeled in other simulations. When a strong information component is added to either a square or a linear law, it results in what the researchers call a "mixed" law. Increasing or decreasing the increments of information available to one side or the other, they found, has a powerful effect on the way outcomes of a military engagement are calculated in terms of Lanchester's historical equations. The calculation of combat outcomes revealed the following: a positive effect for the side acquiring additional information; a negative effect for the side lacking or losing information; and formulas for expressing force ratios that change, during the course of the same engagement, from either square or linear formulations in the beginning to some form of Lanchester mixed laws at the end.

These Lanchester-law discussions are, of course, simplifications. More serious combat modeling must resort to simulations. But analogous effects should be visible in combat simulations if they properly reflect information asymmetries well enough to bring out the kinds of effects identified in the research. Put another way, the work would suggest that simulations should be tested to assure that they have reflected information asymmetries well enough to bring out the kinds of effects described in the Arroyo Center's published work.

Measures of Effectiveness for Combat Operations

Using the insights drawn from the gaming theory and Lanchester equations and the probability model of knowledge, researchers developed various analytic relationships that support particular concepts of operations that incorporate information metrics. Specifically, they developed a new knowledge-based MOE—battlespace control—for the concept of dominant maneuver. They also explored the feasibility of developing new MOEs for stability operations.

Of the four new concepts advanced by *Joint Vision 2010*, researchers focused on two: dominant maneuver and full-dimensional protection. For each they developed MOEs and associated metrics and portrayed the effects of information mathematically. For these two concepts, Table 2 shows the following:

- The MOEs,
- The metrics used to calculate these MOEs traditionally, where they already exist, and
- The new Information-Age metrics derived in the research, for the most part by developing a way to calculate the knowledge factor discussed above and including it in every case as a metric.

The mathematical demonstrations show that as the ratio of relative knowledge changes, i.e., what one force knows relative to what the other force knows, outcomes swing in favor of the side with greater relative knowledge. For example, if one

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Table 2: Measuring Dominant Maneuver and Full-Dimensional Protection

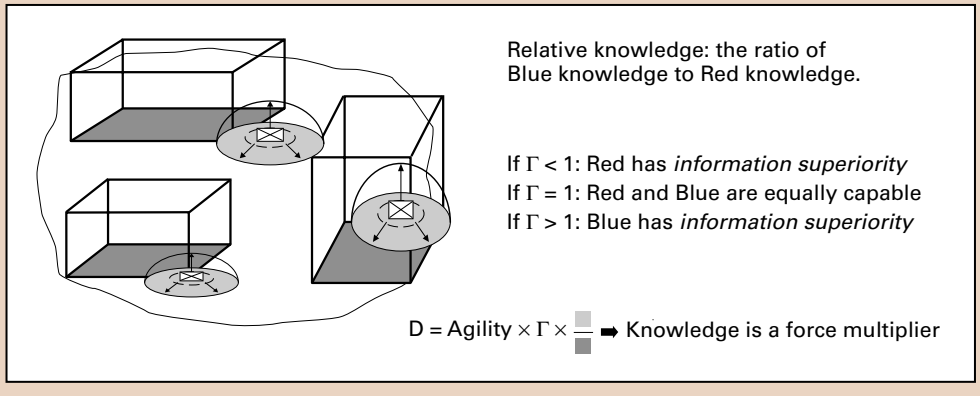
Concept	MOE	Traditional metric	Information metric
Dominant maneuver	Deployment	Items moved per unit time	Knowledge of enemy attempts to block routes
	Operational reach	Kilometers per unit time	Knowledge of enemy resistance along routes of advance
	Battlespace control		Size of unit control radius and speed of unit plus relative knowledge
	Forward line of troops (FLOT) movement	Kilometers	Knowledge of combat capability
Full-dimensional protection	Protection from direct and indirect fires	Hardness, deception, and mobility	Knowledge-enhanced hardness, deception, and mobility
	Casualties	Number of losses	Number of losses

side's commander is deploying forces to engage an opponent and discovers that the opponent has blocked certain avenues of approach, those routes can be avoided, thus speeding the arrival of his forces and increasing the amount of operational reach available to him.

Battlespace Control MOE

Battlespace control, which is listed in Table 2 as an MOE for the concept of dominant maneuver, represents a nontraditional measure made possible, in part, by the knowledge component of its Information-Age metrics. Figure 5 shows the type of situation used in the demonstration. It depicts three units and three portions of the area of operations. The bubble around the unit represents the geometric space it can control as a product of its organic weapons and sensors. But the unit can control more battlespace than that represented by its own "bubble." With knowledge about the enemy and agility, the unit can control a much larger area. The amount of battlespace it can control is the product of its relative knowledge, its own geometry (i.e., what it can control with its own sensors and weapons), and an agility factor that expresses the unit's speed. As shown by the equation at the bottom of the figure, if Blue has information superiority, knowledge multiplies the effectiveness of the force, in this case enabling it to control more battlespace.

Figure 5: The Effect of Knowledge



Measures of Effectiveness for Stability Operations

Of course, the Army does not engage only in combat operations. Thus, the question arises whether Information-Age metrics also apply to stability operations. Researchers explored this issue as well. To do so, they sorted among the 16 types of stability operations listed in current joint doctrine and chose humanitarian assistance as the exemplar for which to develop trial MOEs. They selected this type because the Army has a fair amount of recent experience in such operations, because they typically involve a mix of political and military means, and because they routinely cause the Army to work with many types of actors, e.g., international organizations such as the United Nations High Commission for Refugees and nongovern-

The theory is that the better the forces understand the local environment, the less likely they are to make errors that alienate the population and the more likely the mission is to succeed.

mental organizations such as the Red Cross.

As they did for the combat MOEs, researchers drew on the *Joint Vision 2010* concepts as a framework for developing stability operation MOEs, settling on dominant maneuver as the concept and understanding local environments as the measure. Developing metrics for this MOE (and others like it) is inherently difficult because they are attempting to apply quantitative metrics to qualitative measures. The process becomes even more difficult in addressing humanitarian assistance, since few of the traditional warfighting metrics apply. The metric developed consists of the contribution of knowledge, as defined earlier, to the degree of understanding of the local environment.

The approach is to break the "local environment" down into a number of constituent components (e.g., local government, history, terrain), ascertain where knowledge is deficient, and then identify how knowledge can contribute to stability. The theory is that the better the forces understand the local environment, the less likely they are to make errors that alienate the population and the more likely the mission is to succeed.

Concluding Observations

RAND Arroyo Center work on the MOEs and associated metrics suggests strongly that information—and information superiority—can have a large effect on the outcomes of military operations. The degree of information superiority that one side might be able to achieve over the other is what most needs to be measured in the Information Age. This work is only a first step. However, it shows that developing Information-Age knowledge-based MOEs is feasible, not only for combat operations but for stability operations as well. ★

Defending the Homeland

Following the collapse of the Soviet Union, it became clear that the defense of the United States had assumed a very different character. No longer was the prime concern a nuclear strike from a global opponent, although the specter of such an attack had not entirely vanished. Rather, the threat became much broader and more ambiguous, the foe comprising sub- and transnational groups spurred by different motivations and employing a wider range of means, as demonstrated by the horrific events of September 11. Added to this menace was the long-standing but increasingly sophisticated threat posed by international drug cartels. While the Army has a clear and central role in repelling any invasion, the scope and nature of its responsibilities in other areas is less well defined; many state and federal organizations also have homeland security responsibilities—sometimes overlapping ones. Teasing out which missions require a specific commitment of Army forces is important but challenging. At the request of the Army's Deputy Chief of Staff for Operations, the Arroyo Center addressed the Army's requirements for ensuring the security of the homeland.

How We Went About the Research

Arroyo Center researchers began with the Army's categorization of homeland security into seven mission areas. Table 3 depicts these areas and what each mission generally entails. Researchers then used the Army's experiences in supporting civil authorities in natural disasters and civil disturbances to assess future Army capabilities to plug gaps in civilian responses to potential attacks using conventional, chemical, biological, and radiological weapons. They also examined how the Army prepares to protect the infrastructure and information operations it owns and uses as well as to contribute to counterdrug, missile defense, counterterrorism, and refugee-control activities. Although this work was completed before the September 11 attacks, it provides a conceptual framework for thinking about the Army's future contributions and requirements for homeland security.

Assessment of Mission Areas

Ensuring Sovereignty and Protecting Borders

Every day, federal, state, and local organizations across the country defend U.S. sovereignty and borders. The Army plays a key role in day-to-day counterdrug operations. The Army's counterdrug commitment demanded roughly 280 man-years of effort from active-duty personnel and nearly 3,000 man-years from the National Guard in fiscal year 2000 (FY00). On average per day during FY00, some 3,200 Army personnel from the Active and Reserve Components engaged in counterdrug activities. Trend data developed by the National Guard indicate that demand for Army counterdrug operations has been increasing in recent years, both in the number of missions carried out and in the number of man-years committed.

The Army must also anticipate refugee support operations, although these are sporadic. The scope and duration of these missions are difficult to predict. Based on case studies, we estimate that demand for Army forces could surge to roughly 6,000 personnel to care for 20,000 refugees (i.e., a medium-sized crisis), with significant demands for low-density units (e.g., military police, linguists, civil affairs, and psychological operations). We assume that the personnel numbers and skill sets would roughly scale for larger groups of refugees. And it is

Table 3: Homeland Security Missions

Mission area	Tasks involved
Sovereignty and border control	Control of smuggling, drug traffic, illegal immigration, refugees, territorial incursions, terrorists, theft of resources
Military support to civil authorities	Support for natural disasters, riots, forest fires, special events
CBRNE response	Respond to chemical, biological, radiological, nuclear, and enhanced high-explosive events
Critical infrastructure protection	Protection of U.S. facilities critical to deployment of Army forces
Information operations	Protection of Army communication and information systems and mitigating effects of any attack
Missile defense	Countering limited ballistic missile attacks launched by rogue powers and accidental or unauthorized launches
Combating terrorism	Preventing or resolving terrorist threats or acts

worth noting that, in many respects, the types of units required to support large-scale refugee flows are similar to those deployed in the past for humanitarian operations abroad and civil disturbances at home.

Consequence Management: Support to Civil Authorities and CBRNE Response

Our research suggests that the Army has so far needed relatively few people to support civil authorities in responding to chemical, biological, radiological, nuclear, and explosive (CBRNE) threats. Some 400 personnel provide day-to-day support to civil authorities' response preparations and planning; roughly another 650 are specially trained and standing by to respond to CBRNE incidents.

However, the history of support to civil authority missions indicates that a surge in demand for Army forces to respond to large-scale events could be stressful. For instance, a large-scale natural disaster or CBRNE incident might require up to 23,000 Army responders. About 21,000 active and National Guard soldiers participated in the response to Hurricane Andrew. These personnel would be drawn from a range of Army capabilities, and the demand for low-density specialties—those that employ relatively small numbers of soldiers—could be significant.

The scope of such future contingencies is hard to predict. The size of large-scale natural disasters cannot be foreseen, and the ability of terrorist groups to wreak havoc might be limited only by their resources and imagination. In this uncertain environment, it is difficult to gauge the potential future demand for Army responders. Nevertheless, it is certain that the Army will be directed to respond to future disasters and attacks occurring within U.S. territory. Indeed, among the services, the Army is likely to play the lead role in response operations. And its past missions involving support to civil authorities do point to potential demands for surge capabilities, affecting some 23,000 personnel, for major incidents. Given that many of the same Army capabilities may be called on for future support to civil authorities and CBRNE missions, these historical experiences also inform planning for CBRNE response capabilities.

Critical Infrastructure Protection

The Arroyo Center's analysis of the critical infrastructure protection mission focused on protecting facilities critical to the Army's ability to deploy its forces. The research produced two central findings. First, critical infrastructure protection is best viewed as part of a broader strategy of assuring infrastructure functions. Only a comprehensive, integrated approach will enable the Army to pinpoint which systems and nodes are critical and to reduce their vulnerability to attacks with a minimum of resources. The Army Infrastructure Assurance program is

However, the history of support to civil authority missions indicates that a surge in demand for Army forces to respond to large-scale events could be stressful. For instance, a large-scale natural disaster or CBRNE incident might require up to 23,000 Army responders.

developing such an approach, but it needs to be accepted and implemented by the full Army.

Second, the tasks required to protect critical infrastructure from physical threats—reconnaissance, protection, deterrence, response, and reconstitution—call upon capabilities now present in the Army force structure. We took a building-block approach to get a first approximation of the forces needed to protect small and large facilities. The former requires about 200 people and the latter about 2,600. Unknown is how many sites will have to be protected. About 23,500 soldiers would be required to protect 20 large facilities. The number requiring protection depends on assumptions about the threat, the Army's success in reducing its dependence on critical nodes, the vulnerability of those nodes, and the level of risk it is willing to accept.

Information Operations

The Army must assume that state and subnational adversaries will target its critical information systems. RAND Arroyo Center analysis of past attacks has demonstrated that information attacks follow a conventional risk-consequence curve: limited attacks and damage occur regularly, while highly destructive attacks occur infrequently if at all. Therefore, the Army's risk-mitigation strategy should mirror that curve. It should take normal precautions to defend important but not necessarily critical systems (e.g., firewalls, passwords, virus protection, etc.). For critical systems, the Army should scale its resources to defend against and respond to a serious but limited attack on a critical system. An important first step would be to identify critical systems Armywide. Other steps include developing contingency plans and establishing contacts with civil authorities who control systems important to Army operations. In addition, the Army should work to ensure that the likelihood of catastrophic attacks on its systems remains low by continually improving its processes to safeguard critical information.

The Army's steady-state force commitment to information operations is currently modest. The Army's warfighting and administrative organizations employ some 626 network security managers (i.e., 341 uniformed personnel, 161 contractors, and another 124 personnel who are "borrowed" from Army and civilian organizations). In addition, a staff of 22 uniformed personnel and 123 civilian/contractor personnel conduct the Land Information Warfare Activity's day-to-day information assurance operations. We estimate a steady-state requirement of 400 military personnel, with another 100 needed for surge operations.

The Army will almost certainly play a leading, and perhaps the lead, role in defending U.S. territory against missile attacks.

Although the Arroyo Center has made a number of recommendations aimed at reinforcing the Army's ability to detect, defeat, or recover from information attacks, these capability enhancements will most likely generate only a small demand for additional uniformed personnel. These enhancements principally require (1) new hardware and security software, (2) training for systems administrators, (3) staff to develop contingency plans and agreements, and (4) staff for increased vulnerability inspections, training sessions, and information-operations response teams. However, the Army must identify its critical systems as well as the critical public-sector systems on which it depends.

Missile Defense

The U.S. National Command Authority assesses the missile threat to the U.S. homeland as real and growing. The emerging threat from long-range ballistic missiles has been recognized for some time. However, there is now an increasing realization that cruise missiles and shorter-range ballistic missiles could also be used to strike U.S. territory.

The Army will almost certainly play a leading, and perhaps *the* lead, role in defending U.S. territory against missile attacks. A likely initial deployment of ground-based national missile defense systems will require some 400 uniformed personnel, and most will be drawn from the National Guard. Although this initial demand for Army forces will be limited, the Army should anticipate potential additional demands. Personnel may be required to mount a land and air defense of the initial ballistic missile defense system. The Army may also play a major role in any future cruise missile defense for U.S. territory.

Combating Terrorism

Within the Department of Defense (DoD), the Assistant Secretary of Defense for Special Operations and Low-Intensity Conflict is responsible for military forces used to deter, prevent, or terminate terrorist acts within U.S. territory. The Defense Department's sensitive counterterrorism programs are addressed in National Security Decision Directives, National Security Directives, contingency plans, and other classified documents. Classification prohibits any detailed discussion of the Army's existing, day-to-day personnel requirements for combatting terrorism.

During a national emergency that might arise from a terrorist threat or incident, demands for Army forces might increase dramatically. The Posse Comitatus Act and other statutes restricting the use of DoD personnel in a law enforcement role have exceptions with respect to combating terrorism. As such, Army personnel in large numbers might, for instance, be called upon to assist law enforcement in providing area security during any search for suspected terrorists, to track down and secure terrorists' CBRNE devices, or to defend federal property against imminent threats.

Overall Conclusions

Table 4 summarizes the current size of the Army's commitment to the homeland defense missions and also offers an estimate of the possible surge requirements.

We completed the bulk of this analysis before September 11. However, we believe the methodology employed is valid. What does require reconsideration is the set of fundamental assumptions about the Army's roles and missions in homeland security. The September 11 events showed that terrorists can mount nearly simultaneous attacks. While it is unclear whether Al Qaeda or some other group can also launch simultaneous attacks using nuclear, chemical, biological, or radiological weapons, it is evident that they could manage simultaneous high-explosive attacks using truck or car bombs.

The Army could plausibly acquire larger roles in some of the mission areas listed above. For example, at present the Army's responsibilities in critical infrastructure and information operations are restricted to protecting its own capabilities. Conceivably, the Army could be called on to protect civilian assets just as it has been asked to help protect airports. Its role with the FBI in defeating terrorism could also expand, for example, to protecting federal buildings or providing security in searches for terrorists. Beyond these areas, a substantial increase in preparing for CBRNE events appears likely, both for steady-state and surge commitments. An additional requirement now under discussion is border security.

As the Army redefines its homeland security requirements, it would do well to keep in mind that civilian authorities tend to use military forces to make up for shortages in civilian capabilities. Ideally, civilian governments and private organizations can meet the demand. However, disasters on the scale of that experienced by New York would overwhelm all but the largest cities. History shows that frequently only the Army has adequate surge capacity to respond quickly to large-scale disasters. If the nation experiences a general increase in the level of terrorism, political authorities will have to decide whether to use more Army forces for security or to turn to the civilian sector.

In the past, the Army has met the demand for homeland security requirements with forces designed for conflicts abroad. September 11 has made that approach

Table 4: Homeland Security Missions (as of July 2001)

Mission area	Steady-state requirement	Surge requirement
Sovereignty and border security	~3,200	~2,500–6,000
Military support to civil authorities*	~400	~6,000–23,000
CBRNE response	~650	~4,000–23,000
Critical infrastructure protection	~100	~2,600–23,000
Information operations	~400	~100
Missile defense	~600	~100
Total	5,350	Not applicable

*Does not include National Guard soldiers on state active duty.

History shows that frequently only the Army has adequate surge capacity to respond quickly to large-scale disasters.

obsolete. According to the recently completed Quadrennial Defense Review, "the new construct explicitly calls for the force to be sized for defending the homeland" as well as to deter aggression in critical areas, defeat it in overlapping major conflicts, and conduct smaller-scale contingency operations.[12] Just as it does in planning for a major theater war, the Army will have to determine the type and number of forces that should be available to support this mission. For CBRNE responses, for example, the Army could design a set of capabilities that includes the Technical Escort Unit and Chemical Reconnaissance and Decontamination Teams, Chemical Biological Rapid Response Teams, Biological Integrated Detection System companies, and Explosive Ordnance Disposal Teams. These specialist capabilities could be located in either the Active or the Reserve Components. If placed in the latter, numerous issues such as training, readiness status, basing, and so forth would have to be resolved. Supporting capabilities such as transportation and medical could be based on projected threats.

The size and scope of homeland security requirements will remain a matter of debate. Analysis can inform that debate. Historical operations have more lessons to teach, and these could usefully supplement planning for military support to civil authorities. New organizations will have to be designed for requirements that differ significantly from past operations (e.g., quarantining an urban area). The analysis must take both public and civilian resources into account, because they may offset some of the requirements. More analysis also needs to be done to understand what flexibility current and planned capabilities have for simultaneous warfighting and homeland security commitments. This analysis should include Active, Reserve, and National Guard forces. ★

[12] Department of Defense, *Quadrennial Defense Review Report*, September 30, 2001, pp. 17–20.

Improved Inventory Policy Contributes to Equipment Readiness

When Army equipment fails, the speed with which maintainers can restore it to mission-ready condition hinges on the availability of needed spare parts. As Army inventory managers decide which spare parts to stock in their deployable Supply Support Activities (SSAs), they must balance performance goals against cost and mobility constraints. On the one hand, a massive inventory could potentially fill a large proportion of customer demands; on the other hand, such an inventory would carry vast dollar and mobility costs. To manage the tradeoff, the Army has used an algorithm that tracks customer demands in order to compute which items and how many of each to stock.

Unfortunately, past demand does not predict future need very well because unit activities can vary a lot. Different types or paces of activities generate different demands for parts. As a result, Army maintainers too often found that the parts they needed were not stocked locally, which could mean lengthy delays of days or months as parts were requested from other sources. Long "customer wait times" frequently resulted in longer repair cycle times. They could also increase workloads if maintainers chose to work around a problem by removing needed parts from other pieces of downed equipment. When no workaround was possible, repairs could not be completed until all needed parts had arrived, thus hurting equipment readiness. It became apparent that the algorithm was not well suited to the kinds of demand patterns generated by the variable operational tempo of deployed Army units. Moreover, commercial developments in inventory management suggested that better performance was possible.

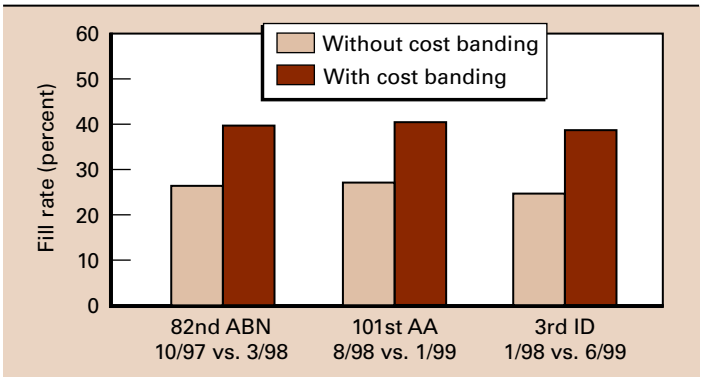
The Army's Deputy Chief of Staff for Logistics asked RAND Arroyo Center to develop a new algorithm for calculating inventory levels in SSAs. Known as dollar cost banding (DCB), the new algorithm has produced immediate and significant gains in performance at little or no additional inventory cost.[13] Improved inventory performance means that customers spend less time waiting for parts. As a result, repairs can be completed more quickly, which translates into higher equipment readiness rates. The Army has moved quickly to approve the use of dollar cost banding as a policy option for setting inventory at retail supply points Armywide. It is currently in use at over 40 percent of SSAs and is being implemented at many more.

Cost Banding Improves Inventory Performance in Two Ways

SSAs that have implemented dollar cost banding have seen immediate improvements in performance. The primary metric for inventory performance is fill rate: When a customer needs a spare part, how frequently does the inventory fill the request? The fill rate at an SSA depends on both the inventory's breadth (Is the needed item stocked?) and its depth (Is the item available or has the supply run out?). Improved local fill rates mean that fewer requests have to be referred to outside supply sources, thus reducing the number of delays. As shown in Figure 6, divisions using cost banding have seen a substantial increase in local fill rates. The aggregate fill rates for SSAs at the 82nd Airborne, 101st Air Assault, and 3rd Infantry divisions have all improved, in some cases by nearly 50 percent.

[13] The algorithm is called dollar cost banding because it takes into account both the cost and criticality of the item rather than simply the number of demands over time. It establishes cost bands, imposing less stringent criteria for cheap items, which results in more items being stocked.

Figure 6: Divisional Fill Rates



How has dollar cost banding brought about improved performance? First, the new algorithm has made it possible to expand the breadth of deployable inventories. Traditionally, Army SSAs used a "one-size-fits-all" approach to determining whether to stock a particular line. An item not currently stocked would need nine requests in the prior year to be added, while an item already stocked would need three demands to be retained. These criteria were applied equally to a 10¢ screw and a $500,000 tank engine, despite the very different levels of investment associated with each item. In contrast, the dollar cost banding algorithm adjusts the criteria for determining whether an item should be added or retained according to the item's criticality, mobility requirements, end item density, and dollar value. It uses a two-year, rather than one-year, demand history. Under cost banding, a small, inexpensive, but mission-critical item might be added to inventory with only two demands and retained with just one. Cost banding has also automated the process for identifying nonessential, bulky items to be removed from deployable inventories.

Second, dollar cost banding allows for greater variation in the depth of stock for those lines that have qualified for inventory. The new approach abandons the Army's traditional but problematic "days-of-supply" algorithm for determining the quantity of each authorized item to stock. The traditional approach assumed that demands occurred uniformly throughout the year and simply divided the annual number of demands for an item by 365 to derive an average daily demand rate. To provide "extra" stock, the algorithm computed a "safety level" of five days of supply.

This approach frequently resulted in stock shortages, particularly in cases of variable or highly clustered demands. It was unable to address two key challenges associated with stocking deployable SSAs:

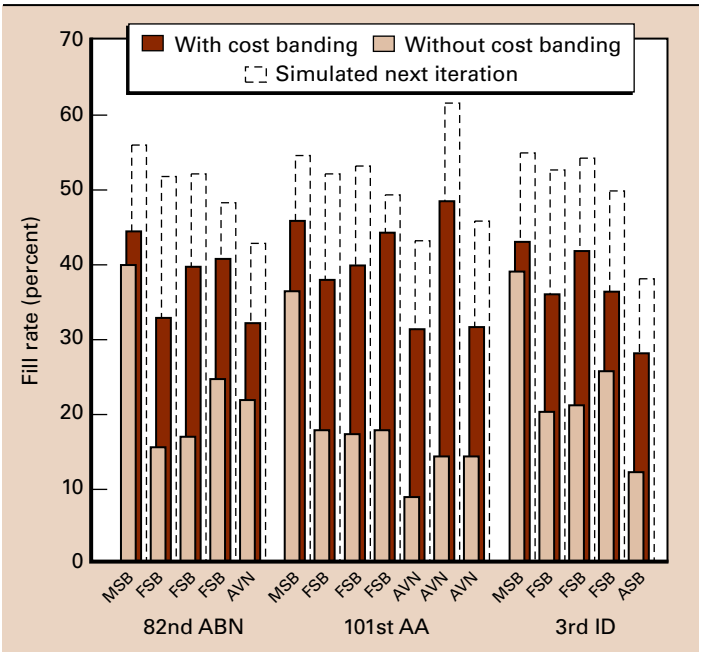
- Some small, inexpensive, but critical items receive few annual demands.
- The highly variable operational tempo of deployable Army units can lead to sudden increases in demand (e.g., during training exercises).

Dollar cost banding addresses these challenges by increasing the likelihood that small, inexpensive, but mission-critical items will be available locally. Cost banding works by setting fill-rate-driven goals for each stocked item in terms of how many days the customer must wait to receive it (customer wait time or CWT). Small, inexpensive, mission-critical items receive shorter CWT goals. The CWT goals are used to set appropriate stock levels. For example, to meet CWT goals, stock levels are adjusted for items that would incur long delays if not available locally. Dollar cost banding thus reduces the risk of stock shortages and provides greater flexibility to SSAs in setting depth levels that are appropriate to both customer demands and replenishment patterns.

Cost Banding Improves Supply Performance Dramatically with Little or No Additional Investment

Those divisions implementing dollar cost banding have seen improved performance throughout their SSAs, including main, forward, and aviation support battalions. Figure 7 provides a more detailed version of the improvement in fill rates shown in Figure 6. Figure 7 displays fill rates before (light shade) and after (dark shade) cost banding for each division's SSAs. Expected future performance is represented by the white bars. As the figure shows, SSAs in the forward support battalions achieved particularly impressive levels of improvement, but all SSAs (main support battalions and aviation support battalions) show improvement. The predicted future performance for the divisions illustrates the potential for even greater improvement, as SSAs become more and more responsive to customer needs.

Figure 7: SSA Performance in Forward Support Battalions



As indicated by the multiple levels of improvement shown in Figure 7, dollar cost banding has allowed SSA managers to change their inventories in phases. This approach gave managers flexibility in shifting inventories by choosing to draw down or return unneeded items to obtain funds for acquiring new items. Managers were initially provided with five alternatives, representing different levels of investment, mobility, and performance. Most SSAs began with the least expensive alternative. The first time cost banding was implemented, therefore, the immediate effect was typically a significant increase in the number of critical low-dollar lines. To accommodate the increased breadth, SSAs reconfigured their warehouses and containers to use space more efficiently. Subsequent reviews using the cost banding algorithm resulted in further improvements in supply performance, which increasingly resulted in changes to more expensive items.

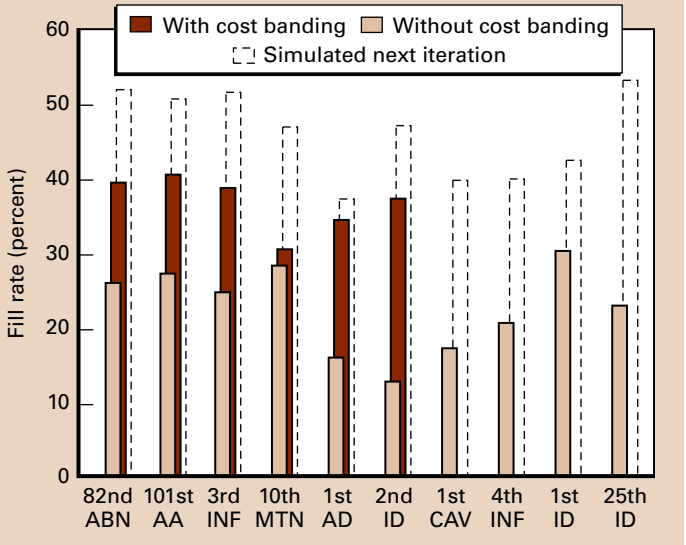
Using this phased approach, divisions implementing dollar cost banding have achieved improved performance with little or no additional investment. The total weight and volume of inventories using cost banding have usually increased only marginally and in many cases declined, sometimes significantly. Much of the increase in breadth has taken place in lines costing less than $100, and many of these items are small, allowing SSAs to remain mobile. After implementing cost banding, the 82nd Airborne Division saw the value of its spare parts inventory rise from $9.5 million to $10.4 million, while the 101st Air Assault Division saw the total value of its spare parts inventory decline dramatically, from $20 million to $10.2 million.

The Army Is Implementing Dollar Cost Banding Quickly

Once a few pilot sites had demonstrated the dramatic effectiveness of cost banding, the Deputy Chief of Staff for Logistics approved it as a policy option for setting inventory at retail supply points Armywide. The Army has 149 spare parts supply warehouses serving customers on active duty, 127 of which are deployable. Over 40 percent of these sites have fully implemented cost banding, while another 50 percent are in the process of doing so.

The contrast in SSA performance for the Army divisions that have implemented cost banding and those that have not yet done so can be striking, as shown in Figure 8. On the left side of the figure are fill rates at six divisions whose SSAs have implemented dollar cost banding. On the right side of the figure are fill rates for four divisions that have yet to implement dollar cost banding, together with the estimated fill rates that

Figure 8: Fill Rates for Divisions With and Without Cost Banding



might be achieved if the division shifted to the new algorithm. All four divisions show potential for dramatic improvement.

As SSA Fill Rates Rise, Customer Wait Time Falls

Higher local fill rates are beneficial in several ways. When parts orders can be filled from local stocks, maintainers typically receive their items on the same day or the next day, allowing repairs to be completed more quickly. In contrast, requests that must be referred to distribution centers, maintenance activities, or manufacturers can result in delays ranging from five to ten days to many months. The impact of such delays multiplies when several parts are needed to complete each repair.

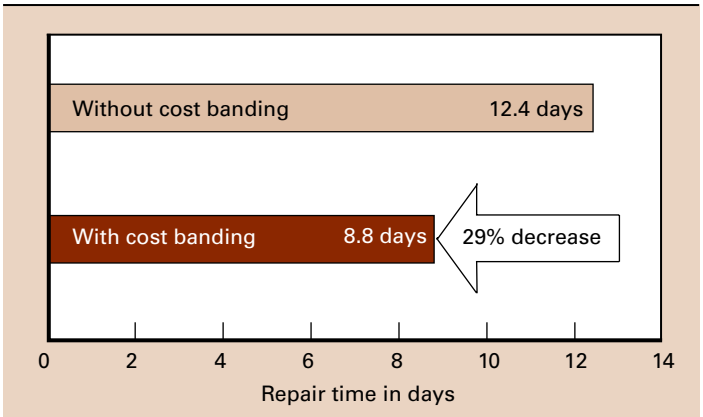
One important benefit of dollar cost banding is apparent in the improved CWT at Fort Knox. As one of the most recent Army installations to implement cost banding, Fort Knox offers the most complete data set currently available to track supply performance. Although the SSA at Fort Knox is not deployable, the fort's role as the site of the Army's tank training school means that its supply support needs are similar to those of deployable units. Fort Knox illustrates how improved local supply fill rates can affect CWT. With the shift to dollar cost banding, the fill rate at Fort Knox improved from 41 percent to 63 percent. During the same period, median CWT for high-priority demands collapsed from 2–3 days to just 0–1 days. In other words, half the parts that maintainers order for the repair of downed equipment are now available immediately.

As Customer Wait Time Speeds Up, So Do Repairs

Improved local supply fill rates and reduced CWT have led to quicker tank repair times. One of the reasons for this improvement has been an increase in the percentage of repair jobs that can be completed with all locally available parts. When all parts needed for a job are stocked locally, repairs can be completed more quickly because no parts need to be ordered off post. At Fort Knox, for example, the average repair time for jobs completed with all locally supplied parts was just three days, while jobs requiring at least one part from an outside source often averaged more than two weeks. After the implementation of cost banding, the percentage of jobs at Fort Knox that could be completed with all locally supplied parts rose from 21 to 28 percent—a 33 percent improvement.

Average tank repair times also went down because of a reduction in the number of parts that had to be supplied from distant sources. At Fort Knox, the percentage of jobs requiring at least one part from an off-post source fell from 57 to 51 percent. In addition, many jobs that in the past would have required several referrals now could be completed with only one, thus reducing the total time spent awaiting parts. As shown in Figure 9, after the implementation of dollar cost banding, the average repair time for M1A1 tanks at Fort Knox decreased from 12.4 days to 8.8 days, a 29 percent drop.

Figure 9: Repair Times at Fort Knox



Quicker Repairs Help Improve Equipment Readiness

The performance improvements provided by cost banding benefit soldiers both in garrison and during deployment. Improved repair times directly affect equipment readiness. If repairs are completed quickly, equipment can be returned to mission-capable status. For example, since the implementation of dollar cost banding at Fort Knox, the percentage of mission-capable M1A1 tanks has risen from an average of 79 to 86 percent.

Dollar cost banding offers an opportunity for Army supply sources to make immediate and lasting improvements in filling customer orders. The new algorithm has been a critical component of the Army's effort to streamline and improve the responsiveness of its logistics processes. Velocity Management research at RAND continues to seek new opportunities for continuous improvement of Army supply performance. ★

New Opportunities for Army Collaboration and Partnership with Industry

In recent years, the Army has recognized a growing need to collaborate and partner more with industry. This need has been driven in part by the Army's interest in leveraging additional resources to offset a decade of downsizing and reduced budgets. Since the end of the Cold War, the Army has dramatically cut both military and civilian personnel. Its research and development (R&D) budgets have remained stagnant, while its resource allocations for property maintenance have fallen by 50 percent. Its interest has also been driven by the need for innovative, fast-moving technologies that are difficult to obtain using cumbersome traditional acquisition procedures.

Despite this downsizing, the Army's core mission of preparing for, deterring, and fighting the nation's wars has remained constant, and the Army itself is undergoing a broad transformation to ensure that it maintains future dominance across the full spectrum of operations. The Transformation Army—with Future Combat Systems[14] at its core—will require significant advances in Army science and technology (S&T) capabilities. Moreover, the Army's other responsibilities remain substantial. For example, despite the reduced resources for property maintenance, the Army's land holdings have decreased by only 2 percent in the past decade, leaving it as one of the nation's largest property owners. Much of this real property—which includes more than 207,000 buildings; tens of thousands of miles of road; and a million square yards of pavement, ports, runways, and utility structures—has a substantial backlog of needed maintenance.

[14] The Future Combat Systems is the Army's concept for the systems needed to fight future wars. A system of systems, it will improve the Army's ability to deploy rapidly and still place a formidable force on the battlefield.

A brief consideration of the resources available to the Army and its requirements, in terms of maintaining current infrastructure and readiness while it undergoes a transformation, suggests an urgent need for innovative methods of leveraging additional resources. But which methods would benefit the Army the most?

Recent research at RAND Arroyo Center has explored opportunities for Army-industry collaborations and partnerships and has identified three promising candidates: real-estate public-private partnerships, a venture capital fund, and spin-offs of Army activities into Federal Government Corporations. Used imaginatively and flexibly, these activities can help the Army meet its technology requirements, improve its readiness posture, and support its core mission.

Public-Private Partnerships (PPPs)

Public-private partnerships (PPPs) offer a means for the Army to use its substantial physical resources, including real property, to support its objectives in other areas. A PPP is a flexible arrangement in which private and public organizations share resources to achieve similar or at least not incompatible goals.

Much of [the Army's] real property—which includes more than 207,000 buildings; tens of thousands of miles of road; and a million square yards of pavement, ports, runways, and utility structures—has a substantial backlog of needed maintenance.

For example, the Navy leases part of its Port Hueneme facility to the Mazda Corporation, which in return helps the Navy maintain the facility in case of future need. Through PPPs, the Army can better leverage the value of its currently underused property holdings.

Of all the potential benefits of PPPs, perhaps the most important is their ability to improve the Army's readiness posture. To the extent that PPPs allow the Army to reduce the number of personnel involved in property maintenance, the Army will have more resources available for its core mission. And, unlike a property sale, a PPP allows the Army to retain control of the asset in case of future need.

Despite the many benefits of PPPs, such arrangements have raised concerns, and their expanded use would require the Army to establish safeguards to prevent their misuse. For example, the Army will need to stipulate which businesses can be allowed onto installations. Adequate security plans must be a central component of any installation's real property PPP plans. In addition, the Army should issue and enforce rules and guidelines for evaluating the fair market value of assets offered and will need to devise measures to ensure that both local and broader political priorities are addressed in setting up PPPs.

Assuming that the Army can establish adequate rules and guidelines for PPPs, it will then need to identify candidates for successful partnerships. In this effort, the Army will benefit by taking a proactive approach that starts from the premise that many good ideas for PPPs are currently being discussed at local installations. Installation managers are probably savvy enough to come up with an impressive list of PPP candidates, which can provide a core of workable ideas for the Army to pursue. If the Army were to adopt a proactive approach to PPPs, the Army Staff level would likely aid the process by providing guidance on compatible business options, sound business approaches, partnership tools, and management practices.

Of all the potential benefits of PPPs, perhaps the most important is their ability to improve the Army's readiness posture.

Successful real property partnerships between the Army and private developers will depend heavily on the match between the local community's needs and the assets available on the installations. For this reason, it will be necessary for the Army to devise an effective system to evaluate PPPs. A series of value indicators such as those shown in Table 5 can be used for this purpose. Once a decision is made to proceed with a real estate PPP, the DoD has a number of tools in place that the Army can use to develop it, such as leases, facilities use contracts, and special legislation.

Venture Capital Approaches

Another option that can be used to meet the Army's future technological needs is a venture capital fund. Venture capital funds can be high risk, but they also can be highly profitable. An Army venture capital fund that invests in companies and technologies that have military interest yet also significant commercial potential could greatly help the Army develop needed technologies and reduce costs.

The commercial sector has used venture capital firms successfully to develop and exploit innovation. Venture capital provides inherent incentives and an organizational structure that facilitates the development of innovative ideas. For the Army, a venture capitalist could act as a middleman who understands the needs of both the Army and the business and technology communities, thus shaping agreements that meet the needs of all parties. A venture capital organization funded and chartered by the Army, but run outside the government by a venture capital professional, could circumvent much of the government red tape that has traditionally impeded greater collaboration between the Army and commercial firms. A venture capitalist would have flexibility in negotiating intellectual property rights agreements—a key issue to be resolved in any Army-commercial partnership.

A venture capital fund would give the Army a means to leverage non-Army resources and earn a return on investment. Assuming the Army's fund invests in technologies that have considerable commercial potential, significant outside co-investment is likely. Through such leveraging, the Army could stretch its own R&D resources to accelerate the development of

Table 5: Value Indicators for Assessing Potential PPPs

Indicator	Key issue(s)	Sample variables
Quality of local community	• Relevant economic and demographic conditions in the community	• Projected economic growth • Projected employment growth • Projected growth industries • Projected population growth • Projected labor force growth
Mission of installation	• Installation's major land, construction, and infrastructure assets	• Buildings • Type of services • Equipment • Land • Available workforce
Available capacity	• How current installation assets can be consolidated, relocated, or restructured to accommodate a PPP • Military assets that can be used for the PPP	• Buildings • Dual-use equipment
Criteria for success	• Consonance of PPP with the installation's military goals • Benefits of PPP • PPP's ability to meet success criteria outlined by the Government Accounting Office	• Army mission at installation • Catalyst for change • Statutory basis • Detailed business plan
Potential uses for installation assets	• Types of private enterprise that should be encouraged to engage in PPPs	• Consistency of potential businesses with installation assets and capabilities

key technologies while continuing to invest in a range of new ideas. Most of the technologies appropriate for investment by an Army venture capital fund would meet near-term Army requirements but have longer-term commercial potential, including the possibility of spawning whole new industries.

The Army could use existing contracting tools, such as the Other Transaction (OT) authority, spelled out in federal law, to get the venture capital fund off the ground by initiating an agreement with an established organization to work on a limited set of problems. An OT offers greater flexibility than the Army's traditional contracting tools, in that it allows negotiation on intellectual property rights, government oversight, cost-sharing, and business arrangements. Using an OT, the Army could embark on a venture capital arrangement for a relatively small amount of money, perhaps less than $10 million. With an agreement in place and a small number of projects under way, the Army could then look for congressional endorsement and additional funding through the authorization and appropriations process.

An Army venture capital fund would require careful management. The Army needs to ensure that selected technologies have clear military and commercial applications. In each case, the Army must be the "power user" for the new product or technology; that is, the Army's need for the new product or technology must come ahead of that of other users. The technology must also be mature enough to develop into a product or proprietary technology within the limited time and with the limited dollars that venture capital investing implies. It will also be critical for the Army to find "sponsors" and users for the venture-backed technologies. To realize the greatest benefit from its efforts, the Army should integrate its venture capital investments with other ongoing technology programs, including current R&D and the Small Business Innovation Research program.

Federal Government Corporations

Federal Government Corporations (FGCs) give the Army a potentially useful organizational alternative that straddles the divide between public and private management. FGCs were originally established by Congress more than 200 years ago as a way to manage government-run operations that need a high degree of autonomy and flexibility. FGCs in operation today include Fannie Mae, Freddie Mac, and other large lending organizations; the U.S. Postal Service; and a variety of corporations designed to achieve specific national policy goals, such as the Tennessee Valley Authority and the Smithsonian Institution. For the Army, the FGC model could be a particularly attractive option for those operations—such as depots—that

exist between the core and the periphery of its operations. Army depots are an overwhelmingly civilian operation: for FY00, the Army projected that the system would have 9,502 civilians on the payroll, but only 21 military personnel. Thus, one immediate advantage of spinning off the depot system as an FGC would be to reduce the number of Army civilian personnel without eliminating jobs.

But FGCs have three important features that make them an attractive option for the Army in other ways as well:

- **Efficiency.** The free market forces confronting FGCs generally lead to lower-cost products and services. Beyond the economic efficiencies, the FGC option creates a highly focused organization with a well-defined national policy goal.
- **Flexibility.** FGCs have much more regulatory flexibility than do traditional government agencies. FGCs can enter contracts for goods and services independently and can buy and sell assets.
- **Financial freedom.** FGCs also benefit from financial freedoms beyond those allowed to federal agencies. They can borrow funds, issue debt, and own property. They are not subject to year-end budgets and can engage in multiyear commitments.

Depot operations could benefit from the flexibilities and efficiencies inherent to the FGC. As a Working Capital Fund (WCF) activity, the Army depot system is already required to operate in many respects like a business: it relies on customers to bring in work and pay for services, and it must balance its share of the WCF financial bottom line. Unlike a commercial business, however, the depot system is part of the planned economy of the DoD, which places very unmarket-like constraints on such things as the total amount to be spent, the kinds of investments that can be made, and the pricing of goods and services. The FGC model would remove these constraints and allow the system to function more efficiently. Moreover, if the new FGC were able to take advantage of the opportunities to seek new customers and markets, its business could grow, thus creating new jobs.

As with the other partnership opportunities, some concerns about FGCs would need to be resolved before the model can be put to full use. The FGC's position atop the divide between federal and private roles and responsibilities has raised questions about the organization's level of accountability to the public. Each FGC would need a well-crafted congressional charter laying out the roles and responsibilities of the corporation, the executive management, and the board of directors. In addition, it is not yet clear whether external commercial opportunities exist for Army operations such as the depots; such opportunities must be found if the FGC concept is to function at its best. Any FGC arrangements would also necessarily entail establishing special working arrangements with the Program Offices and Item Managers in Army Materiel Command's Major Subordinate Commands, who are critical for providing guidance, direction, and workload assignments to the organization.

Conclusion

Each concept described above requires the resolution of key issues before the Army can implement it fully. In the case of PPPs, the Army must determine whether financially sound concepts can be proposed by the installations. In the case of venture capital, the potential of such a concept to meet the Army's technology needs must be addressed in further detail. In the case of FGCs, the value of establishing Army depots or other operations as FGCs will depend on how many external opportunities can be found and how continuing relationships with other Army organizations can be structured.

Once these key issues are addressed, the Army can best gain a fuller understanding of the opportunities inherent to these new approaches by establishing pilot programs to test the concepts. Following such a method would put the Army in line with the new industry paradigm that argues that one learns more by acting on an approach than by waiting until all possible questions about the new method are answered. Such an active approach is not only advisable but probably necessary. In the quest to secure the fast-moving technologies needed to support the Army of the future, not acting is the equivalent of staying behind. ✯

Enhancing Personnel Readiness with Distance Learning

Over the past decade, the Army has become increasingly interested in the potential of distance learning (DL) to tackle its unique training. Accordingly, it has implemented the Army Distance Learning Program, investing in the development of some 500 courses as well as an infrastructure consisting of networks and hardware. However, some observers have questioned the feasibility of the current program design. A series of recent reports by Arroyo Center researchers examines the potential roles for DL in the Army training process.

The Army Perceives Benefits for Distance Learning

The Army has invested heavily in DL because of its obvious benefits, which include the flexibility to offer training at multiple locations, thus reducing soldiers' travel costs and time away from home station, as well as the ability to integrate training into individual work schedules and to train continuously. Moreover, by using DL to train soldiers at their home posts instead of requiring them to travel to schools, the Army involves them and their chains of command more fully in the training process. Such involvement should help ensure that soldiers have time to complete their course requirements and in some cases may allow the tailoring of courses to the needs of both soldiers and their particular units.

New DL technologies promise to increase the effectiveness and efficiency of Army training. Yet the ultimate success of DL will depend upon its ability to bring about improvements in critical areas such as personnel readiness. Thus, the Army asked RAND Arroyo Center to assess DL's potential to alleviate selected personnel readiness problems. A recent report does this along two dimensions:

- Personnel shortages.
- Stability and professional development.

Personnel Shortages Affect Army Readiness

The Army of the 21st century has embarked on a large-scale transformation effort that aims to create a force that can deal with the changing nature of projected threats. A key component of the Army's transformation is personnel readiness: maintaining a force that is prepared to respond quickly to any situation. Yet the Army Chief of Staff's Monthly Readiness review and other reports have documented the significant influence on readiness of shortages in active-duty enlisted personnel. Personnel shortages are measured as the gap between the number of assigned soldiers in a particular grade and skill and the number of positions authorized to be filled by a soldier of that grade and skill. The Army, like the other services, has faced personnel shortages in a number of critical military occupational specialties (MOSs). Indeed, the Arroyo Center estimates that some 19,000 positions remained unfilled in FY99, representing 5.4 percent of all authorized positions in the enlisted force. Moreover, personnel shortages resulted in a number of positions being filled by lower-grade soldiers who lacked the education or training required to prepare them for

By using DL to train soldiers at their home posts instead of requiring them to travel to schools, the Army involves them and their chains of command more fully in the training process.

those duties: About 8,500 (2.5 percent) of the highest-level enlisted slots (E6 and E7) were filled by soldiers who had not yet received the required training.

Training Can Influence Readiness

Historically, the Army has addressed the issue of personnel shortages by stepping up recruitment and retention in the shortage skills, and by using training strategies to move soldiers into the shortage skills. The current personnel shortages have been attributed to a number of factors, including recruiting shortfalls and attrition. The training process has the potential to reduce shortages and improve readiness by employing a variety of strategies:

- Offering reclassification training;
- Offering cross-training or consolidating MOSs; and
- Accelerating the pace of noncommissioned officer education/training.

Reclassification training would allow soldiers in MOSs with surplus personnel to learn the skills needed to switch to a new, critical MOS, presumably obviating the need to recruit soldiers to fill those positions. Cross-training would qualify soldiers to perform duties in more than one MOS, making them available to fill in informally for soldiers in a different occupation when necessary. With MOS consolidation, soldiers in two or more occupations receive additional training to form a new combined occupation. While cross-training and consolidation do not reduce personnel shortages per se, they do render such shortages less damaging to personnel readiness. Finally, accelerating the pace of education and training would enable those in leadership development programs to assume their new roles more quickly, thereby reducing the number of these positions filled by unqualified personnel.

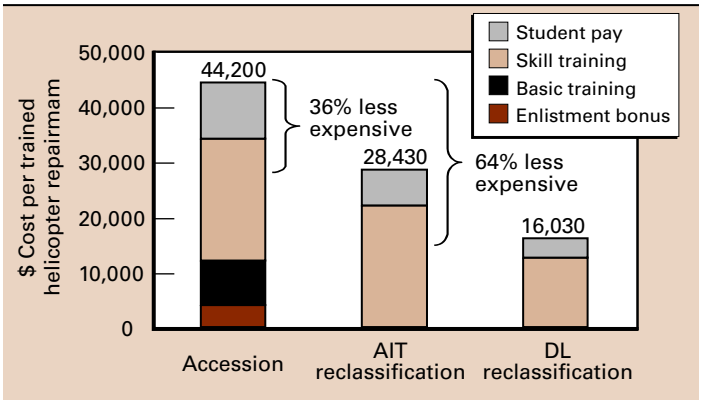
The Arroyo Center Has Assessed the Potential of DL to Help with Personnel Shortages

Arroyo Center researchers have conducted a series of studies to assess how DL might play a part in reducing personnel shortages by improving training. In their report, *Army Distance Learning: Potential for Reducing Shortages in Enlisted Occupations*, researchers looked at how DL might help the three training strategies mentioned above decrease personnel shortages. Choosing several MOSs as examples, they used inventory projection models and other analytical tools to assess DL's ability to enhance each strategy's possible contribution to the goal.

The potential advantages of DL over traditional residential learning stem largely from its greater flexibility. While residential learning tends to provide all learners with the same material in the same format over the same time period, some DL media allow learning programs to be tailored more easily to the current skill levels, new assignments, and time constraints of individual soldiers. DL courses could be designed and offered as modular units so that learning programs might be tailored flexibly to the individual's prior experience and skill level. Moreover, DL can more easily provide refresher training and "just-in-time" training, allowing soldiers to remain proficient in a wider range of skills. Finally, DL allows the faster completion of coursework: instead of having to await the start of a new class, training can begin any time it is needed.

The researchers found that DL has the potential to decrease personnel shortages by expanding the Army's reclassification program. Because DL courses take less time to complete and involve less time away from home and family than the traditional alternative, obstacles to entering a new occupation are lower. Further, as shown in Figure 10, DL reclassification would cost considerably less than the traditional residential course (that is, reclassification by Advanced Indi-

Figure 10: Cost of DL Reclassification



DL courses could be designed and offered as modular units so that learning programs might be tailored flexibly to the individual's prior experience and skill level.

vidual Training) or training new recruits.

Similar effects of DL were predicted for cross-training and MOS consolidation. DL's ability to be delivered in modules would permit soldiers already trained in one skill set to acquire only the additional skills they need to assume new responsibilities. Moreover, given a likely large increase in MOS consolidation in the near future, DL could play a significant role. Thus, the savings to be gained by applying DL to cross-training and MOS consolidation could be even greater than that for reclassification.

DL also has the ability to accelerate training by allowing it to begin earlier and enabling students with prior training or experience to test out of some coursework. Thus, soldiers would be able to assume new positions more quickly.

DL Can Enhance Stability and Decrease Personnel Turbulence

Military training and education are vital to readiness. Paradoxically, though, to the extent that institutional training and education programs take leaders away from their units, these vital activities can reduce the Army's readiness. Enlistees must attend school periodically to advance their job skills beyond what they learned in Basic Training and Advanced Individual Training, and career soldiers must pursue professional military education in addition to upgrading job skills. Fulfilling these training and educational requirements has traditionally entailed a lengthy period of temporary duty, and in many cases a permanent change of station for six months or more to a specialized training facility for residential learning. Reclassification training and cross-training also entail varying periods of residential learning.

Residential learning by permanent change of station or by temporary duty assignment is a costly process financially, personally, and in terms of readiness. At the level of the individual soldier, traditional military education takes its toll in terms of the actual costs of a permanent move or extended temporary assignment as well as the length of time needed to take the course, which translates to time away from duties. Furthermore, personal costs accrue from time spent away from family or from frequent moves. The increased turnover of personnel in leadership positions, brought on by the departure of leaders to attend professional development courses, also affects unit readiness.

Arroyo Center researchers assessed how DL might be used to improve personnel stability. Focusing on a representative sample of officer leadership preparation courses, they compared the costs and time away from home for varying combinations of course attendance: temporary duty alone, permanent change of station alone, permanent change of station combined with temporary duty, and permanent change of station combined with DL. As they described in the report *Enhancing Stability and Professional Development Using Distance Learning*, the researchers found that converting even part of the coursework into DL would allow the soldier to spend significantly greater time at his or her assigned post compared with courses taken in residence, even taking into account the time required for coursework. These benefits of DL could extend to many other courses as well.

DL Has Potential Benefits for Other Areas of Military Training and General Education

In the latest report, *Army Distance Learning and Personnel Readiness*, researchers took a more general look at additional potential benefits of DL. Career soldiers undergo military-specific training throughout their careers, and DL can make this continuing education process easier to achieve in terms of both costs and soldiers' time. Similarly, DL can make civilian education programs more accessible for soldiers: the smaller learning modules achievable with DL, and the relative ease of fitting them into busy schedules, create educational opportunities that would not have been possible under a residential program.

The advantages that DL offers for alleviating personnel shortages most likely apply to other areas of military-specific training. These advantages include the potential to provide "just in time" training as well as refresher coursework. An

The correct balance between DL and residential learning must be established and periodically reevaluated for each course.

additional advantage of DL is that the material can be updated continually and monitored for effectiveness. DL could also be used to provide unit training as well as supplemental skill training for those in leadership positions and would enable creation and sharing of training materials with coworkers and other members of the unit.

General education also may derive some benefit from DL capabilities. In addition to allowing the general level of education among soldiers to increase, DL may be used increasingly to complete classes and, in some cases, entire university degrees via Web-based coursework. The costs of such educational options may be lower for the military than comparable campus-based training, and soldiers would be able to complete their coursework without leaving their duty stations.

Changes in Policy Emphasis May Be Needed for the Army to Implement DL

DL can enhance existing strategies for reducing personnel shortages and also provides additional capabilities. However, careful planning will be required as the Army implements DL, including selection of courses that prepare soldiers for key occupations facing personnel shortages as well as those that enhance professional stability. In addition, since the MOSs that are deemed critical are subject to change, mechanisms will need to be in place to respond in a timely manner by developing new coursework.

Industry and academe have had extensive experience with DL. To optimize the use of DL, the Army must learn from that experience and take full advantage of emerging learning technologies, with emphasis on asynchronous Web-based courses. Moreover, Army leaders need to ensure that students have the time they need to study and complete DL coursework. In addition, administrative support is vital for scheduling, monitoring, and recording training results.

Course content must be chosen carefully for adaptation to a DL environment. Some course material is simply not amenable to DL. The correct balance between DL and residential learning must be established and periodically reevaluated for each course. For those courses or parts of courses selected, the time required for successful course completion must be realistically assessed and then granted.

Finally, care must be taken to ensure that training delivered by DL maintains the required quality and effectiveness. Some studies of DL have found tradeoffs between effectiveness and reduced training time. In addition, periodic refinement of coursework will be needed to improve learning and maintain currency. ★

Publications

Analysis of Air-Based Mechanization and Vertical Envelopment Concepts and Technologies

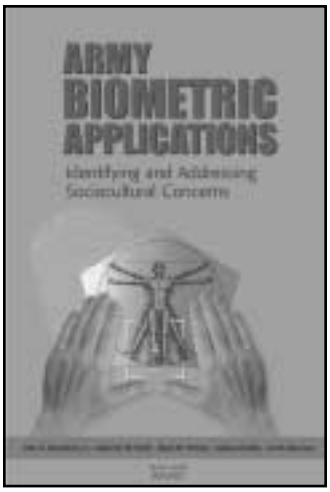
Jon G. Grossman, John Matsumura, Randall Steeb, John Gordon, Tom Herbert, William Sollfrey | DB-321-A

The Army After Next (AAN) concept of rapidly deployable mechanized battle forces in a tactical environment requires the forces to be readily transported by vertical, or near-vertical, lift aircraft. In the nonlinear AAN battlefield, this may require the forces to deploy near the enemy's second echelon. The authors examined the performance of the notional AAN advanced airframes to survive this initial air maneuver/insertion under a variety of conditions. These included level of situational awareness and intelligence provided to pilots, level of suppression of enemy air defenses (SEAD), flight tactics and ingress routes used by the pilots, and signature characteristics of the airframes (both RF, IR, and optical). The authors used high-resolution constructive simulations to explore and assess the airframes' survivability against an integrated air defense system operating in mixed terrain. The air defense system was one the Russians are capable of deploying today. The results of the analysis indicate that no one approach can guarantee aircraft survivability. Combinations of aggressive SEAD, use of stealth technology, and enhanced situational awareness can, under certain conditions, result in good survivability rates for the aircraft. The large size and slow flight speeds of the aircraft, however, make them susceptible to optically guided munitions. These weapons are difficult both to find and to counter. New technologies, tactics, and techniques will be needed to deal with this threat if the AAN air insertion concept is to succeed.

Army Biometric Applications: Identifying and Addressing Sociocultural Concerns

John D. Woodward, Jr., Katharine Watkins Webb, Elaine M. Newton, Melissa Bradley, David Rubenson, Kristina Larson, Jacob Lilly, Katie Smythe, Brian K. Houghton, Harold A. Pincus, Jonathan M. Schachter, Paul Steinberg | MR-1237-A

Every human possesses more than one virtually infallible form of identification. Known as "biometrics," examples include fingerprints, iris and retinal scans, hand geometry, and other measures of physical characteristics and personal traits. Advances in computers and related technologies have made this a highly automated process through which



recognition occurs almost instantaneously. With concern about its information assurance systems and physical access control increasing, the Army has undertaken an assessment of how it can use biometrics to improve security, efficiency, and convenience. This report examines the sociocultural concerns that arise among soldiers, civilian employees, and the general public when the military mandates widespread use of biometrics. The authors see no significant legal obstacles to Army use of biometrics but recommend that the Army go beyond the provisions of the Privacy Act of 1974 to allay concerns related to this emerging technology.

Army Distance Learning and Personnel Readiness

John D. Winkler, Henry A. Leonard, Michael G. Shanley | MR-1389-A

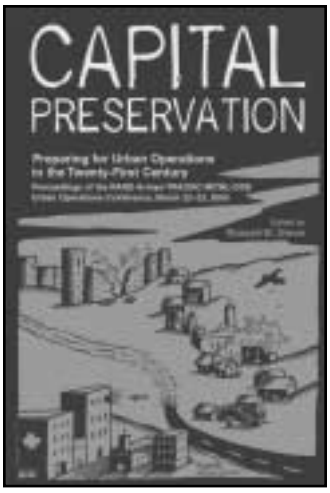
This report summarizes the results of a project that studied ways in which distance learning technologies could enhance Army personnel readiness. Distance learning technologies can be used, for example, to improve strategies designed to alleviate shortages of enlisted personnel in key military occupational specialties. DL can also enhance personnel stability and reduce the need for officers and noncommissioned officers to make frequent moves to complete their required training. The research concludes that the Army should make improving personnel readiness a primary goal of the distance learning program, and it recommends changes to the Army's investment plans to support this goal. For example, the Army should enhance investment in courseware relative to infrastructure, such as developing courseware for reclassifying Active Component soldiers from surplus to shortage military occupational specialties. The Army should also employ the most flexible distance learning training methods to support this goal, e.g., expand development of asynchronous courseware in officer and NCO professional development courses.

Army Medical Strategy: Issues for the Future
Gary Cecchine, David Johnson, John R. Bondanella, J. Michael Polich, Jerry Sollinger | IP-208

The U.S. Army Medical Department (AMEDD) provides peacetime health care for military beneficiaries while also maintaining readiness for war and peacetime deployments. In this paper, the authors raise four issues that could affect this readiness and that deserve further study. These issues address the appropriateness of, and the ability to man, AMEDD's planned medical structure, future operational concepts, and near-term operational planning in unified commands. The paper also discusses influences that have recently shaped medical planning. More-precise analyses of the issues raised and careful consideration of related risks are recommended.

Biometrics: Facing Up to Terrorism
John D. Woodward, Jr. | IP-218

As the nation recovers from the attacks of September 11, 2001, we must rededicate our efforts to preventing any such terrorist acts in the future. While there is no easy, foolproof technical fix to counter terrorism, the use of biometric technologies might help make America a safer place. Biometrics refers to the use of a person's physical characteristics or traits to identify, or verify the claimed identity of, that individual. Fingerprints, faces, voices, and handwritten signatures are all examples of characteristics that have been used to identify us in this way. Biometric-based systems provide automatic, nearly instantaneous identification of a person by converting the biometric, for example a fingerprint, into digital form and then comparing it against a computerized database. This RAND Issue Paper discusses how biometric technologies could be used to impede terrorism in three critical areas: (1) controlling access to sensitive facilities at airports, (2) preventing identity theft and fraud in the use of travel documents, and (3) identifying known or suspected terrorists with a proposed counterterrorist application known as FaceCheck.



Capital Preservation: Preparing for Urban Operations in the Twenty-First Century—Proceedings of the RAND Arroyo-TRADOC-MCWL-OSD Urban Operations Conference, March 22–23, 2000
Russell W. Glenn (editor) | CF-162-A

In March 2000, RAND Arroyo Center, Marine Corps Warfighting Laboratory, U.S. Army Training and Doctrine Command, and the Office of the Secretary of Defense hosted a conference on urban operations. Its objectives were to explain the significance of urban areas in current and future military operations; consider and discuss methods and means of seizing, stabilizing, or controlling such areas in the 21st century; identify technology requirements across the spectrum of urban operations; and identify C4ISR requirements inherent in military urban operations and ways of meeting them. Along with a detailed introduction, this document includes transcriptions of each presentation.

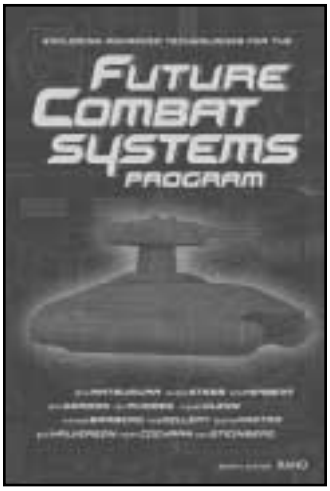
Deployments and Army Personnel Tempo
Ronald E. Sortor, J. Michael Polich | MR-1417-A

Over the past decade, numerous observers have expressed concerns about "increased tempo" and overseas deployments. This report derives quantitative measures of unit and individual deployments in the period 1994 through 2000 and uses them to create an empirically grounded description of tempo and its possible effects. Results show that, over time, Army deployment levels have increased appreciably. For example, the average time deployed rose nearly 30 percent between 1997 and 2000, and the number of units with lengthy periods away from home was also up sharply. In 2000, the average soldier in a TO&E unit spent about 7 days away from home on deployments each month, or 85 days per year. The impact was much more pronounced among some units, branches, and individuals, particularly those deployed to the Balkans. However, less than 4 percent of the force was subject to repeat overseas deployments during a three-year period, and less than 1 percent was deployed more than one-third of the time. The authors conclude that these static measures of tempo and deployment do not by themselves explain a widespread "tempo" problem, but that a problem results from two other sources. One is the workload generated by the combination of warfighting readiness, deployments, and day-to-day peacetime demands of operating a unit and installation. The second arises from the dynamics of the system that must sustain the force, prepare for deployments, and adhere to peacetime operational and policy constraints. As a result, the authors suggest that the major focus of Army concern about deployments should probably be not on the amount of time that individual soldiers spend overseas (although that should be monitored), but on overall force management, to distribute the burden evenly, minimize short-term readiness effects, and ensure that longer-term skill development and warfighting capability are sustained.

The Emergence of Peer Competitors: A Framework for Analysis
Thomas S. Szayna, Daniel L. Byman, Steven C. Bankes, Derek Eaton, Seth G. Jones, Robert E. Mullins, Ian O. Lesser, William Rosenau | MR-1346-A

The potential emergence of a peer competitor is probably the most important long-term planning challenge for the Department of Defense. This report addresses the issue by developing a conceptual framework of how a proto-peer (meaning a state that is not yet a peer but has the potential to become one) might interact with the hegemon (the dominant global power). The central aspect of the framework is an interaction

between the main strategies for power aggregation available to the proto-peer and the main strategies for countering the rise of a peer available to the hegemon. Then, using exploratory modeling techniques, the pathways of the various proto-peer and hegemon interactions are modeled to identify the specific patterns and combinations of actions that might lead to rivalries. The dominant power has an array of options available to limit the growth of its rivals or to change their ultimate intentions. Too confrontational a strategy, however, risks making a potential neutral power into a foe, while too conciliatory a stance may speed the growth of a competitor. Exploratory modeling suggests which attributes of the countries are most important and the sensitivity of the dominant power to perception errors.



Exploring Advanced Technologies for the Future Combat Systems Program
John Matsumura, Randall Steeb, Tom Herbert, John Gordon, Carl Rhodes, Russell Glenn, Michael Barbero, Fred Gellert, Phyllis H. Kantar, Gail Halverson, Robert Cochran, and Paul Steinberg | MR-1332-A

This report summarizes the research findings of a short-timeframe study conducted by RAND Arroyo Center to support the Army Science Board (ASB) Summer Study 2000, "Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015–2020 Era." The purpose of the RAND research was to explore a range of advanced technologies for potential contribution to the Future Combat Systems program. In the context of the ASB's fundamental purpose—to evaluate advanced technologies within new operational concepts for the future vision of the Army—this research focused on a small-scale contingency and the associated spectrum of challenges this type of scenario might entail. In conducting the study, the research team interacted with various members of the ASB and, in particular, with key members of the Operations panel, drawing extensively on their forward-looking ideas and ultimately integrating many of these ideas into the research. High-resolution combat modeling and simulation was used to assess the many key aspects of force performance, environmental effects, and system-of-system effects.

Exploring the Use of Microworld Models to Train Army Logistics Management Skills
Dina G. Levy, Matthew W. Lewis, John R. Bondanella, Michael Baisden, Emile Ettedgui | MR-1305-A

The authors performed a study to assess the effectiveness of using microworlds to train Army logisticians. The study was part of an effort to design new training for an emerging organization in the Army, the Theater Support Command, which, among other things, manages the flow of people and materiel throughout the theater of operations. The authors designed a three-hour training curriculum around a microworld model that represents a simplified but dynamic model of the distribution management process.

The Future of Warfare: Issues from the 1999 Army After Next Study Cycle
Walter Perry, Bruce Pirnie, John Gordon IV | MR-1183-A

What will be the nature of warfare thirty years into the future, and what is the Army's long-term vision of how it will prepare for and fight those wars? To help address these questions, the Army After Next cycle of events during FY99 included games on Army Special Operations, Army Medical Department, Information Operations, Space, Force Projection, National Security, Campaign Planning, Preassessment, and the Spring Wargame. The authors discuss issues that emerged from the games regarding coalition warfare, strategic preclusion, war with a nuclear-armed opponent, exploitation of space, sea control, air superiority, sustainment, combat in urban terrain, refugees during conflict, air mobility of battle forces, survivability of battle forces, and training battle-force soldiers.

Improving Army Planning for Future Multinational Coalition Operations
Thomas S. Szayna, Frances M. Lussier, Krista Magras, Olga Oliker, Michele Zanini, Robert Howe | MR-1291-A

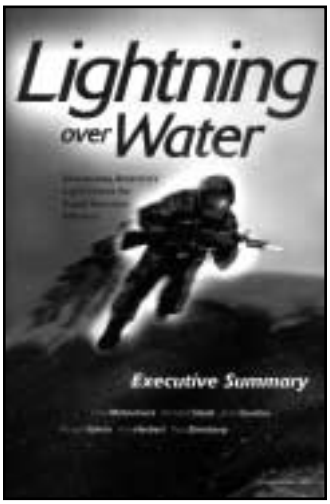
The Army currently lacks effective and appropriate processes to plan for enhanced multinational force compatibility. The current system was not designed for, and therefore is not capable of, supporting centralized oversight of multinational force compatibility activities. The authors address this problem by focusing recommendations on two primary issues, the management of resources and a means of prioritizing between partners and activities. On the first point, the authors point out the difficulties in identification and control over resources devoted to force compatibility and stress the need to sensitize the Army Program Evaluation Groups to provide the data required. On the second point, the study outlines a four-step integrated planning system that: (1) identifies the most likely long-term U.S. coalition partners; (2) provides a way to pinpoint the compatibility shortcomings of the potential partners; (3) links specific Army multinational force compatibility policies to the shortcomings; (4) allows for the determination of cost-effective resource allocation.

Issues and Insights from the 1998 Army Technology Seminar Game
Richard Darilek, Bruce Pirnie, Steve Drezner, John Gordon IV, Leland Joe, Walter Perry | MR-1299-A

The Spring 1998 Technology Seminar Game was designed to advance the AAN process by bringing together military operators and civilian scientists and technologists to examine future force development issues. It used 15 mini-scenarios extracted from previous AAN games. For each scenario, an overall mission and required force capabilities required to achieve that mission were identified beforehand. A set of system cards, used in the game as a means of achieving the required capabilities, was also preselected. The cards included information about the specifications of a particular system and the technologies that could be used to build those systems. System cards were thus the fundamental component of the game, linking systems and technologies to the required force capabilities. The players' involvement included examining the preselected cards, revising or adding new cards, and then cross-evaluating them with the intention of identifying the most important critical technologies of the future. The authors believe that while these scenarios can reveal many useful issues and insights with regard to technology's role in achieving future AAN force objectives, they do not extract the most value from such exercises. The linkages between force capabilities, systems, and technologies need to be sorted out more clearly, and the game organizers need to decide what kinds of discussions will produce the required information.

Keeping the Warfighting Edge: An Empirical Analysis of Army Officers' Tactical Expertise
Maren Leed | MR-1378-A

This document explores whether between 1990 and 1998 the tenure of key developmental assignments for infantry and armor officers became shorter; the tactical training during those assignments declined significantly; and earlier shifts in career patterns and training meant that such recent officers arrived in key positions with less experience than earlier generations of officers. The analysis finds that while some assignments did become shorter, especially for platoon leaders, on average the length of most key jobs was about the same across the time period. However, in terms of content, assignments involved less field training (much less for armor officers). Finally, there did not appear to be substantial changes in the overall career patterns of officers, except for lieutenants, who showed a rising propensity to serve on staffs at the expense of time as platoon leaders. These findings suggest that the tactical foundation of recent infantry and armor officers is weaker than it had been previously, most seriously at the junior levels. Establishing a mechanism to monitor the content of unit assignments is the most important action the Army can take to improve its officers' tactical development.



Lightning Over Water: Sharpening America's Light Forces for Rapid-Reaction Missions—Executive Summary
John Matsumura, Randall Steeb, John Gordon, Russell Glenn, Tom Herbert, Paul Steinberg | MR-1196/1-A/OSD

The strength of today's Army lies in its ability to fight and win a major theater-level war. It is easy to argue that the Army leadership succeeded, since no anticipated enemy force can match the firepower and maneuver capability of a combined arms mechanized U.S. force, equipped with the Abrams main battle tank, the Bradley infantry fighting vehicle, and the AH-64 Apache attack helicopter. However, smaller regional conflicts and crises are continuing to emerge around the world, and as the frequency of such events continues to increase, so does the need to adjust the U.S. capability for direct response to, and intervention within, these situations. This book represents a compilation of research drawn from numerous studies conducted in the past few years on the topic of improving light air-deployable forces. The focus is on new operational concepts along with the underlying enabling technologies. Three very different means for improving rapid-reaction capability are considered and analyzed in detail.

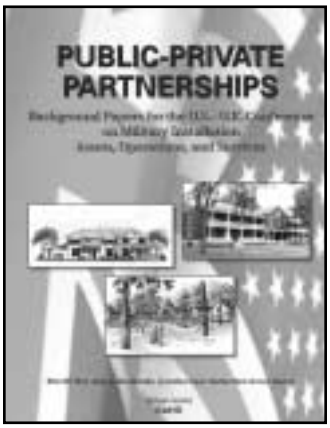
Preparing for Future Warfare with Advanced Technologies: Prioritizing the Next Generation of Capabilities
John Matsumura, Randall Steeb, John Gordon IV, Paul Steinberg | IP-215-A

A new era in military planning is under way. As the defense leadership attempts to define and prepare a more efficient and effective military from the top down, the services are selectively transforming key capabilities to meet the anticipated needs for warfare in the new millennium. Past planning emphasized developing a superior military capability by way of manpower and materiel that would in large part already be in place. Where parity in manpower could not be achieved, technology was implemented to level the playing field. Many "force multipliers" were designed and fielded, including the first generation of truly "smart" and precision-guided weapons. In this new era of planning, the immediate challenge is about understanding the problem, not just the "who" and the "where," but also the "why" and "to what extent." One fundamental

question is, "What capabilities are essential for the future, and how should they be prioritized?" This issue paper seeks to address this question, bringing to bear empirical analysis based on sophisticated modeling and simulation recently carried out by RAND researchers. In particular, using a scenario based on experiences in Operation Allied Force in Kosovo in 1999, researchers evaluate how three prioritizations of capabilities might play out in a similar small-scale contingency in the 2015 timeframe.

Protecting the Homeland: Insights from Army Wargames
Richard Brennan | MR-1490-A

In February 1996, the Chief of Staff of the Army directed U.S. Army Training and Doctrine Command (TRADOC) to conduct studies of future warfare. As part of these studies, TRADOC sponsors workshops and encourages franchise games in areas of interest. This report describes RAND Arroyo Center's analysis of homeland security. The insights and issues raised in this study address new and emerging threats and vulnerabilities of the United States to militarily significant attacks within the continental United States during times of conflict. The work broadly fits into the larger body of research relating to asymmetric warfare and counterterrorism.



Public-Private Partnerships: Background Papers for the U.S.-U.K. Conference on Military Installation Assets, Operations, and Services
Ellen M. Pint, John R. Bondanella, Jonathan Cave, Rachel Hart, Donna Keyser | MR-1309-A

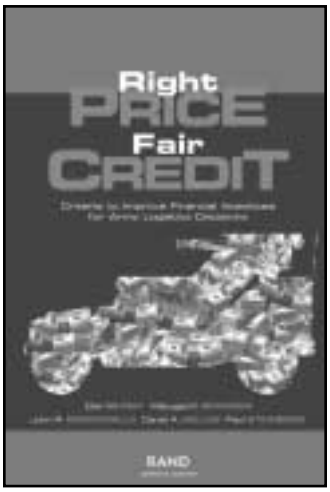
The U.S. Department of Defense and the U.K. Ministry of Defence (MoD) face a common challenge: to modernize their forces to meet changing military threats under reduced budgets. To meet this challenge, both organizations are increasingly interested in leveraging private-sector capital and expertise to provide defense activities and support services. This report provides an overview of private-sector involvement in the provision of defense support services in the U.K. MoD and the U.S. Army. It describes outsourcing and privatization initiatives in the United Kingdom from 1980 to the present. It then details the application of these initiatives to housing, base operations, and logistics services in the United Kingdom and offers examples of comparable U.S. Army initiatives. This report is based on background materials prepared for a three-day conference on privatizing military installation assets, operations, and services held in Oxfordshire, England, in April 2000. The conference brought together U.S. and U.K. defense officials, U.S. Army leaders, and business executives from both countries to discuss the British experience with privatization and explore its applicability to the U.S. Army.

Public-Private Partnerships: Proceedings of the U.S.-U.K. Conference on Military Installation Assets, Operations, and Services, April 14–16, 2000
Ellen Pint and Rachel Hart | CF-164-A

This conference report details the proceedings of the conference described in the abstract for MR-1309-A.

A Report on the Army Transformation Wargame 2000
Walter Perry, Bruce Pirnie, John Gordon IV, Louis Moore, Robert Howe, Daniel R. Gonzales, David Johnson | MR-1335-A

The Army Transformation Wargame 2000 was a free-play, operational strategic-level game held at the Army War College April 30 to May 5, 2000. It was designed to generate insights into demands on the future Army in a scenario of major theater warfare occurring in 2015 using a notional Objective Force. It focused on two themes: Why an Army? Why this Army (Objective Force)? ATWG demonstrated that the United States needs an Army to control large expanses of the earth's surface for extended periods of time, a mission no other armed service can accomplish. It also showed that rapid deployment of Army forces gives new options to deter prospective opponents and terminate conflict quickly. However, there will often be a window of opportunity early in a campaign when rapid deployment is needed. Thereafter, the United States might prefer to pause while it builds overwhelming force. Participants in the Strategic Insights Panel thought the Army should consider several operational concepts to hedge against failure in case an air-mechanized concept proves to be infeasible or unaffordable.



Right Price, Fair Credit: Criteria to Improve Financial Incentives for Army Logistics Decisions
Ellen M. Pint, Marygail K. Brauner, John R. Bondanella, Daniel A. Relles, Paul Steinberg | MR-1150-A

Under the Army's financial management system for spare parts, logistics customers receive budgets to buy spare parts from the supply system and receive credits for returning parts to the supply system, either for repair or because they are no longer needed in local inventories. The Army's wholesale inventories of spare parts are financed by a "stock fund," which uses its income from the sale of parts, net of credits issued to customers, to pay for repairs and procurement of replacement parts. Some installation-level, or retail, inventories are also financed by stock funds. During fiscal year 2001, the Army's stock funds were in a period of

transition from separate wholesale and retail components to a Single Stock Fund (SSF). As part of this change, the Army implemented new price and credit policies for spare parts. In this document, the authors introduce a set of criteria to assess price and credit policy changes in terms of their effectiveness in meeting the overall objective of maintaining the logistics customer's ability to meet mission requirements while keeping weapon systems in operating condition at the lowest total cost to the Army. The authors then use these criteria to compare and evaluate pre-SSF, SSF, and proposed future price and credit policies, and define the characteristics of an optimal Army price and credit policy.

Russia's Chechen Wars 1994–2000: Lessons from Urban Combat
Olga Oliker | MR-1289-A

Russian and rebel military forces fought to control the Chechen city of Grozny in the winters of 1994–1995 and 1999–2000, as well as clashing in smaller towns and villages. The author examines both Russian and rebel tactics and operations in those battles, focusing on how and why the combatants' approaches changed over time. The study concludes that while the Russian military significantly improved its ability to carry out a number of key tasks in the five-year interval between the wars, other important missions—particularly in the urban realm—were ignored, largely in the belief that the urban mission could be avoided. This conscious decision not to prepare for a most stressful battlefield met with devastating results, a lesson the United States would be well served to study.

Seeking Nontraditional Approaches to Collaborating and Partnering with Industry
Bruce Held, Kenneth P. Horn, Christopher Hanks, Michael Hynes, Paul Steinberg, Christopher Pernin, Jamison Jo Medby, Jeff Brown | MR-1401-A

The Army has a growing need to collaborate and partner with industry. This document describes three nontraditional approaches to that goal, namely (1) forming real-estate public-private partnerships (PPPs), (2) using Army venture capital mechanisms as a research and development funding and collaborating tool, and (3) spinning off Army activities into federal government corporations (FGCs). The research shows that while the three concepts appear promising, each requires resolution of key issues before it can be seriously considered for implementation. In the case of PPPs, issues include whether Army installations can propose financially sound concepts. In the case of venture capital, the potential merits of such a concept to meet the Army's technology needs must be addressed in further detail. In the case of FGCs, the value of establishing the Army laboratories and depots as FGCs will depend on how many external commercial opportunities exist and further analysis of how best to structure continuing relationships with other Army organizations. Once these key issues are satisfactorily addressed, the Army should create pilot programs to test the concepts.

Smart Management of R&D in the 21st Century: Strengthening the Army's Science and Technology Capabilities
Kenneth Horn, Carolyn Wong, Bruce Held, Elliot Axelband, Paul Steinberg, Sydne Newberry | IP-210-A

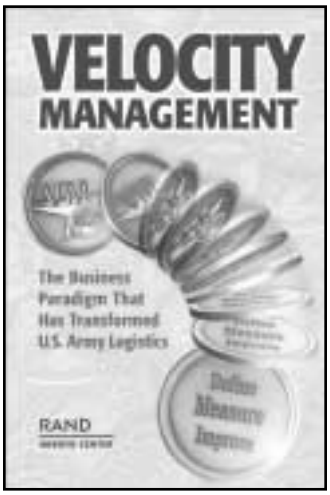
This issue paper discusses ways the Army can maintain robust and innovative science and technology capabilities in the 21st century. The quality of the Army's technology has given it a decisive edge in recent conflicts. But declining budgets and technical workforce have eroded the Army's ability to maintain such an edge. Simultaneously, competition from the private sector has made it difficult to attract new scientists and engineers into the Army's civilian workforce. This paper argues that an integrated strategy of smart outsourcing, expanded collaboration with industry, and optimal in-house research and development will enable the Army to be the smart buyer and provider it must be to meet the science and technology goals necessary to complete the Army's transformation.

Super Bowl Surveillance: Facing Up to Biometrics
John D. Woodward, Jr. | IP-209-A

The use of biometric facial recognition technology raises concerns about its potential dangers to privacy rights. The author examines the use of this technology at the Super Bowl in January 2001, exploring the countervailing benefits to national security and law enforcement. The author concludes by offering policy recommendations to help maximize the technology's utility while minimizing its threat to our privacy.

Taking Stock of the Army's Base Realignment and Closure Selection Process
William M. Hix | MR-1337-A

The Army has been doing its part to help downsize the defense establishment, closing 23 major installations in the four rounds of base closures and realignments, closing many more minor installations, and realigning others. Nevertheless, many believe that excess installation capacity remains, so more rounds are sure to come. The Army's process for selecting installations has received the most praise among those of the military departments, but it can be improved. Important steps in an improved process might include inventorying assets at all installations; estimating future requirements; being explicit about uncertainties and considering long-term trends; developing alternative ways to allocate the requirements to specific assets; for all these alternatives, estimating the costs both of individual transactions and of entire alternative packages; and taking into consideration such externalities as political, environmental, and community influences. In all this, it is important to keep in mind that the current use of a given installation may not be the best use.



Velocity Management: The Business Paradigm That Has Transformed U.S. Army Logistics
John Dumond, Marygail K. Brauner, Rick Eden, John Folkeson, Kenneth Girardini, Donna Keyser, Eric Peltz, Ellen M. Pint, Mark Y.D. Wang | MR-1108-A

Velocity Management has brought a new way of doing business to U.S. Army logistics, with a sharpened focus on the Army customer and a powerful approach for process improvement that cuts across three critical performance dimensions: time, quality, and cost. The goal is to reduce the need for massive logistics resources by increasing the speed and accuracy with which materials and information are delivered. Key logistics processes are defined, measured, and improved continuously, so that customers (Army units in garrison and deployed worldwide) get what they need, when they need it, and at minimal cost. Today a high-velocity, streamlined supply process delivers repair parts in less than half the time it took to deliver them just three years earlier.

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