RAND Arroyo Center
ARMY RESEARCH DIVISION

Meeting Tomorrow's Challenges

Annual Report 2000

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Contents

The United States currently enjoys widespread prosperity and a dominant position in the world. But neither its prosperity nor its dominance preclude significant challenges. And, of course, the Army will face its own subset of problems to solve. This year's Arroyo Center annual report focuses on five prominent challenges: recruiting and retention, the rise of potential adversaries, installation structure, improving readiness, and retaining scientific and technical expertise. For each, we outline the most salient results from Arroyo Center's analysis.

Recruiting. For many years the Army had no difficulty filling its ranks with high-quality youth. But a combination of factors (including a prosperous economy and rising returns to the educated) have complicated that task. Our analysis indicates that the Army must now focus its efforts more broadly.

Potential adversaries. The most serious challenge to the United States could come from a peer competitor. The rise of such an opponent is not preordained. Analysis suggests that the actions we take as a nation can decisively influence whether a potential competitor becomes an ally or an antagonist.

Installations. In spite of much success in trimming the installation base as part of the Base Realignment and Closure (BRAC) process, the Army has still has a way to go before its installations are "right sized." Arroyo Center research shows that significant change outside of a BRAC or BRAC-like process is unlikely, so the Army should welcome and even press for another round of closures. Key to the process is a long-term vision for the Army's installation infrastructure.

Readiness. The Army has made impressive gains in its logistical processes by applying Velocity Management principles. However, the major dividend to the warfighter—improved readiness—has not yet been paid. To assist, Arroyo Center researchers have developed an analytic tool, the Equipment Downtime Analyzer, that gives the Army a way to examine the link between logistics processes and equipment readiness. It enables the Army to determine which parts of the process are delaying equipment repairs.

Retaining scientific and technical expertise. Since advanced technology underpins the Objective Force, the Army must have knowledgeable people who can serve as "smart buyers" and meet industry representatives on a level playing field. Unfortunately, the robust economy and the premiums those with technological skills can command make it difficult for the Army to attract and retain scientists and engineers. We believe that the Army can get the access to the advanced technology through a mix of strategies. The Army needs to retain in-house expertise, but primarily for technologies that are uniquely military. Collaborating with industry and outsourcing will give the Army access to technologies that have wider applications. New contracting vehicles such as Other Transactions, which are free of many burdensome federal regulations, can give the Army access to advanced technologies being developed by firms that would not normally do business with the government.

The Arroyo Center has been privileged to work with the Army in devising ways to meet these challenges. We are grateful for the support and assistance so many have provided, and we welcome the opportunity to work with the Army to meet the challenges the future might bring. ■

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. Paul J. Hoeper (Co-chair), Assistant Secretary of the Army (Acquisition, Logistics and Technology)

Mr. Patrick T. Henry, Assistant Secretary of the Army (Manpower and Reserve Affairs)

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

Mr. Gayden E. Thompson, Deputy Under Secretary of the Army (International Affairs)

General John W. Hendrix, Commanding General, U.S. Army Forces Command

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

General John G. Coburn, Commanding General, U.S. Army Materiel Command

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

Lieutenant General Kevin P. Byrnes, Deputy Chief of Staff for Programs, U.S. Army

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

Lieutenant General Larry R. Ellis, Deputy Chief of Staff for Operations and Plans, U.S. Army

Lieutenant General Charles S. Mahan, Jr., Deputy Chief of Staff for Logistics, U.S. Army

Lieutenant General Timothy J. Maude, Deputy Chief of Staff for Personnel, U.S. Army

Lieutenant General Robert W. Noonan, Jr., Deputy Chief of Staff for Intelligence, U.S. Army

Executive Agent for the Arroyo Center

Major General A. J. Madora, Director, Program Analysis and Evaluation, Office, Deputy Chief of Staff for Programs, U.S. Army

Recruiting the Force: Innovative Programs to Attract More Good Soldiers

Nothing is more important to the Army than the people who fill its ranks. Yet for the first time in a generation, the Army is finding it difficult to recruit the soldiers it needs. And the prospects for the future are not much better.

In the early 1990s, the goal for new recruiting was cut below the level necessary to sustain the force. This allowed the services to shrink with the end of the Cold War without having to force out many of its members who wanted to stay or pay them large sums to induce voluntary separation. But it also meant that the services would face an upswing in accession requirements once the cuts had been achieved. Indeed, recruiting requirements began to increase sharply in fiscal year 1996. Shortfalls emerged and increased in the late 1990s, and longer-term trends are not favorable.

The recent booming economy and resulting low unemployment rate mean that the military must compete in a job market that offers many alternatives to young people who are making career choices. How long the boom will continue is unknown, but it will continue to pose difficulties for recruiting and retention until it runs out of steam.

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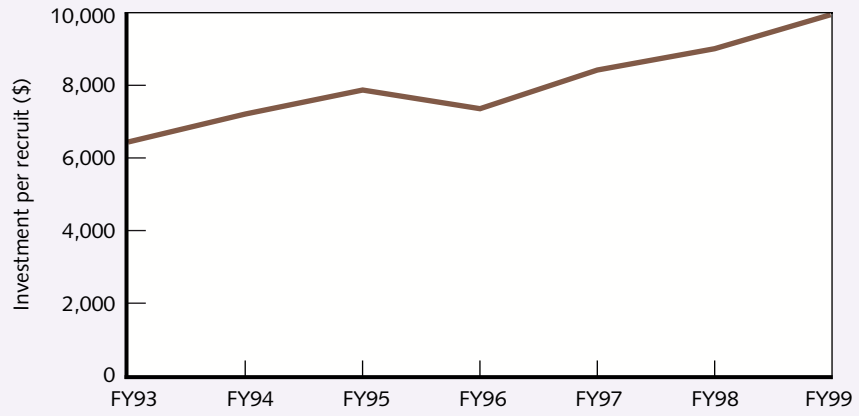
The increased financial benefits of higher education can be expected to attract more youth—especially high-aptitude high school graduates—to college at the same time that the military's demand for such people could increase. The long-term outlook would not be disturbing if the military could afford to see its traditional source for high-quality recruits shrink. But the future force will need technological prowess and operational flexibility; it is unlikely that the military's demand for high achievers will fall.

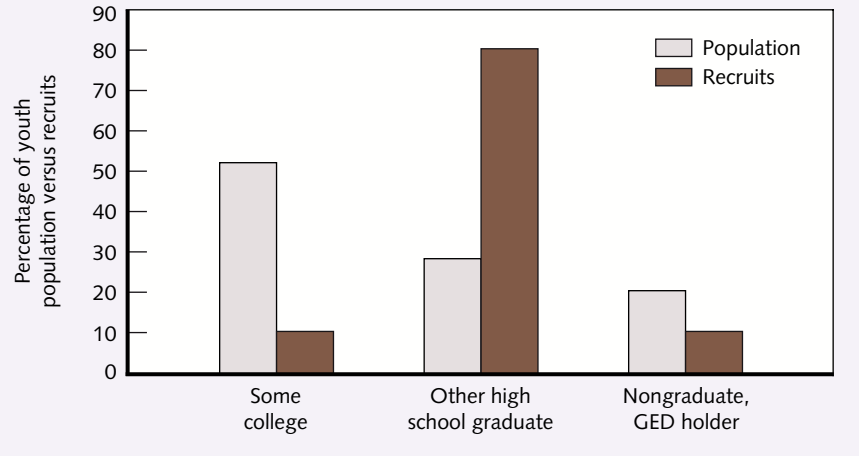
It is possible, as the United States continues to be involved in military operations for humanitarian missions, disaster relief, peace enforcement, and other purposes, that the services will seek not just to meet current recruiting targets, but to increase the number of their personnel.

FIGURE 1



Cost of Recruiting

FIGURE 2



Target Populations and Recruits

Services Have Increased Recruiting Resources

In response to their recruiting difficulties, the services have substantially increased the amount they spend on recruiting. Figure 1 illustrates this increase as the "investment per recruit," the yardstick kept by the Office of the Secretary of Defense. This index includes educational benefits, money for enlistment bonuses, advertising dollars, recruiter costs, and some recruiting support. The index shows that across the four services, the investment per recruit increased from just over $6,000 in 1993 to about $10,000 per recruit in 1999. That is an extremely large increase, about 50 percent in relative terms.

How did the market respond to this increase? Unfortunately, things actually deteriorated, not because of the increase in recruiting resources, but in spite of it. This raises a concern that further increases in resources, while a necessary part of the strategy to deal with recruiting difficulties, may not alone be sufficient to address potential recruiting shortfalls.

Demographic Changes Require New Strategies

One key to improving the recruiting picture can be found in RAND research indicating that the military's traditional recruiting strategy is mismatched with the distribution of today's youth population.

In Figure 2, the dark bars show the Army's current recruiting strategy; the light bars show the distribution of the 18- to 24-year-old youth population that the Army recruits from. Note in the center of the chart that the Army is trying to take 80–85 percent of its recruits each year from high school graduates (which includes those with less than a year of college). However,

this group today makes up only about 25 percent of the youth population, and that number is shrinking each year. On the other hand, the Army takes only 5–10 percent of its recruits from those with some college, i.e., a year or more, as shown on the left. As indicated by the light bar, this group makes up more than 50 percent of the youth population, and it is growing. Clearly, this is a mismatch that the Army cannot afford; it needs to improve its position substantially within the college market. At the right of the chart, we see a second mismatch among those without a high school diploma. Consistent with the standard imposed by the Office of the Secretary of Defense, the Army has taken only 10 percent of its cohort each year from this group, but the group makes up 20 percent of the youth population and, if anything, is growing larger.

RAND and the Army Work Together to Find a Solution

RAND and the services have worked together to address recruiting issues throughout the history of the All-Volunteer Force, and in recent years they have focused specifically on the difficulties confronting military recruiting during the post–Cold War drawdown era.

In the spring of 1999, with the Army projected to fall well short of its 1999 recruiting objective and recognizing that the traditional approach was not working, the Army Secretariat requested RAND's assistance in developing programs to address the recruiting shortfall. That collaboration resulted in two experimental programs: College First and GED Plus. The two programs are not solutions in and of themselves; rather, they are part of the Army's larger strategy to minimize potential recruiting shortfalls.

College First aims to improve penetration of the high-quality college market by enabling high school graduates to attend college and acquire an Associate of Arts (AA) or vocational degree before active duty. GED Plus helps to expand the market by accepting more high-aptitude recruits who achieve alternative high school credentials.

College First Targets the Large Market of College-Bound Youth

The College First program is targeted at a potentially large market of young people who are interested in attending junior college or vocational school. Research suggests that many such youth have high aptitude as well as potential interest in joining the military. Some are in high school, and some have started college and then stopped for financial or other reasons. The most significant characteristic of this group is that they do not want to put their education on hold while they go on active duty. Thus the name of the program, "College First."

The College First program is targeted at a potentially large market of young people who are interested in attending junior college or vocational school.

How Does It Work?

To help attract its target market, College First provides incentives to help cover the cost of going to school. It does that by

paying a monthly stipend of $150 for up to two years while the recruit earns an AA or vocational degree, and repaying school loans after the recruit actually begins active duty.

The program offers other incentives that are designed to address the wage premium earned by youth obtaining an AA degree relative to a high school graduate with no college education. RAND research suggests that youth with an AA degree earn about 20–30 percent more than those without. So the Army allows College First participants to enter the Army at pay grade E4 rather than E1, which means they get a higher salary and benefits as soon as they begin active duty. The Army also pays them a "high grad" bonus of $8,000. This does not completely match the AA wage premium, but it does amount to more than a 20 percent premium compared with those recruits who enter the military at normal grade and pay.

While they are in the College First experimental program, participants must either join the Delayed Entry Program or serve in a drilling reserve unit. This is an important feature, since reserve service is the only provision that provides an immediate payoff to the Army during the two-year College First period (by putting the college attendee in uniform). Reserve service also could offer financial advantages for the youth, because reserve drilling pay is substantial, exceeding the $150 monthly stipend. However, we are uncertain how many youths who might be willing to participate in College First would be unwilling to do so if they must drill in the reserve at the same time as attending classes. This potential downside needs to be quantified and will be evaluated as part of the experiment.

College First Soldiers Will Perform Better

It makes sense from a numerical standpoint for the military to focus recruiting efforts on the large numbers of young people who are college bound. But there is another reason for focusing on this market: the higher-aptitude young people whom the Army would like to recruit are concentrated disproportionately in the college market.

The Army wants higher-aptitude youth because studies show that they perform better than their lower-aptitude counterparts. These studies have measured performance on actual wartime jobs, and the results are not only consistent but robust for numerous occupational specialties and outcome measures.

GED Plus Brings in New Recruits Right Away

The second experimental program, GED Plus, targets young people who lack a high school diploma and helps them enroll in a state or local program to obtain their General Educational Development Equivalency (GED) certificate before they go on active duty with the military.

How Does It Work?

GED Plus is designed to improve the Army recruiting picture right away by bringing in up to an additional 6,000 recruits. Four thousand of these recruits would come on active duty as soon

as they obtain their GED credentials, and 2,000 are targeted for the reserve.

In one of the experimental groups, enlistment incentives would be enhanced to equal those offered to high school graduates with the hope of gaining an additional 1,000 recruits who already hold GEDs. The reason for this is that the market is sufficiently difficult today that the Army is having trouble recruiting the number of high-aptitude GEDs allowed under the 10 percent cap set by the Office of the Secretary of Defense.

GED Plus targets young people who lack a high school diploma and helps them enroll in a state or local program to obtain their General Educational Development Equivalency (GED) certificate before they go on active duty with the military.

The screening criteria used for GED Plus are more extensive and tougher than those used for high school graduates. To begin with, all the youth who participate in this program have to score in the upper half of the distribution on aptitude (Armed Forces Qualification Test categories I–IIIA). This will help ensure satisfactory job performance.

Second, they will have to score in the top 75 percent on the Assessment of Individual Motivation test. This test was developed by the Army Research Institute. The institute has found that persons scoring in the bottom quartile have substantially higher loss rates over the first term of service. Thus, they will not be allowed to participate in this program.

Participation is also restricted to youth who left high school of their own choice—i.e., they were not told to leave—and who are now ineligible to return, primarily because of age. There is no intent to compete with high schools for these youth. Rather, the intent is to help youth who may not have an alternative means of acquiring their GED.

Finally, waivers will not be granted for moral or drug/alcohol offenses to enable participation in this program. Again, this is a tougher yardstick than that used for high school graduates.

Nongraduates Have Higher Attrition, But the Attrition May Be Manageable Over Time

Traditionally, recruits who have not graduated from high school have had higher loss rates over the first term of service than youth with high school diplomas. To see if this was still true, we followed up recent recruits—those who entered the military in 1994 to 1997—and assessed their loss rates over the first term of service. Our results were consistent with those of earlier studies. Entrants without traditional high school diplomas had higher loss rates over the first term; the difference was about 10 to 15 percentage points.

However, the nondiploma group represents about 20 percent of the youth market and may be growing, so this market cannot be ignored. And these nongraduates are disproportionately minority youth, so excluding them would raise equity issues. Moreover, this group represents a viable recruiting market, since there is distinct variability in loss rates over the first term depending on the subgroup. For example, minorities with lower educational levels tend to have

loss rates similar to those of whites with more education. In particular, Hispanic nongraduates tend to have loss rates over the first term that are close to those of white high school graduates. Clearly, the military is not going to recruit by race/ethnicity. Rather, the key is to find measures that quantify the relationship between various background factors underlying the differences in loss rates and early departures and to use those measures to select youth who have the greatest potential for success in the military.

How Will We Know If the Programs Are Successful?

The two pilot programs are being tested in a national experiment that started in February 2000 and will run for four years. This experiment is patterned after other national recruiting experiments conducted by RAND in the 1980s and 1990s.

To determine the success or failure of these programs, we will look at how well they perform in a balanced set of areas across the country and compare them with recruiting outcomes in areas that do not offer the programs.

We balanced the recruiting areas on an extensive set of factors to obtain a distribution in which each test cell's average for a factor is close to the national mean. And, indeed, they are. These factors include

- Geography
- Past recruiting production
- Recruiting quotas as well as the number of recruiters and advertising dollars
- Demographic and economic characteristics.

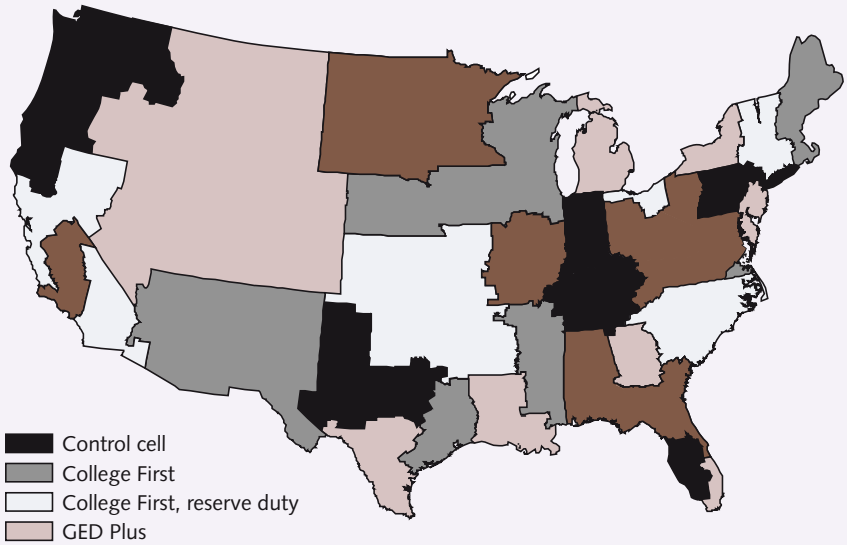
Educational factors include the level of education attained by the residents and whether there are other Army programs that offer funding for college (in particular, the programs offered by the Army National Guard).

Figure 3 illustrates the distribution of the test cells across recruiting areas. The control cell is one of five test cells that each make up 20 percent of the youth population of the country. College First is offered both with and without a mandatory reserve duty requirement. GED Plus is offered without enhanced incentives and with the same incentives as are offered youths with high school diplomas.

As we test the two experimental programs, we are looking for several key outcomes. First, we are looking for market expansion. This means that the new programs produce enlistees the Army would not have gotten otherwise, but they do not reduce any of the enlistments the Army would have gotten absent the test programs. The new programs will do the Army no good if instead of bringing in new recruits they simply trade those individuals against other recruits that the Army would obtain in the absence of the programs; of particular concern is that the GED Plus program not reduce enlistments among Armed Forces Qualification Test category I–IIIA youth with traditional high school diplomas.

We are also interested in whether there is a need for enhanced enlistment incentives in both programs. For example, it may be that the College First monthly stipend currently sized at $150 and the loan repayment program are insufficient to provide the expansion into the college-bound market that the Army urgently requires. We will thus compare the magnitude of the market expansion against other estimates of the potential in the college-bound market to determine if more generous incentive packages are required. In the case of GED Plus, we are interested in the amount of expansion in the enhanced-incentives cell relative to that in the basic incentives cell. How many additional recruits are obtained and at what cost?

FIGURE 3



Distribution of Test Cells

Last, attrition rates and their relation to the screening criteria under GED Plus must be quantified, and loss rates under College First during the two-year school period need to be assessed.

Stay Tuned for Early Findings

Although this is a four-year test, because the number of enlistments and new potential recruits is large, the initial results will be available long before that. We are just now getting basic results on enlistments and some results on attrition. The latter requires more time because participants have to be allowed to go on active duty, and then there has to be adequate time to follow them up and determine loss rates.

If the initial results are encouraging and strong in their implications, then they can be used to recommend permanent adoption of the pilot programs without waiting for the four-year test period to be concluded, in order to obtain their full benefits in the near term. On the other hand, if the early results indicate that changes in the programs are required, then the programs can be modified accordingly and evaluated in their revised form during the remainder of the test period. ■

Peering into the Future

The role the United States is playing on the world stage today is unparalleled in its history. It has no significant opponent, is allied with most states that could compete with it on anything approaching equal terms, has the largest and most robust economy in the world, has the largely dominant ideology, and has a military that guarantees the security of the homeland from any major conventional threat. In such a rosy situation, what could go wrong? For one thing, the United States could fail to recognize the rise of a state or alliance that could compete with it on equal terms (as a peer) soon enough to respond. Too prompt a response, however, is as foolish as moving too slowly. By reacting prematurely, the United States could exhaust its resources and transform a potential ally or neutral state into a competitor. The potential emergence of a peer competitor is probably the most important long-term planning challenge for the Department of Defense.

By reacting prematurely, the United States could exhaust its resources and transform a potential ally or neutral state into a competitor. The potential emergence of a peer competitor is probably the most important long-term planning challenge for the Department of Defense.

RAND Arroyo Center researchers addressed this issue by developing a conceptual framework of how a potential peer (called a proto-peer, meaning a state that is not yet a peer but has the potential to become one) might interact with a dominant global power (called a hegemon). Then, using exploratory modeling techniques, they examined the interaction of the various proto-peer and hegemon interactions as a way of identifying specific patterns and combinations of actions that might lead to rivalries.

What Is a Peer Competitor, and How Might One Arise?

For a state to be a peer, it must have more than a strong military. Its power must be multidimensional, including economic, technological, and intellectual components, and it must be capable of harnessing these capabilities to achieve a desired policy goal. For a proto-peer to become a competitor (and thus a danger to the U.S. position) it must also have the desire to challenge the status quo and the rules of the international system that are largely upheld by the hegemon. To be a true peer, it has to be capable and willing to challenge the hegemon on a global scale, and such a challenge must also have some possibility of success.

Analytically speaking, the problem confronting a proto-peer is how to aggregate power as fast as possible without alarming the hegemon and provoking a response that would reduce

the proto-peer's pace of growth. A proto-peer has four main roads to becoming a peer: reform, revolution, alliances, and conquest. These terms are analytical constructs rather than conscious strategies a state might adopt on its ascent to power. A proto-peer can be expected to pursue more than one strategy simultaneously, but generally one will dominate. Externally focused strategies (alliances and conquest) have the potential to aggregate power faster than internally focused ones (reform and revolution), but they are also more likely to threaten the hegemon and provoke a hostile response from other states. Especially when the hegemon dominates at a global level, a proto-peer must tread carefully, since it faces a potentially devastating response that could delay or end its aspirations of becoming a peer.

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A **reform** strategy refers to the process of accruing power by increasing the proto-peer's national resources, or "inputs," by such means as improving the educational base or devoting greater funds to scientific research and development efforts. This strategy is incremental and generally respects the accepted "rules" of the international system. Since this strategy is relatively predictable and since it follows the rules of the existing system, the hegemon has considerable time to respond and is unlikely to be threatened by a proto-peer that pursues it.

Revolution focuses on the dramatic transformation of a state's ability to extract resources by such means as more effective governance or substantial improvement in the country's capability to provide resources for state goals. This strategy contains more uncertainty, but it has the potential to increase a state's power greatly and relatively quickly. The unpredictability of the strategy—revolutions often bring new governments as well as new capabilities—means that the hegemon may have less time to respond (and thus will feel a greater sense of potential threat). The hegemon will want to keep a wary eye on a proto-peer following such a strategy.

An **alliance** strategy, entailing an alliance by a proto-peer with another major state, poses a clear challenge to the hegemon because of its potential to overturn the status quo and reduce the hegemon's dominant role in the international state system. The effect of an alliance on power calculations is immediate, and although effective integration of the allies is likely to take many years, the hegemon can only see such a move as threatening.

A rising power can also attempt to increase its power by way of a **conquest** strategy, forcefully subjugating another state. Such a strategy immediately changes power calculations and represents an overt attempt to overturn the existing order. Typically, such a strategy requires large and capable military forces, both to make the conquest and to consolidate its gains. Not surprisingly, the hegemon finds this strategy highly threatening.

Possible Hegemon Responses

In analytical terms, the problem facing the hegemon is how to remain one, for as long as possible and at an acceptable cost. A peer does not arise in a vacuum. If the hegemon sees a potential peer competitor emerging, it will act to impose additional costs upon the proto-peer to slow down its growth and prevent a challenge from emerging. However, the hegemon wishes to avoid conflict because it can be expensive, may alienate allies, and can lead to overextension.

The problem facing the hegemon is how to remain one, for as long as possible and at an acceptable cost.

A hegemon could respond in a number of ways, and Arroyo Center researchers posit four: conciliate, co-opt, constrain, and compete. Like the hegemon strategies, these terms are analytical constructs, and the primary difference among them is the level of conflict with the proto-peer, with "conciliate" representing the least conflict and "compete" the most. The goal of the strategies is to preclude any proto-peer from metamorphosing into a "principal rival," reminiscent of the Cold War.

Conciliate, as its name implies, entails mostly cooperative behavior by the hegemon and is designed to increase common goals and limit friction. The hegemon expects the proto-peer to be an ally rather than a competitor as it grows in power, and its actions toward such a proto-peer are relatively free of conflict. Inherent in this strategy is the hegemon's view that the proto-peer does not pose a fundamental threat, even if it matches the hegemon's capabilities, because the states have similar or compatible interests.

The **co-opt** strategy is a hedging strategy designed to increase the proto-peer's stake in the status quo, thus reducing the motivation to change it. It is primarily a "carrots" approach, but the cooperation is more conditional than in a conciliate strategy. The hegemon is willing to let the proto-peer's power rise, but only if it modifies its behavior sufficiently so that it does not threaten the rules of the international system or the status quo.

If the co-opt strategy hinges on "carrots" as a way of causing a proto-peer to respect the international rules of the game, the **constrain** strategy is a hedging approach that employs "sticks." Its goal is to delay peer status without provoking a military conflict. The hegemon concludes that the proto-peer is likely to become a competitor and, to moderate its rise to power, aims to make clear the costs of such a competition. Conflict predominates in such a strategy, although the hegemon still sees a possibility of forestalling the emergence of a long-term competitor. Should the proto-peer moderate its behavior, the hegemon can modulate its strategy, holding back on the stick if the proto-peer becomes more conciliatory.

The **compete** strategy is primarily one of conflict designed to impose costs on the proto-peer, reduce its power, and preclude it from achieving peer status. Ideally, the conflict is not military, but that is the ultimate risk of this strategy. Given the high costs of the compete strategy, the hegemon must conclude that competition with such a proto-peer is inevitable, that the

proto-peer poses a fundamental threat, and that the risks of not engaging in a strategy of conflict outweigh its costs. This strategy offers little positive reinforcement, since the competition is seen in zero-sum terms. Once adopted, such a strategy may be difficult to modify or abandon.

As with the proto-peer strategies, the hegemon can blend strategies. However, the hegemon must walk a fairly narrow line: too much conciliation can speed the growth of a competitor, and too much conflict can do the same. The time horizons associated with the strategies tend to be very long, which means that all the choices are clothed in a good deal of uncertainty.

The Role of Modeling

Predicting the emergence of a peer competitor is exceedingly difficult. However, aggressive proto-peer strategies and a hegemonic response high in conflict imposition are likely to lead to a rivalry and competition.

By using exploratory modeling techniques, the Arroyo Center research models the interaction of the various proto-peer and hegemon strategies to clarify specific patterns and combinations of strategies that might lead to rivalries. The modeling starts with the idea that projections and assessments of relative power growth lead to strategy choices and that the four possible strategies each side can employ interact to produce dynamics of their own. The model is a reasoning tool rather than a forecasting one. It is useful for understanding the implications of decisionmaking represented in the decision rule, though it has the potential to be developed into an operational tool.

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Modeling provides insights into the conditions that lead to competition, the pivotal attributes of the players, the potential policy results from different assessments, and the variation in value of intelligence assessments across alternative situations. The model illustrates how a hegemon's perceptual error can easily escalate competition. Because strategies are chosen on the basis of projections and expectations over a long time frame, inaccuracies in the hegemon's assessments of either the power of the proto-peer or how fast its power is growing can compound over time and may cause the hegemon to adopt a nonoptimal strategy that results in conflict and costs that might have been avoidable. The perception errors of a proto-peer, however, are less influential in leading to competition. Because of the proto-peer's inferior power, its perceptual error would have to be massive—or it would have to be very close to actual peer status—for its misperceptions to have sufficient influence to alter strategy.

The model also shows that a hegemon is more prone to perception error when faced by a powerful proto-peer. The hegemon is likely to be highly sensitive and may overreact to limited or ambiguous information. Thus, for small values of proto-peer state power, the hegemon is not threatened, and the proto-peer sees a clear differential in capability, regardless of per-

The United States too must strike the right balance in finding policies that are not overly confrontational toward potential peers but also do nothing to hasten their rise.

ceptual errors. Conflict remains at low levels. Similarly, for large initial values of proto-peer power (in other words, when already facing a peer), perceptual errors do not affect the play of either side. But for intermediate values of initial proto-peer power, escalation can occur. The model allows for thinking more clearly about the circumstances under which intelligence assessments may have a strategy-changing impact and thus must be especially scrutinized for perceptual error.

The Arroyo Center work has several implications for long-term defense policies. With the predominance that the United States currently enjoys, emergence of a peer competitor stems as much from U.S. actions as it does from those of potential peers. The United States can act either to delay the emergence of a peer or to try to moderate its potential competitive tendencies. Potential peers have a limited number of roads to becoming peers, and they face a difficult balancing act between aggregating power without simultaneously alarming the United States. On the other hand, the United States too must strike the right balance in finding policies that are not overly confrontational toward potential peers but also do nothing to hasten their rise. The long-term assessment of any potential peer to the United States must always be alert to the possibility of error, because miscalculation can lead to unnecessary escalation and potential rivalry that would be difficult to undo. ■

Right-Sizing Army Installations

The Army maintains a large, sprawling complex of installations to support its operations. These include major posts, training areas, schools, industrial facilities, proving grounds, and ammunition plants to name a few. They spread across the United States and, indeed, the globe, with installations in Europe, Asia, and elsewhere. The current set of installations within the United States largely results from the mobilizations the country went through for World Wars I and II. Following the Cold War, it was clear that, in light of the new geopolitical realities, the military services could do with a smaller base structure.

Closing bases is always politically contentious, and Congress has jealously guarded its right to participate in decisions that affect military bases or their workforces. In 1988, the Secretary of Defense chartered a commission to identify bases for closure and realignment. The Congress supported his initiative with legislation that provided relief from certain statutes. Then Congress passed the Defense Base Closure and Realignment Act of 1990, which authorized three further rounds in 1991, 1993, and 1995. The four rounds were relatively successful, resulting in DoD closing 97 major installations, 23 of which belonged to the Army, and realigning numerous other ones.[1]

Although successful in many ways, the base realignment and closure (BRAC) process left the Army with a substantial number of CONUS installations. Moreover, the installations that remain are not optimized for the Army's purposes. There are too many small, single-function installations, and some carry out redundant functions. Furthermore, although the BRAC process encouraged consideration of cross-service closings, none occurred.

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Much of the difficulty in obtaining an optimum base structure was inherent in the BRAC procedures. The services were constrained to a relatively short time horizon, because their recommendations had to be based on the force that was defined for the six years following the commission. Furthermore, many costs of closing a post had to be paid out of the service's current operating budget. Both provisions caused the services to take a relatively short-term view, concentrating on installations whose closings would not require high initial costs and would yield savings relatively quickly. This approach minimized the drain on current operating funds

[1] U.S. General Accounting Office, *Military Bases: Lessons Learned from Prior Base Closure Rounds*, GAO/NSIAD-97-151, June 1997, p. 17.

and yielded the cost savings sooner. But it ignored potential realignments and closures with high front-end costs but large long-term savings.

An Approach to Right-Sizing

The current situation is that the Army has a set of CONUS installations that is probably larger than it needs to be and does not support operations as well as it could. But, recent BRACs notwithstanding, closing installations remains difficult. This article offers two suggestions about how the Army might approach right-sizing its installations.

- First, recognize that the current structure does not optimize the Army installations but that any significant base closures will not occur outside of a BRAC or a BRAC-like process. Therefore, the Army should support and, indeed, even press for another round of BRAC closings.
- Second, assess the recent BRAC process to identify lessons that might assist in future efforts to tailor the installation structure.

Current Installation Structure Not Optimal

Even a cursory review of the current installation structure shows it to be less than optimal for the Army's purposes. It still contains many single-function installations, and it does not align its unit needs with installation capabilities.

The Army might combine certain of its training and professional school installations with some of its eleven maneuver posts, not only to save money but also to enhance the export of doctrine and provide the schools quick feedback from tactical units.[2] Similarly, in the long run, the Army might consolidate its arsenals and ammunition plants on large, multifunction installations. Even in the near term, there may be opportunities to consolidate these industrial facilities onto fewer existing sites or to privatize these activities.

Maneuver area is a growing concern for the Army's combat units. As units increase their capabilities to acquire and attack targets at greater distances, they require ever-larger maneuver training areas. Increasing the maneuver area available to combat units is quite difficult, as seen in the multiyear effort to expand the National Training Center. However, the Army's major combat units are not stationed at the installations with the most maneuver area. The two posts with the most land are Fort Bliss (about 1.2 million acres) and White Sands Missile Range (about 2 million acres). By contrast, the National Training Center, considered the Army's premier training site, has fewer than 700,000 acres. Yet no combat units are stationed at either Fort Bliss or White Sands. Looking across the services, Nellis Air Force Base has more than three million acres. While most of this land belongs to the Bureau of Land Management and is used

[2] Forts Hood, Lewis, Bragg, Stewart, Carson, Campbell, Drum, Riley, Wainwright, and Richardson, and Schofield Barracks, were designated maneuver installations.

by the Air Force for specific training purposes, it is clearly feasible to get approval to use it for Army purposes as well. Locating Army maneuver units there would not only give them large maneuver training areas but would also provide increased opportunities for joint coordination.

BRAC: The Sine Qua Non

It is one thing for the Army to recognize that it has a suboptimal installation structure. It is quite another to rectify the problem unilaterally. The history of DoD's attempts to close or realign installations on its own has been dismal. Indeed, when it has tried to act unilaterally, the pattern has generally been that Congress stops the proposed action and then imposes additional limits what DoD can do with respect to installations. This issue traces back to 1965, when DoD attempted to close several bases without what Congress perceived as due consultation. The specific issue revolved around a request for funds in the FY 1966 Military Construction Authorization Act, which President Johnson initially vetoed rather than cede authority for base closings to Congress. The act that was finally passed restricted DoD's base-closing authority to installations with populations of fewer than 250 military and civilian personnel. A 1976 attempt to close or realign 85 bases played out similarly, failing to close the bases and producing legislation limiting DoD's ability to act independently.[3]

It is one thing for the Army to recognize that it has a suboptimal installation structure. It is quite another to rectify the problem unilaterally.

Even when a service has the statutory authority to act independently, it is not always able to do so, as the example of the Fort Lee library illustrates. Fort Lee had a small, dated library that had never employed more than ten people, none professional librarians. Furthermore, the surrounding civilian community had 15 libraries, all offering more capability than the one on post and easily accessible to military personnel. Moreover, a county bookmobile was available to the installation. Closing the library was well within the authority of Fort Lee's commander, and he decided to do so and devote those resources to more pressing community concerns. The Training and Doctrine Command commander approved the request, and the closure of the library was announced. However, about 20 library patrons, mostly retirees, complained about the closure to their congressional representatives. Congress responded by not only forbidding the Army to close the Fort Lee library but also directing that all installations have a library. Congress also instituted procedures for closing libraries that were much more complicated and constraining than those in place before the attempt to close the Fort Lee library.

No progress in base closings occurred until 1988, when the Secretary of Defense proposed a twelve-member Base Realignment Commission that was subsequently endorsed by

[3] Military Construction Authorization Act, 1966, Section 611(b), Public Law 89-188, September 16, 1965; Military Construction Authorization Act, 1977, Section 612(a), Public Law 94-431, September 30, 1976.

Congress. That legislation provided for three additional rounds of base closings using the BRAC format, which requires the military departments to forward a list of recommended closings through DoD to the President, who sends it to the Commission, and in turn to the Congress. In an attempt to minimize partisan influences, the recommended list had to be voted on as a package. Although politics inevitably intruded, the process worked well enough to close almost 100 major installations. Furthermore, it provided funding for major transition activities like environmental restoration and local economic assistance. A major drawback from the services' perspective was that they could base their recommendations only on the force projected for the next six years, a prohibition that forestalled any consideration of long-term trends.

If the Army is to refine its base structure further, it needs to plan on doing so within the framework of a BRAC and, indeed, should vigorously support proposals for an additional round of BRAC closings.

History thus shows that independent attempts to restructure the installation base do not work and that BRACs, whatever their imperfections, do. If the Army is to refine its base structure further, it needs to plan on doing so within the framework of a BRAC and, indeed, should vigorously support proposals for an additional round of BRAC closings. However, it should draw on the lessons taught by previous BRACs and attempt to structure future rounds in ways that will enable it to end up with the best possible set of installations.

Lessons from BRAC Closings

Given that the Army would benefit from further tailoring of its installation base and that any such change must occur within the framework of a BRAC, it is instructive to review past BRACs to determine what lessons might be gleaned from previous efforts.[4] The approach here is to propose a set of criteria against which to evaluate the Army's previous closure efforts with an eye to assessing the strengths and weaknesses of the process and identifying potential design standards for a new BRAC. The criteria outlined here are meant to be illustrative and not prescriptive. Nor are they complete. They were derived from an analysis of the 1995 BRAC process and its outcomes. Certainly, additional criteria could be added. The purpose here is to suggest the kinds of criteria that could be included.

Here, we offer ten criteria, which group into three larger categories that address essential internal characteristics, the breadth of the process, and the outcomes. Within the three categories, the ten criteria are as follows:

[4] A complete analysis of the Army's 1995 BRAC process appears in W. Michael Hix, *Taking Stock of the Army's BRAC Selection Process*, Santa Monica, CA: RAND, MR-1337-A, forthcoming.

Essential Internal Properties

- **Can be audited and reproduced.** A process can be audited and reproduced if a qualified person who was not part of the process could take the data used and independently produce the same result. This implies a process based on clearly defined quantitative measures and explicit qualitative assessments.
- **Maximizes objectivity and internal consistency.** An ideal process contains no hidden or explicit bias toward change or toward the status quo. Instead, it generates and assesses options according to an objectively determined set of goals. Further, its various steps would rest on assumptions used consistently in all parts of the process.
- **Uses separate and independent assessment criteria.** Criteria should be considered singly and not imbedded in multiple criteria. For example, cost should not be considered explicitly and also embedded in other criteria such as condition of buildings.

Breadth of the Process

- **Considers externalities.** Externalities consist of effects on people or activities outside the Army. Solutions that ignore externalities are unlikely to survive the political process. Four classes of externalities are important—economic impact on communities, local infrastructure, environment, and politics.
- **Provides a complete option set.** A process that, due to its design or rules, limits the range of options stands to miss creative and beneficial changes. It is easier for decisionmakers to discard options that, for whatever reason, are later considered unattractive than to try to generate those options at the end of the process.
- **Considers current and future needs.** While satisfying today's requirements is straight-forward, this criterion presents difficulties with respect to the future. First, the effects of BRAC decisions last for decades, and some are irreversible. Yet national security strategies change from administration to administration and sometimes even during an administration. Such changes drive force structure changes and resulting installation requirements. Hence, BRAC decisions need to serve not only the current national security strategy but also likely future strategies. The time horizon of the analysis is crucial. The 1990 law that authorized the last three BRAC rounds restricted the Defense Department to considering only the force structure programmed out to a six-year horizon. Longer-term trends and events could not be considered. For example, the trend toward faster vehicles and longer weapon ranges has long-term implications for the utility of today's maneuver and training installations, but the Army was not allowed to address such considerations.
- **Hedges against important certainties.** Because the future is cloudy, an ideal BRAC process would produce closure and realignment options that hedge against likely changes in future demands and against less likely but potentially sweeping changes. A

BRAC can err in one of two ways: It can realign and close too few installations, permitting unneeded ones to persist and thereby wasting limited resources. Or it can permanently divest installations not needed today but which may be needed in the future.

Outcomes

- **Leads to efficient use of assets.** At one level, this is an obvious criterion. But it also has less obvious implications. For example, it implies considering all the potential uses of each installation. In particular, it implies considering the cost-effectiveness of using each installation for as many functions as it can support so that the maximum number of small, inefficient, single-function installations can be closed.
- **Leads to lower long-term costs.** High initial costs may be required to achieve substantial long-term savings. Options that require substantial up-front construction or other transition costs should not be dismissed out of hand before considering the net present value of the long-term stream of costs and savings.
- **Leads to improved operations.** Certain realignments or closures could have synergistic effects on the activities that occupy the installations. While these operational improvements may be difficult or impossible to quantify, they may be real and potentially significant. For example, the collocation of individual training schools and maneuver units could enhance the export of doctrine to the field and better capitalize on the field experience in schools. Such considerations should be brought into the qualitative portion of the assessment.

TABLE 1
EVALUATION OF ARMY BRAC PROCESS

Criteria	Assessment
Internal properties	
Can be audited and reproduced	+
Maximizes objectivity and internal consistency	+
Uses separate and independent criteria	+
Breadth of process	
Considers externalities	++
Provides complete option set	–
Considers current and future requirements	–
Hedges against important uncertainties	–
Outcomes	
Leads to efficient use of assets	–
Leads to reduced long-term cost	–
Leads to improved operations	–

Table 1 presents our assessment of how well the Army 1995 BRAC process satisfied each of the ten criteria. A ++ rating means a criterion was fully satisfied; a + means largely satisfied; a – means somewhat satisfied, and a – – indicates not met at all. As the table indicates, the 1995 process fully satisfied only one criterion: consideration of externalities. It largely satisfied three, and it somewhat satisfied six. In no instance did the Army process completely fail to satisfy the criteria.

The scoring is, of necessity, subjective. However, it is based on clear criteria and informed judgment. Gauging the process by the three areas, its internal

properties largely met the criteria but could still be improved. The breadth of the process had somewhat more serious shortcomings, even though one rating was scored as fully meeting the criteria. All outcomes, perhaps the most important metric, were judged as having room for improvement. The groupings of the criteria and the scoring imply an important message: unless the process contains sufficient breadth, it is unlikely to achieve the desirable outcome of better and more efficient operations at a reduced cost.

Unless the BRAC process contains sufficient breadth, it is unlikely to achieve the desirable outcome of better and more efficient operations at a reduced cost.

Probably the most significant failing in the Army's BRAC deliberations is that they did not surface a full set of options. In large measure, this failure stemmed from an implicit assumption of the process: functions and installations are linked. That is, it assumed that if a function was necessary, so was the installation that hosted it. This deficiency results from the Army's practice of assigning installations to one of fourteen exclusive categories and considering installations for closure or realignment only *within* categories. This approach precludes the option of consolidating different functions on a single, large installation. For example, the process exempted Carlisle Barracks, which houses the Army War College, from closure or realignment because of the important contribution the war college makes to officer professional development. However, while the *function* needs to be retained, it does not necessarily follow that the installation does. It may well be that the cost of moving the college makes relocation infeasible, but such judgments should be made based on long-term savings and not be forestalled by the categorization process. Thus, the failure to establish a full set of options for review at the outset of the process almost guarantees that the goals of better and more efficient operations and long-term savings will not be achieved.

Exacerbating the problems caused by an incomplete set of options was the short-term focus that the Army adopted. Important aspects of the process drove the Army to this focus. First, the DoD guidance directed the services to base their recommendations on a six-year force structure plan. Second, the military departments had to fund up-front closure costs from the existing budgets and programs. Thus, they had little incentive to close or realign bases that would pose high initial costs, even if the long-term savings were substantial. Third, a key selection metric used was the number of years required to recoup the costs of closure, the fewer years the better. So only installations that offered a quick payback were selected. A net present value approach would have led to a very different slate of installations for closure. However, the Army would have had to bear higher up-front costs and accept a longer payback period.

The inevitable complement of a short-term view is a failure to consider long-term trends or to hedge against uncertainties. The effects of BRAC decisions last for decades; divestitures in particular can be irreversible. National security strategy will change periodically, as will force

structure, force design, and the extent of forward presence. While the Army's 1995 recommendations did hedge against the possible return of forces from Korea and Germany, they did not consider other plausible scenarios, including major shifts in the national security strategy or major changes in force structure and capability.

In sum, the Army process had many positive attributes, but it also had some negative ones. To retain the positive and eliminate the negative, the Arroyo Center recommends a different process than the one employed in the last round of BRAC closures. The recommended process includes five steps and takes as its central purpose the reduction of the long-term costs of installations. It implies a set of multifunction installations designed to make optimum use of physical assets, subject to environmental restrictions, community considerations, and long-term costs.

The five steps of the process are as follows:

- **Inventory assets.** This would include all assets (natural and physical) of all installations, regardless of their function. Thus, maneuver area, which did not count in the previous BRAC if it was on a proving ground, would factor into the consideration of all installations.
- **Estimate future requirements.** This step would extend the time horizon beyond the programmed force and consider a range of future possibilities. For example, the analysis might assume that a return of substantial forces to the continental United States from overseas bases is plausible enough to warrant hedging against that possibility.
- **Develop alternative allocations of requirements to assets.** This step is the most complex and differs from previous efforts in that it takes a holistic approach rather than the functional category approach used in the prior BRAC. This approach attempts to optimize the installation set by distributing the functions across the full set of bases.
- **Estimate cost of alternatives.** This step determines the aggregate cost of the set of installations for a given alternative.
- **Apply constraints.** This step modifies the alternatives by considering such things as the effects on the local community, with an eye to improving an alternative's political viability.

This approach should eliminate or at least substantially reduce the major shortcomings of previous BRACs. The process should produce a leaner, more efficient set of installations that retain enough flexibility to respond to future events. The result will be an Army better situated to serve the nation—and at less cost. ■

Is the Army's Equipment Ready to Go? Diagnosing Equipment Readiness with the Equipment Downtime Analyzer

In 1995, the U.S. Army took a bold step forward when it embraced a new idea called Velocity Management. Velocity Management was a term coined by RAND and adopted by the Army to describe a new methodology to improve the processes the Army uses to support and sustain its weapon systems. Velocity Management requires that the Army evolve from the mass-based "just in case" culture of the Cold War era to "just right" delivery of needed support products and services.

Velocity Management (VM) adopts tenets of such private sector programs as Motorola's Six Sigma and the Toyota Production System but adapts them to the needs of the Army. The first two steps in the VM methodology—define the process and measure the process—create the additional expertise that is needed for improved performance. The third step—improve the process—capitalizes on the increased expertise developed during the first two steps. Armed with a deeper understanding of the process as it is and with an improved ability to measure performance in terms that customers value, experts can devise changes to make the process more efficient.

It's working. VM has demonstrated the successes that can result from systematic analysis and the empowerment of a committed team of military logisticians. The Army has reduced the time it takes to order and ship supplies by as much as 60 percent. When materiel arrives on a predictable schedule, guesswork is eliminated; inventories can be leaner yet more effective, and personnel lose the incentive to hoard extra repair parts and supplies. In turn, the process of determining what stock to keep on hand and what to order becomes more effective. In short, VM is achieving its goals of making logistics processes measurably faster, better, and cheaper.

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The Next Step: Diagnosing Equipment Readiness

Now RAND and the Army are working together to take VM to the next level by better focusing on the Army's ultimate "customer": the warfighter at the end of the supply chain whose con-

cern is not how well individual logistics processes are working, but equipment readiness, the aggregate outcome of those processes. Logisticians need to understand and improve the individual processes, but within the context of how best to improve equipment readiness.

The focus on the warfighter until now has been indirect, by necessity, because tools to link process improvements to overall equipment readiness have not been available. The Army did not have a tool for drilling down to discover what components and processes drive readiness.

In contrast, some private-sector corporations have activity-based cost systems that are designed to assess the contribution of each process to overall operational results. Managers in these organizations know where the problems and opportunities are, which process improvements are paying off, and where additional leverage is possible. Without a similar approach with regard to equipment readiness, the Army could improve performance in some logistics processes, yet still fall short of improving overall equipment readiness.

Recognizing this gap, senior Army policymakers asked RAND Arroyo Center to examine the feasibility of creating a tool that links measurement of the performance of logistics processes to equipment readiness. This phase of the VM research began in 1999.

The EDA will help the Army employ VM's Define-Measure-Improve methodology more effectively by tightening the linkage between measurement activities and improvement activities.

The Equipment Downtime Analyzer

The Equipment Downtime Analyzer (EDA) is the result of this effort. The EDA will help the Army employ VM's Define-Measure-Improve methodology more effectively by tightening the linkage between measurement activities and improvement activities.

The EDA consists of a PC-based relational database and hierarchy of linked metrics that form a decision support tool. Assessments of the EDA have shown that it can help Army logisticians understand equipment readiness as well as their private-sector peers understand operating profits. The EDA will help the Army answer such questions as:

- How does improving order-and-ship time affect equipment readiness?
- Which parts contribute disproportionately to lost readiness?
- What is the readiness rate of the Army's equipment when it is at work in the field during training exercises? When it is sitting in the motor pool?
- How reliable are different types of equipment?
- What percent of a fleet can the Army expect to make it through a "combat pulse" (72 hours to two weeks) without external logistics assistance—either spare parts not carried on board or maintenance beyond the capability of the crew?
- How long does it take to return a fighting force to a high state of readiness following operations?

- What process improvement or expenditure of resources would produce the biggest gain in equipment readiness?

Here's How It Works

The EDA captures a history, by day, of the supply and maintenance activities executed to correct every reported failure that causes a piece of equipment to be not mission capable (NMC). From these daily histories, the EDA produces metrics that fully describe equipment failure rates and the "broke-to-fix" process. Thus, the EDA provides a systems view that can detect whether improvements in basic processes such as order-and-ship time "bubble up" to affect equipment readiness or whether reactions in other processes consume the improvement. And it can be used to highlight the places where improvements would make the most difference.

The EDA provides the needed metrics by saving, integrating, and processing data already collected by existing standard Army management information systems (STAMIS). It requires no new or special data collection.

Key to the EDA: The Two Components of the Not Mission Capable Rate

The NMC rate is the percentage of time when a weapon system is not available for anticipated missions; e.g., a NMC rate of 10 percent means that the equipment was not ready 10 percent of the time.

To diagnose the reasons why a system is NMC, the EDA starts with a simple mathematical relationship:

$$\text{NMC rate} = \text{average repair time} \times \text{average failure rate}.$$

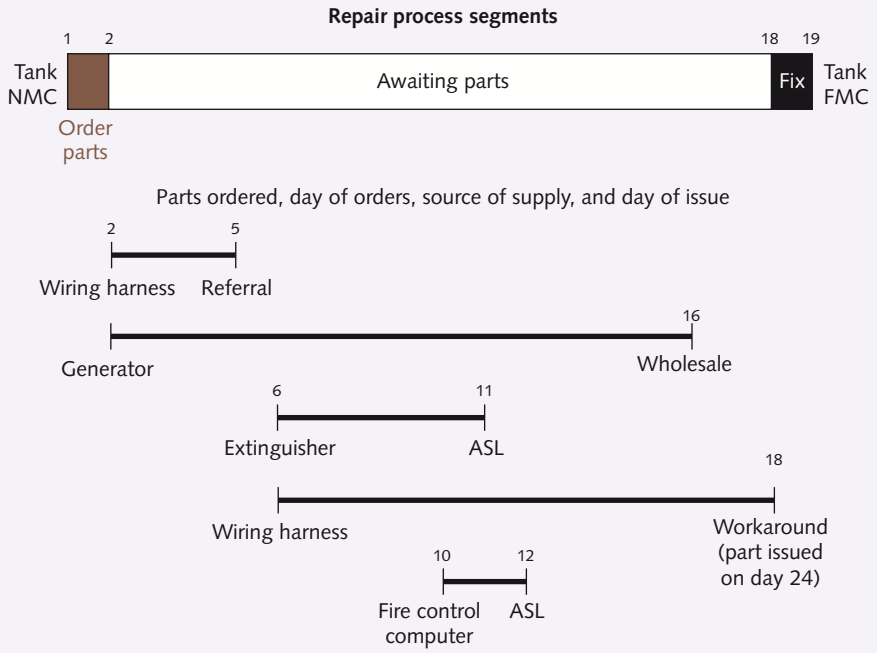
That is, the NMC rate is the product of the average repair time and the failure rate. This split begins a further drill-down in two directions, to the reasons underlying the repair time and the failure rate.

The EDA Takes a Closer Look at Repair Time

One way that the EDA sheds light on equipment readiness is by providing more information about the broke-to-fix process. Figure 4 illustrates an actual history recorded by the EDA for a deadlined (NMC) tank. First, the figure shows that the tank was deadlined for 19 days, during which time there were three major repair segments: diagnosis and parts ordering, awaiting parts, and the actual fix process. After the initial diagnosis, parts were ordered on day two, and the tank was then awaiting parts until day 18. The tank was then fixed and returned to fully mission capable (FMC) status one day later.

The figure also shows the day on which maintenance ordered each part, when the part was issued, and the source of supply. For example, a wiring harness was ordered on day 2 and

FIGURE 4



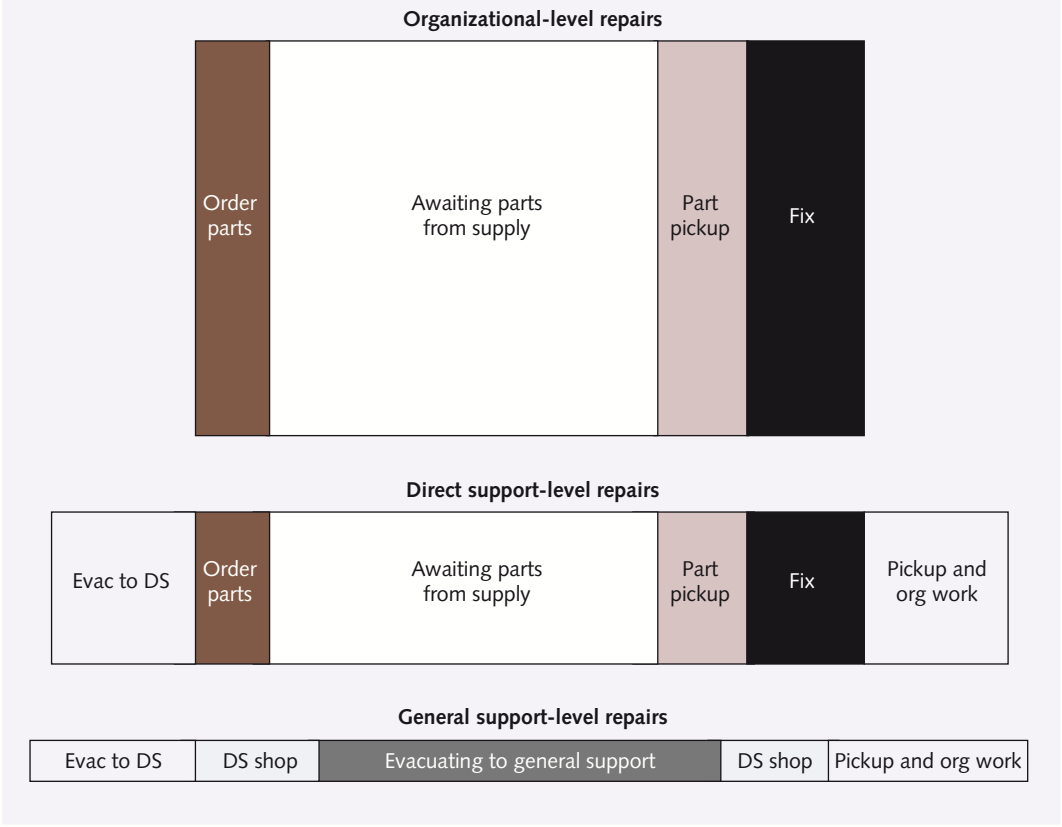
An EDA Repair History for a Deadlined Tank

was supplied via a source on post, which was issued on day 5. The second wiring harness was ordered because the wrong one was received the first time; the extinguisher was ordered late because maintenance personnel didn't realize at first that they needed it; and this tank's fire control computer was provided to another tank. This pattern is typical; EDA metrics show that maintenance personnel frequently work around the supply system to get a part, especially if a requisition has been outstanding for a long time. Also, there may be diagnostic problems or problems with the requisitioning or delivery of parts, any of which can cause multiple rounds of part orders, which we term "order cycles."

Of further note, after waiting twelve days for the second wiring harness ordered, maintenance personnel decided to stop waiting for an issue from supply and satisfied the need through a workaround by taking the wiring harness off another deadlined tank, which allowed completion of the repair six days before supply issued the part. By combining these detailed histories, the EDA can produce both repair process and reliability metrics at any level of aggregation from an individual tank through the entire Army fleet to gain a better understanding of what it takes to keep equipment ready. For example, early analyses suggest workaround rates of up to 30 percent. Measuring workaround rates is important because workarounds affect maintenance workload and are an indication of how well the supply system is satisfying maintenance needs.

The EDA combines the histories for groups of tanks or any other equipment and employs a set of process-based rules to produce a decomposed view of the repair process. In Figure 5, the thickness of the bars indicates the percent of repairs completed at each echelon of maintenance. Thus, the thick bar at the top of the figure shows that most repairs are handled at the local level by maintenance crews within the organization that owns the equipment. The length of each section of the bar represents how much time relative to the whole process each segment required. The chart shows that no matter where the repair took place (at the organizational level or through direct or general support), the most time-consuming segment was awaiting parts.

FIGURE 5



Awaiting Parts Is the Biggest Driver of Total Repair Time

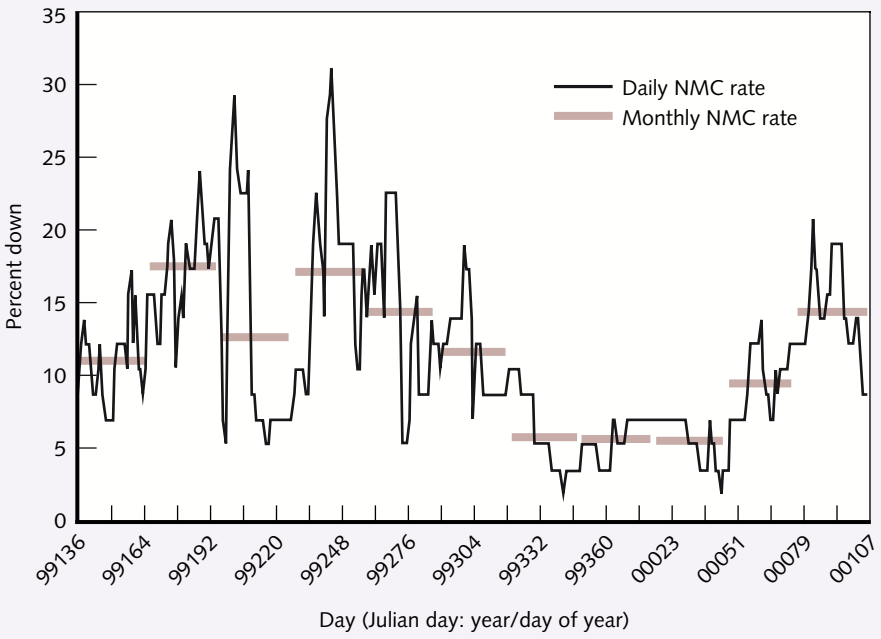
A More Fine-Grained View of NMC Rates

The EDA can also provide a richer, more accurate portrayal of equipment readiness by looking more closely at how equipment performs in varying circumstances. In Figure 6, the straight horizontal lines depict the monthly NMC rates for the tanks in one armor battalion. The jagged line shows the NMC rate by day. This line reveals highly volatile daily NMC rates that paint a much different picture of equipment readiness than the "smoothed" monthly rates, which combine long periods when the equipment sits idle in the motor pool with short, intense periods when the equipment is used for training.

The EDA can also provide a richer, more accurate portrayal of equipment readiness by looking more closely at how equipment performs in varying circumstances.

As an example, in late July 1999 (99206 on the chart, the 206th day in 1999) an exercise caused the NMC rate to increase from 5 percent to almost 30 percent in just four days. Once

FIGURE 6



Tank NMC Rate by Day and Month for One Armor Battalion (based upon daily deadline reports)

the battalion completed the exercise, it experienced just two tank failures during the remainder of the monthly reporting period, recovering to 94 percent readiness in early August. The result was a monthly NMC rate of 13 percent, reflecting neither the battalion's sustainment capability when equipment was used in a mission profile (which was worse) nor the condition of the tanks after recovery (which was better).

Putting the EDA to Work

In tests of the EDA, Army organizations such as division support commands and the Office of the Army's Deputy Chief of Staff for Logistics (ODCSLOG) have already identified several ways to exploit the more precise and complete insight that the EDA data allow. They can evaluate and improve design reliability to make recapitalization decisions, identify operating shortfalls, and enhance supply and maintenance policy analyses. The U.S. Army Materiel Command can take a fleet perspective to identify systemic part and weapon systems issues and to identify units that might benefit from technical assistance. The Tank-Automotive and Armaments Command (TACOM) is incorporating the EDA into its Situational Awareness effort, which is designed to provide better visibility into customer needs in order to better target TACOM support. At the ODCSLOG's request, RAND is already using EDA information for equipment readiness analyses. For example, it has been especially useful in understanding the high-pressure, deployed environment of the National Training Center at Fort Irwin, California. And this coming year, the Arroyo Center will use the EDA to help evaluate the potential readiness benefit of the Army Diagnostic Improvement Program, which encompasses the Army's efforts to deploy embedded and offboard diagnostic sensors to enable anticipatory maintenance.

The EDA will be a crucial component of a new research project that RAND Arroyo Center is conducting for the Assistant Secretary of the Army for Acquisition, Logistics, and Technology. This project aims to model and assess the reliability, availability, maintainability, and durability of current, recapitalized, and future systems, producing estimates of how improving these factors will affect mission reliability, total cost, and intratheater footprint.

In some of these applications, the EDA provides information not previously available that will improve the quality of decisionmaking. In other cases, it will help automate tasks that are now executed manually. For example, some Division Material Management Centers manually compute average repair time using the daily deadline reports. This time-consuming process can be executed in seconds with the EDA.

The EDA Supports the New Army Vision

Development of the EDA is especially timely given that the new Army Vision emphasizes rapid force deployment followed by immediate employment. As part of this vision, the Army has set aggressive deployment targets. These include requirements for a brigade to deploy within 96 hours, a division in 120 hours, and a five-division corps in 30 days. Under these timelines, soldiers and equipment must pick up and go in whatever readiness state they are in when they receive the order. Just as critically, they are expected to transition immediately to employment, meaning that they must arrive at the area of operation ready to fight. And then they must continue to operate at a high level of effectiveness. This demands robust equipment and streamlined logistics processes that help soldiers keep equipment ready.

Development of the EDA is especially timely given that the new Army Vision emphasizes rapid force deployment followed by immediate employment.

In the long term, the Army is seeking to achieve these goals by developing and acquiring more supportable weapon systems. At the same time, the Army is also relying on continued improvement in logistics processes and recapitalization of current equipment to play important roles. These improvements are often achieved at relatively little cost compared to the procurement of new systems and sometimes can even reduce total costs. Regardless, the Army knows that it cannot afford complete replacement of its fleets, nor does it expect technology alone to be able to achieve the new vision. More effective processes are recognized as essential.

Implementing the EDA Throughout the Army

In late 1999, after being briefed about the successful development of an EDA prototype, the Army's DCSLOG, in conjunction with the Combined Arms Support Command and the Ordnance Center and School, began taking steps to make this powerful information tool available for use throughout the Army. It is targeted for integration into release 1 of the new Global Combat Support System–Army management module.

Looking Ahead: Making the EDA Even Better

The ultimate promise of this effort is an enhanced capability to focus constrained resources where they will have the greatest effect on keeping equipment ready to fight, whether by improving equipment reliability or by reducing repair time. By enabling logisticians and those

engaged in the acquisition and recapitalization processes to examine which improvements are most likely to achieve higher equipment readiness, the EDA should improve the Army's ability to sustain equipment readiness while reducing total support costs and enhancing mobility.

RAND Arroyo Center is continuing to enhance EDA's ability to do all of the above. For example, the Arroyo Center will explore extending the EDA's capabilities by including mileage information for individual tanks, directly embedding customer-wait-time diagnostic metrics such as ASL fill rate (the percentage of orders filled from the Army's stock of most-often-used supplies) and referral order-and-ship time, and, if possible, isolating data from periods with high operational tempos. ■

Strengthening the Army's Science and Technology Capabilities for the 21st Century

To ensure that the Army will meet future defense challenges, the Secretary of the Army and Army Chief of Staff have articulated a *Vision for the Army of the 21st Century* that involves transforming the Army into an Objective Force that is responsive, deployable, agile, versatile, lethal, survivable, and sustainable.[5] Achieving this Objective Force will require that the Army maintain its superior science and technology (S&T) capability through its research and development (R&D) and procurement efforts. For example, the advanced-technology Future Combat System is the cornerstone of the Army's Objective Force, thus making the maintenance of top-notch S&T capability critical to the Army's transformation.

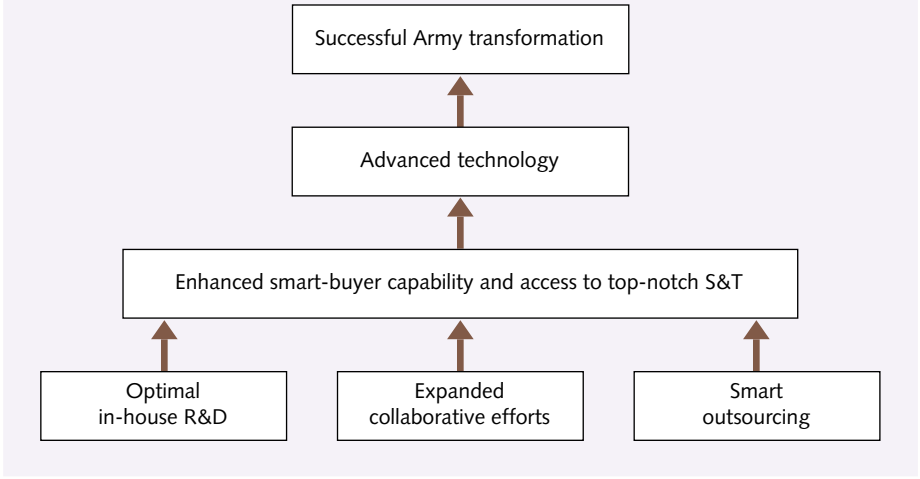
A number of trends over the past decade have made it especially challenging for the Army to maintain the critical S&T element of its transformation. First, the R&D budget has been declining for the past 15 years, and this trend is likely to continue. Second, the Army's civilian workforce, many of whom are the scientists and engineers (S&Es) integral to the Army's R&D capability, has declined in numbers because of acquisition workforce reductions. In addition, increased competition with private industry for highly qualified technical staff has made it difficult for the Army to attract and retain the talented S&Es it needs to ensure a continued superior S&T capability for the coming decades.

Faced with these shortfalls, how should the Army sustain superior S&T capabilities to support the Army transformation? During the past five years, the Arroyo Center has worked with the Army to address this question.[6] Arroyo research has shown that a strategy built on a foundation of three integrated building blocks will enable the Army to be the effective smart buyer and smart provider it must be to achieve the challenging S&T goals required to support

[5] U.S. Army Headquarters, Department of the Army, U.S. Army Transformation Campaign Plan (June 15, 2000).

[6] The research described in this section is detailed in a number of publications. See Kenneth P. Horn et al., *Performing Collaborative Research with Nontraditional Military Suppliers*, Santa Monica, CA: RAND, MR-830-A, 1997; Kenneth P. Horn et al., "Conducting Collaborative Research with Nontraditional Suppliers," *Army RD&A*, November–December 1997, pp. 39–41; Carolyn Wong, *An Analysis of Collaborative Research Opportunities for the Army*, Santa Monica, CA: RAND, MR-675-A, 1998; Carolyn Wong et al., "An Approach for Efficiently Managing DoD Research and Development Portfolios," *Acquisition Review Quarterly*, Vol. 5, No. 4, Fall 1998, pp. 339–356; Ike Chang et al., *Use of Public-Private Partnerships to Meet Future Army Needs*, Santa Monica, CA: RAND, MR-997-A, 1999; Kenneth P. Horn et al., *Maintaining the Army's Smart Buying Capability in a Period of Downsizing*, Santa Monica, CA: RAND, WP-120, 1999; and Carolyn Wong et al., "Maintaining the Government's Ability to Buy Smart," *Acquisition Review Quarterly*, Vol. 7, No. 3, Summer 2000, pp. 259–274.

FIGURE 7



Strategy for a Successful Transformation Through Maintaining and Strengthening S&T Capabilities

the Army transformation. The three building blocks are optimal in-house R&D, expanded collaborative efforts, and smart outsourcing. An overview of this strategy is shown in Figure 7.

This figure shows that the three basic blocks form the foundation of a successful Army transformation: (1) Optimal in-house R&D refers to the pivotal and supportive research performed solely by Army S&Es; (2) expanded collaborative efforts refers to the research that Army personnel carry out in conjunction with scientists and engineers from one or more non-Army organizations; and (3) smart outsourcing refers to the research that is performed by non-Army personnel with Army oversight. This integrated three-block foundation enables an enhanced Army smart-buyer capability and Army access to top-notch S&T. In this context, smart-buyer capability refers to only the technological aspect of the smart-buyer function that includes the integrated efforts of many disciplines (e.g., technological, engineering, legal, procurement, management, and funding expertise). Hence, smart-buyer capability is the Army's collective technical expertise that helps the concept and materiel developers conceive, formulate, and execute materiel programs. Optimal in-house research combined with collaborative efforts with technological leaders and well-designed, expertly executed outsourcing will also give the Army access to top-notch S&T. With enhanced smart-buyer capability and access to top-notch S&T, the Army will be well equipped to acquire the advanced technology it requires for a successful transformation.

In the following sections we discuss the integrated foundation and then detail the roles that the individual building blocks play in establishing an enhanced smart-buyer capability and providing Army access to top-notch S&T.

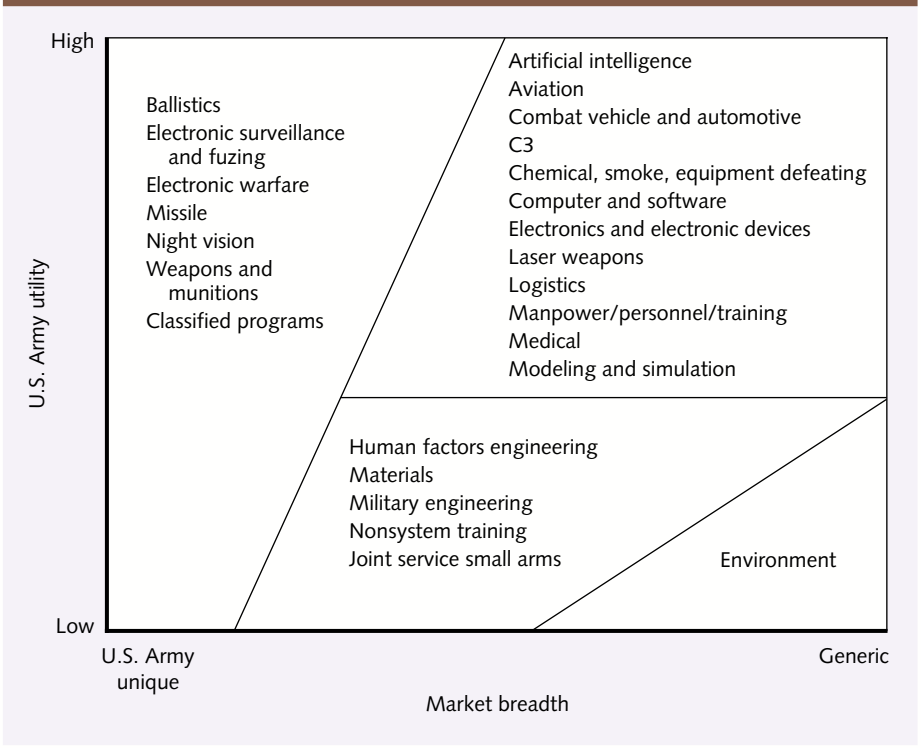
The Integrated Foundation

All Army research is performed in one of three ways. It is either performed in-house by Army S&Es, performed collaboratively by Army S&Es and scientists from organizations outside the Army, or outsourced and performed by scientists from external organizations with Army oversight. Normally, these three approaches are mutually exclusive in that research performed using one approach is not performed using either of the other two. However, the approaches are also integrated in that they are all mutually supporting components of a whole. Clearly, then, an

important decision that faces the Army is determining which technologies should be researched in-house, which are best suited for collaborative efforts, and which should be outsourced. To help the Army formulate a strategy for making these decisions, Arroyo Center researchers developed a framework that helps the Army understand the technology knowledge bases both inside and outside of the Army, facilitating informed choices about how to allocate research efforts among the three approaches. This framework categorizes efforts along two dimensions: Army utility, and appeal to the broader research community outside the Army.

Figure 8 illustrates the use of this framework to categorize the Army's technologies as described in the RDT&E Programs (R-1) section of the DoD budget for fiscal year 1995. Technologies highly specific to the U.S. Army—the leftmost portion in the figure—are good candidates for doing in-house because they lack sufficient appeal to attract partners from outside the Army and also lack the generic applicability desired by such organizations. Analogously, the technologies in the upper right quadrant—which have high Army utility and high industry appeal (and to a lesser extent those in the middle quadrant, which have more moderate Army utility and industry appeal)—are ideal candidates for collaboration. Similarly, technologies in the lower right quadrant (and some in the middle quadrant) are best suited for outsourcing because their high industry appeal and relatively lower Army utility indicate that the technological leaders in these areas reside in industry.

FIGURE 8



Framework for Determining Appropriate Sources of Technology

The framework provides a good starting point for the Army to decide the best approach for each research effort. However, its only basis for decision is technological factors. For any given research effort, other factors, such as schedule and resources, must also be considered and may in some cases prevail in determining the approach the Army takes.

Optimal In-House Research

In-house R&D is research performed solely by Army personnel. The majority of this research is performed at Army labs by Army S&Es. The Army, of course, has full access to all S&T ema-

nating from its own labs. The S&Es who perform this research are also the Army's smart buyers. Hence, it is evident that the research they perform contributes directly to the Army's smart-buyer capability. The Army can manipulate this capability by optimally choosing the types and amount of research performed in-house. The framework described above can elucidate that task. The Army can also ensure the quality of its in-house research by maintaining a cadre of talented and trained S&Es. To do so, the Army must attract talented staff to work in its labs, provide career development opportunities to ensure that this staff has the necessary skills to perform their smart-buyer duties, and create incentives to encourage the talented staff to stay. Accordingly, our research focused on these three personnel aspects of enhancing the Army's smart-buyer capability. In the sections below, we describe the current personnel situation and then detail recommended recruitment, training, and retention actions.

The Army must attract talented staff to work in its labs, provide career development opportunities to ensure that this staff has the necessary skills to perform their smart-buyer duties, and create incentives to encourage the talented staff to stay.

The Current Situation

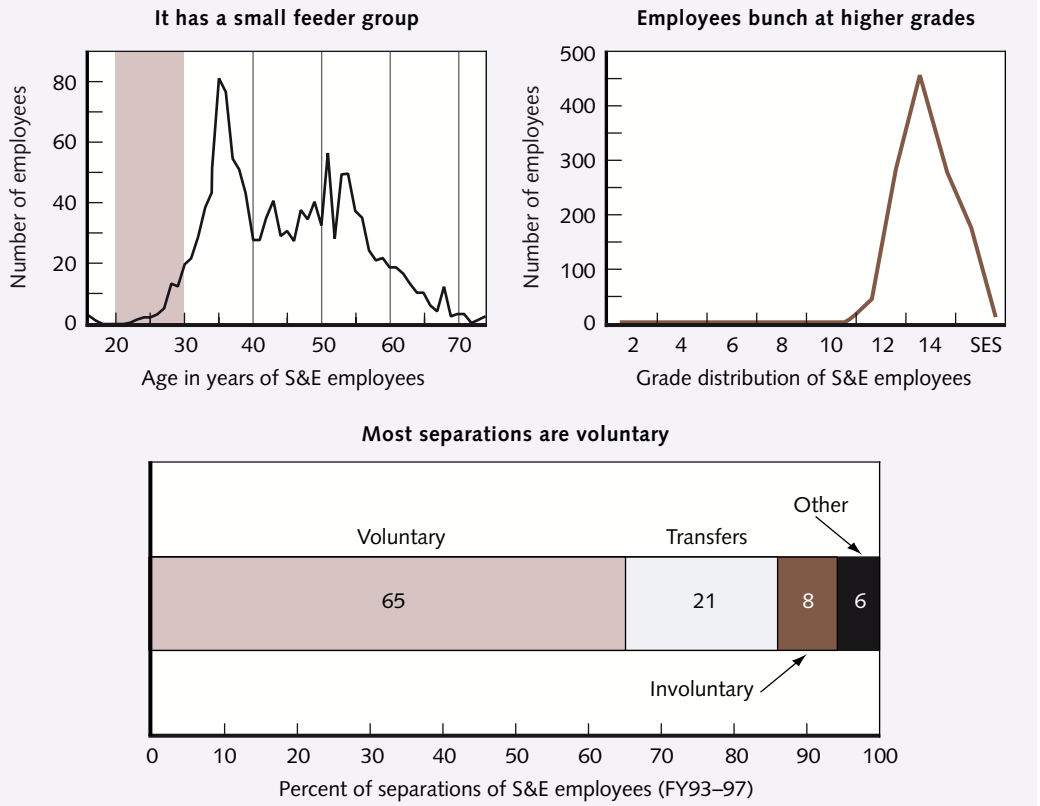
As we have noted, the Army is losing S&Es—and the smart-buyer capability that goes with them. Outsourcing the smart-buyer capability would be difficult because of the potential conflicts of interest, the need to maintain loyalty to the Army's interests, the need to maintain corporate memory, and the potential cost involved. Thus, one of the questions Arroyo researchers have addressed is what the Army needs to do to obtain the smart buyers it needs.

Until recently, civilian personnel policies have tended to undermine hiring and retaining the best and brightest S&Es. For example, as Arroyo Center research on the Army Research Lab illustrates (Figure 9), most S&Es are in their mid-30s or mid-50s. Thus, few recently trained S&Es are being hired, and many senior S&Es will retire within the next five years, creating gaps at the highest and lowest levels of seniority. In addition, the majority of lab scientists who do not wish to leave research for managerial positions face a glass ceiling in promotions and raises. As a result, many researchers have attained the highest grade level they can, equivalent to that of a middle manager, a situation that encourages talented S&Es to leave for more rewarding positions in the private sector. Furthermore, most separations are voluntary, which supports the idea that competent scientists leave the labs for better positions.

While the Army recognizes the importance of the smart-buyer capability, our research also shows that this function is not always truly rewarded. Awards for outstanding performance in the smart-buyer capacity have not always been forthcoming, and opportunities for ongoing training and development have been limited.

What kinds of measures are needed to overcome these problems? Our research has shown that to enhance its smart-buyer capability, the Army must institute personnel reforms

FIGURE 9



Personnel Challenges at the Army Research Lab

that strengthen its in-house S&T expertise. The Department of Defense is currently exploring a wide range of personnel reform initiatives aimed at increasing the hiring, training, and retention of quality S&Es. We examined these initiatives and concluded that a number appear to have the potential to improve the processes of attracting, developing, and retaining talented S&Es, as discussed below.

Attracting Talented Staff

The Army should exploit the full range of recruiting tools to attract the most promising candidates. For example, intern programs—such as the Career Related Experience Science and Technology Program that provides summer or part-time employment to undergraduate and graduate students, the Student Temporary Employment Program, and the Student Career Experience Program—appear to be successful and should be continued. Other tools, such as recruitment bonuses, are limited by available funds, and some pilot trials with these tools will help establish their role in successful recruitment practices.

The personnel initiatives proposed and introduced thus far represent an important step toward strengthening the Army's cadre of S&Es. But given the strong competition with private industry, these reforms may not be sufficient to ensure adequate S&E capability. An alternative mechanism we have proposed for attracting additional new talent is greater use of temporary or visiting staff such as Intergovernmental Personnel Act workers. Another option that has been proposed is to create a reserve S&E corps that could be called up from the civilian sector in times of critical technological need.

Career Development Opportunities

The Army needs to provide career development opportunities to ensure that its S&Es have the necessary skills to be competent smart buyers. Initiatives aimed at training and development include providing educational fellowships, creating assignments that foster development, and allowing rotation through a variety of government and private labs. These initiatives are consistent with the four proficiencies that Arroyo Center research has deemed necessary to become a good smart buyer. First, the Army must provide opportunities for S&Es to acquire industry experience, perhaps through industry exchange programs and well-designed collaborative efforts. Second, S&Es must be able to devote a portion of their time to hands-on research. To ensure ample opportunities to gain this experience, the Army must devise criteria for determining what and how much R&D should be kept in-house. S&Es must also be able to acquire the required level of education in their fields. The Army and its workers will mutually benefit if the Army encourages and supports education at the nation's top universities. Finally, S&Es need general engineering experience. The Army can ensure that this requirement is met through a well-planned series of work assignments.

Retention

Some of the initiatives aimed at retention include performance-based (rather than seniority-based) promotion and implementation of a special pay scale that would reduce the government-industry pay gap. These reform initiatives will help, but more innovations may be needed to ensure that career advancement opportunities are available to S&Es. In addition, the Army must ensure that tangible recognition of good smart buying reflects the importance placed on this capability. For example, criteria for salary increases, promotions, and awards may have to be defined, established, or revised to better tie these rewards to outstanding performance of smart buying.

Expanded Collaborative Efforts

Despite the Army's best efforts to maintain an adequate number of talented S&Es, downsizing and budgetary decreases, combined with the ever-growing need for cutting-edge technologies,

will require the Army to look to other government labs and the commercial sector to meet its technological needs. As Figure 8 shows, we believe that in some cases, it makes the most sense to gain the technological capability by engaging in well-chosen, well-designed collaborative efforts.

The hallmark of a well-designed collaborative effort is that the collaborating parties make mutual contributions for mutual benefits. Collaborative efforts call for the sharing of intellectual and material resources to achieve common research goals. In particular, collaborative research efforts involve hands-on participation by Army S&Es and by scientists from the collaborating organizations in the research activities. This factor distinguishes collaborative efforts from in-house research that is performed solely by Army S&Es and from outsourced research that is performed solely by non-Army scientists with Army oversight.

Downsizing and budgetary decreases, combined with the ever-growing need for cutting-edge technologies, will require the Army to look to other government labs and the commercial sector to meet its technological needs.

For a variety of reasons, collaboration can be preferable to performing the research in-house or outsourcing it. One reason is that collaboration offers advantages to both the Army and its partners, such as the opportunity to leverage resources and to broaden in-house expertise. Moreover, collaboration offers the Army the opportunity to access cutting-edge skills, technologies, and products that would otherwise be out of reach.

Potential collaborative partners may include other military or civilian government labs, as well as university labs, established private corporations, and small start-up and venture capital firms. Each of these potential partners has unique knowledge and skills to share with the Army.

Thus far, with some notable exceptions, the Army has had limited success in attracting and forming collaborations, particularly with nontraditional military suppliers, the kinds of potential collaborators most likely to be able to supply the innovative cutting-edge technologies the Army will need to realize its new vision. Why has this been the case? Until recently, federal regulations that discouraged collaborative research forced the Army to outsource to traditional contractors any research for which it lacked the technical skills, manpower, or other resources. However, the acquisition reform measures introduced in the 1980s and 1990s have gradually removed these legislative barriers and paved the way for collaborations and other nontraditional arrangements that will mutually benefit the Army and its partners.

The old acquisition structure relied on traditional contracts that had to adhere to the restrictive Federal Acquisition Regulations and their military counterparts, the Defense Federal Acquisition Regulation Supplement (DFARS). These regulations and their enforcement were believed by many private corporations to foster an atmosphere of mutual mistrust and to be too

cumbersome for research collaborations. Newer tools, applicable to research activities, such as Cooperative Research and Development Agreements and Cooperative Agreements (CAs) removed many government-imposed bureaucratic practices that have discouraged collaborative efforts with commercial entities. CAs allow cost-sharing, hands-on collaborative Army participation in the research, and recovery of funds. Other Transactions (OTs), which are not required to adhere to the burdensome guidelines imposed by the DFARS, allow the military to negotiate terms that are mutually agreeable to itself and its potential research partners. OTs are vital for allowing the military access to many of the advanced technologies offered by firms that will traditionally not do business with the government.

Unfortunately, the Army's initial experience with OTs has been limited. As a result, their potential remains largely untapped. Also hampering research collaborations is the fact that some companies, particularly small, cutting-edge firms, are still hesitant to do business with the Army. Their concerns center on the initial costs of proposal preparation, unpredictable funding cycles, uneven personnel exchange, foreign access limitations, intellectual property rights, and residual fear of burdensome restrictions and controls. To dispel these images, the Army will need to be flexible and establish an atmosphere of trust. In addition, it will need to do its homework and market itself to private firms whose technology is of interest and whose strategic goals match Army needs.

Smart Outsourcing

As shown in Figure 8, some technologies lend themselves to in-house research, others are suited for collaborative efforts, and some may best be researched through smart outsourcing. As mentioned above, despite the increased opportunities and mechanisms for collaboration, some Army research does not lend itself to collaboration. In some cases, firms may have attractive technologies but may lack the will or the staffing to collaborate with the Army. In others, the Army lacks the technical competence to participate with a partner on an equal footing. Finally, the Army is a small market with a need for technological competence in some areas that have little or no civilian application. Outsourcing—in particular, smart outsourcing—is the appropriate strategy to supply those needs that cannot be fulfilled in-house or through collaboration. The importance of this building block is exemplified by the Future Combat System, many of whose critical technologies are being attained through outsourcing.

Outsourcing—in particular, smart outsourcing—is the appropriate strategy to supply those needs that cannot be fulfilled in-house or through collaboration.

Arroyo Center research in smart outsourcing is ongoing. To date, however, we have identified several innovative and unconventional elements of the smart outsourcing building block.

Below, we discuss three of these: the Small Business Innovative Research (SBIR) program, the Fast Track SBIR program, and the venture capital concept.

The SBIR is a congressionally mandated program initiated in 1982. The Army has participated in this program for many years. Its purpose is to increase small business involvement in federal R&D. The Army devotes approximately $100 million annually to the SBIR program. To derive full advantage, the Army has to view SBIR as an integrated part of its outsourcing plan. SBIR should not be viewed as an adjunct program or as a separate element of Army research. The Army needs to view SBIR as a fixed part of the outsourced research and to exploit its unique properties to attract small businesses that can potentially contribute to achieving the Army's S&T goals. For example, SBIR project funding is provided through contracts with short funding cycles and minimal time lapse between proposal submission and funding decisions. These properties can be very appealing to some small businesses, and the Army should use this program to attract and introduce innovative companies with promising technologies to working on Army research. The Army should view the SBIR funding period as a time to evaluate the firm's technologies as well as establish trust and congenial working relationships with firms that may have much to offer in terms of meeting the Army's S&T goals. At the end of the SBIR funding period, the projects that are still promising can be eased into more long-term arrangements. These arrangements include the CAs and OTs discussed above. Although not all SBIR projects can be expected to be candidates for continued Army interest, viewing the SBIR program as a unified part of the Army's outsource program holds more promise than a piecemeal view that tends to result in missed opportunities. In short, using the SBIR program as an integrated part of the Army's outsourced research translates to smart outsourcing.

The introduction of the Fast Track SBIR in 1995 improved the SBIR program. This variation encourages SBIR awardees to find additional money from sources such as venture capital firms, angel investors, and large companies to augment their interests in small technology companies. The Army should fully exploit the Fast Track SBIR program as a means of leveraging private research dollars. In it, the Army gains financial partners in funding projects at small technology firms. The advantage of exploiting the Fast Track SBIR program is that more Army research gets done without spending more Army research money.

A venture capital investment model to leverage outsourced research funds is another option Arroyo Center researchers have explored with the Army. Venture capitalists generally invest in start-up companies that have a concept, a potential market, and a business/marketing strategy but lack adequate capital. In addition to financial resources, venture capitalists also provide time, expertise, and experience to help manage and promote the businesses invested in. The advantage for the Army is the ability to influence the technologies early and gain intelligence on technologies being developed. Additionally, revenue generated can be reinvested in

Army technologies, and partnerships may be formed with other companies to gain further leverage for Army resources. Venture capital has been used successfully by many of the most inventive companies in the world, is accessed by large corporations with significant internal R&D capabilities to develop new technologies, and is also spreading to the public sector.[7] By avoiding the restrictions of traditional contracts, venture capital investment would allow the Army access to needed commercial technology and would permit it to leverage its own limited R&D resources through cost sharing. In addition, the Army could enjoy a return on investment for efforts with potential long-term commercial application as well as the potential for reinvestment. Clearly, not all Army technologies would be good candidates to pursue through venture capital efforts. But for those technologies that are suited to this mode of research, the additional benefits in financial leveraging and access to cutting-edge technological advancements justify including venture capital as an option in smart outsourcing.

By avoiding the restrictions of traditional contracts, venture capital investment would allow the Army access to needed commercial technology and would permit it to leverage its own limited R&D resources through cost sharing.

Conclusions

The Army has made great strides over the past decade to sustain its superior S&T capability. Recent personnel reforms have widened the Army's options to attract and retain the best and brightest S&Es for its labs and thus optimize its in-house research and directly enhance its smart-buyer capability. By taking advantage of the acquisition reforms of the past two decades, the Army has begun to expand its collaborative efforts—efforts that have played and will continue to play vital roles in helping the Army maintain its technological edge through access to top-notch S&T and enhancing its smart-buyer capability. In addition, efforts are ongoing to promote smart outsourcing to help ensure that the Army will maximize leverage of its R&D resources and continue to have access to cutting-edge technological advancements. All these efforts should continue, and in a coordinated fashion.

The key to a coordinated reform effort will be effective communication between the concept and materiel developers. This includes communication among strategists, Army S&Es, other executors of the smart-buyer function, program managers, acquisition experts, users, collaborators, and contractors. For example, our surveys show that to retain high-quality S&Es, the Army must give them opportunities to communicate with S&Es in other military and civilian labs as well as in university and industrial labs. S&Es must be able to exchange ideas with others who are performing similar work and monitor the progress in their fields. Without a

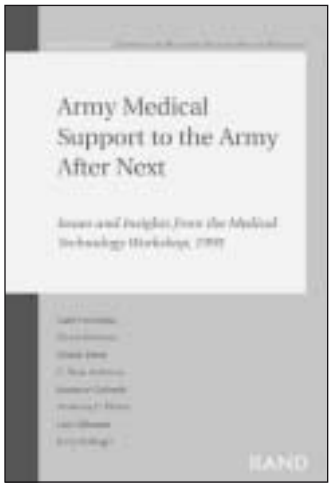
[7] The Central Intelligence Agency's In-Q-Tel is a prime example. See Bruce Held and Ike Chang, *Using Venture Capital to Improve Army Research and Development*, Santa Monica, CA: RAND, IP-199, 2000.

mechanism for regular communication with others in the same technical area, Army S&Es work in a virtual vacuum. The quality of the S&T that emerges from in-house research, from collaborative efforts, and from the Army's associations with contractors all depend on age-old tenets of open, direct, and unencumbered communications. Toward this end, we encourage the Army to continue streamlining the communications channels among organizations and thus significantly enhance informational exchange among all involved in the research that will ultimately result in the Army's successful transformation. ■

A major goal of RAND Arroyo Center is to inform the public policy debate with the results of its research. One of the ways we accomplish that goal is through a variety of written reports, briefings, and short issue papers. Publications released to the public in 2000–2001 are described below. Copies of these publications and others listed herein are available from RAND Distribution Services (telephone: toll free 877-584-8642 or 310-451-7002; FAX: 310-451-6915; or E-mail: order@rand.org). Abstracts of RAND documents can be viewed on the World Wide Web at http://www.rand.org.

Army Distance Learning: Potential for Reducing Shortages in Army Enlisted Occupations
Michael Shanley, John D. Winkler, Henry A. Leonard
MR-1318-A

This report examines ways in which distance learning can help the Army more quickly alleviate active component manpower shortages in understrength military occupations. The analysis finds that distance learning can enable faster completion of reclassification training, faster completion of professional development courses, and more efficient forms of skill training, depending on the nature of the course materials selected for instruction via distance learning. The analysis addresses the costs and benefits of these potential changes as well as potential implementation problems that could raise costs or reduce benefits.



Army Medical Support to the Army After Next: Issues and Insights from the Medical Technology Workshop
Gary Cecchine, David Johnson, Walter Perry, A. Ross Anthony, Beatrice Golomb, Anthony Hearn, Lee Hilborne, Jerry Sollinger
MR-1270-A

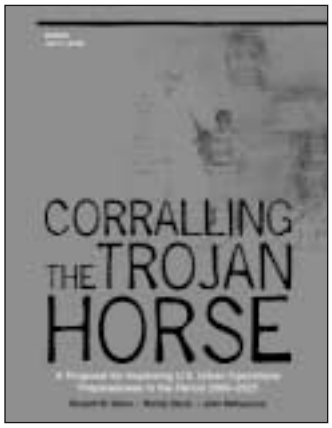
To ensure integration of medical capabilities, programs, and systems with the Army After Next program and the future Army, the U.S. Army Medical Department (AMEDD) participated in the FY99 series of games, conferences, and workshops, serving as players and sponsors of events focused on AMEDD issues and goals. Results from previous AMEDD wargames and participation in the Spring Wargame 1999 along with the current Science and Technology investment strategy provided the framework for the Army Medical Technology Workshop. The current and future systems provided the principal bases for the technology requirements considered. The workshop focused primarily on identifying those portions of the Army's Medical Science and Technology Investment Strategy—principally Basic Research (6.1) and Applied Research (6.2) investment areas—that would be essential in assuring that the Army has the required medical capabilities in 2015–2025. Identification of these capabilities provided the impetus for the development of a revised investment strategy to promote support for the enabling and cross-cutting medical technologies that will be needed in the 2025 timeframe. The authors describe the Medical Technology Workshop design, summarize the major findings of the panels, identify the salient issues and insights that emerged, and make recommendations to improve future workshops.

Asian Economic Trends and Their Security Implications
Charles Wolf, Jr., K. C. Yeh, Benjamin Zycher
MR-1143-OSD/A

In mid-1997, Asia experienced sharp economic reversals variously described as a financial "meltdown," a spreading economic "contagion," or simply as serious economic turmoil. In light of these new economic conditions, this study reviews, revises, and updates the authors' previous estimates of long-term economic and military trends in Asia, and draws inferences from the new estimates with respect to Asian security issues. After considering these sharp economic reversals and taking into account the marked signs of significant recovery in varying degrees by the different countries in the region, the authors consider the medium- and longer-term trends with respect to economic growth, military spending, and military investment in Japan, China, India, Korea, and Indonesia. Following analysis of these longer-term economic and military trends, the study focuses on the security implications of these trends with respect to alternative security environments in the region, changes in the intraregional balance of military and economic power, and other issues such as prospects for multilateral security cooperation, support for forward-based U.S. forces in the region, and burdensharing.

Breaking the Mold: A New Paradigm for the Reserve Components
John M. Halliday, David Oaks, Jerry M. Sollinger
IP-190

Operation Desert Storm and subsequent deployments have made it clear that the Army must be able to deploy its forces rapidly to locations around the world, not just to Europe or Korea. Despite Department of Defense progress in addressing this issue, difficulties still remain. For any major conflict, the United States will require a substantial complement of combat service and combat service support units from the reserve components. This issue paper argues that these units may not be as ready to deploy as they need to be and offers some observations about why that might be the case. Given the large size of the Army reserve components, it would be extremely expensive to bring it to a level of readiness analogous to that of the other services. But the Army does not have to raise the readiness of every reserve component unit to a par with those in the active component. Instead, it could improve the readiness of selected units, determined by CINC war plans. Such an approach would divide units into three categories: early deploying, later deploying, and not in any war plans. Units needed early would be indistinguishable from active units in terms of equipment and would have all the required equipment and personnel. Furthermore, they would have substantial full-time support and enjoy training of both better quality and increased quantity. Units not needed early would function much as the units in the Force Support Program do now, with somewhat lower levels of equipment and personnel, and fewer training dollars than the first-tier units. Units not in war plans would receive equipment and personnel as available and would have last priority for training dollars.



Corralling the Trojan Horse: A Proposal for Improving U.S. Urban Operations Preparedness in the Period 2000–2025
Russell W. Glenn, Randy Steeb, John Matsumura.
DB-322-A

This study presents an alternative to close-combat urban operations that require a commitment of large numbers of soldiers. It has six mutually reinforcing, largely simultaneous components: intelligence, surveillance, and reconnaissance enhancements; denial of access; nodal operations; noncombatant control; selective dominance; and postconflict sustainment. Although the analysis largely focuses on combat operations, these elements also apply to objectives inherent during stability and support missions, whether these are part of a larger combat contingency or stand-alone actions in the theater of operations. Reaching the desired end state of a much improved way of conducting urban operations will demand consistent fiscal policies, technological development, and leader support over the next 25 years.

Enhancing Stability and Professional Development Using Distance Learning
Henry A. Leonard, John D. Winkler, Anders Hove, Emile Ettedgui, Michael Shanley, Jerry Sollinger
MR-1317-A

This study looked at the potential effects of distance learning (DL) on the availability of soldiers and leaders to their assigned units, stability of assignments, and some aspects of institutional training costs. The authors examined the effects of DL in shortening both the residential and total training times of a number of the Army's professional development courses. They estimated the number of additional days students would be available to their units, comparing DL-supported course variants with current fully resident courses. Even after allowing for home-station study time (to complete DL requirements), DL can make a considerable contribution to soldier availability. Partial conversion of courses to DL will also unambiguously reduce the time that soldiers are away from their families, as well as the costs associated with temporary-duty travel to resident courses. The study also offers insights into DL's potential to contribute to more general educational and professional development goals.

Heavy Matter: Urban Operations' Density of Challenges
Russell W. Glenn
MR-1239-JS/A

This study offers a new way of viewing urban operations, among the most complex challenges facing U.S. armed forces. Looking at urban operations in light of densities—people, buildings, vehicles—regardless of whether combat, stability, or support missions predominate, offers a viable means of approaching an otherwise most imposing puzzle. Doing so provides a vehicle for better understanding how to conceptualize issues of pertinence, the

tasks and missions that will address those issues, and the specific ways of employing elements of national power in the service of strategic objectives. Following an overview of density's potential influence on military operations, the author proposes and discusses five approaches to dealing with its challenges: Matching density with density, effectively reducing densities, maintaining selected densities, addressing density asymmetrically, and capitalizing on urban densities. He concludes with an analysis of density and its implications for information operations conducted in built-up areas.

Improving the Army Planning, Programming, Budgeting, and Execution System (PPBES): The Planning Phase
Leslie Lewis, Harry Thie, Roger A. Brown, John Schrader
MR-1133-A

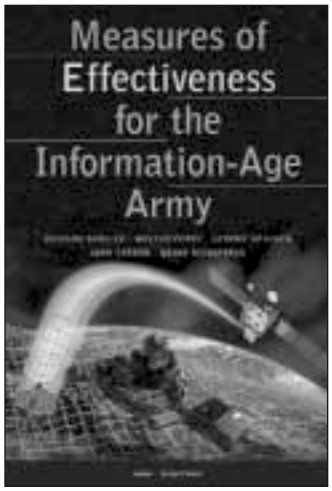
The Arroyo Center assessed the effectiveness of the reengineering of the Army planning and programming process in fiscal years 1995 and 1996. The Army had modified its planning and programming documents and asked the Arroyo Center to determine the extent to which the reengineering was successful and to suggest improvements. This report focuses on The Army Plan (TAP), the document that links planning to programming and provides the initial programming guidance to the Army Program Evaluation Groups. This report assesses TAP 2000–2015 and its Mission Areas (MAs) and recommends improvements for TAP 2002–2017. The authors identify several problems in TAP 00–15: mixing of operational and institutional functions, overlapping areas, overly broad and inappropriate MAs, unwieldy structure, and imprecise performance measures. With respect to TAP 02–17, the authors recommend that the Army reduce MAs to those that focus on operational missions and realign the MA hierarchy; start MA assessments before the publication of Army strategic planning guidance and the beginning of TAP work; and consider shifting organizational responsibility for the MAs and assessments (but not TAP) to give it greater linkage to strategic planning.

Keeping Military Pay Competitive: The Outlook for Civilian Wage Growth and Its Consequences
James Hosek, Jennifer Sharp
IP-205

To help the military attract and keep high-quality personnel, Congress voted in FY2000 for significant increases in military pay. But the military faces stiff competition from higher education as more young people attend college and as the financial value of a college education continues to rise. Will the recent pay increases be enough? To help answer this question, the authors looked at how military compensation will compare with private-sector compensation in the next ten years. They compared current military and civilian pay for persons with similar characteristics, computed the wage gaps, and then compared pay streams for different career paths. The findings suggest that, to meet its manpower challenges, the military may have to adjust compensation further than called for in the recent pay legislation. It may also have to develop new views on career paths, in-service education, and transferability of skills.

Maintaining the Government's Ability to Buy Smart
Carolyn Wong, Kenneth Horn, Elliot Axelband, Paul Steinberg
RP-919

Today, the Department of Defense (DoD) possesses a competent "smart-buyer" capability. But unless corrective measures are soon taken, the effect of shrinking the federal government workforce may undermine the future smart-buyer capability. Three measures will prevent this from happening: the DoD must establish and maintain collaborative research environments; it must try to ensure that work environments encourage direct and open communications among the players; and it must maintain a talented technical staff of scientists and engineers by exploiting the full range of recruiting tools and implementing career development opportunities.



Measures of Effectiveness for the Information-Age Army
Richard E. Darilek, Walter Perry, Jerry Bracken, John Gordon IV, Brian Nichiporuk
MR-1155-A

The 1990s witnessed the beginning of what future historians may call the Information Age. While it is clear that information will have a far-reaching effect on a host of activities—including warfare—how to quantify and measure that effect is less clear. The understanding of how to do so is important to the Army, particularly at a time when it is spending a considerable amount of its scarce investment capital to establish Information-Age links across its forces—the so-called digitization of the Army. As it transforms itself, the Army needs analytic tools to help make the best choices possible. Chief among these tools are good measures of effectiveness that can demonstrate the value of information in terms of military outcomes. This document reports on a small set of Information-Age measures developed in an

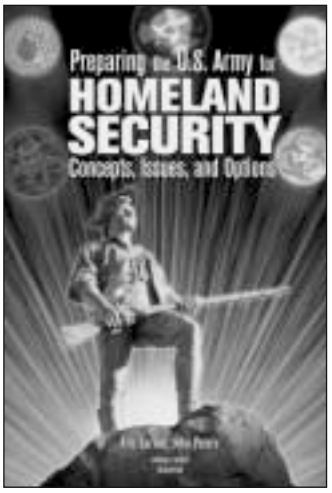
attempt to spark the creation of many more such measures. This research demonstrates that development of measures is feasible, not only for combat operations but also for stability operations.

Military Expenditures and Economic Growth
Jasen Castillo, Julia Lowell, Ashley J. Tellis, Jorge Muñoz, Benjamin Zycher
MR-1112-A

This study explores the historical relationship between economic growth and military expenditures in five "great power" countries: Germany, France, Russia, Japan, and the United States. Using statistical and case-study methodologies, the authors examine how each country's military expenditures responded to increases in economic output levels and in economic growth from 1870 to 1939, and they offer explanations for the relationship in each country. If historical experience holds true, economic growth in some of the present-day candidates for great-power status will spur them to increase the growth rate of their military expenditures and, as a result, their military capabilities. But each country is unique, and strong economic growth need not imply a commensurate expansion of military spending or capability. History suggests that perceived threats from abroad may be the most important factor leading potential great powers to increase military expenditures. This distinction is important, because policies designed to deter foreign military expansions motivated by ambition may have perverse effects if the expansions are in fact motivated by fear. This analysis suggests that today's large and vigorous economies are most likely to devote a growing share of their government and national resources to military expenditures when the external environment appears highly unstable. During such times, an increase in the size and effectiveness of these states' armed forces can lead to a significant reconfiguration of the global balance of power.

Military Recruiting: Trends, Outlook, and Implications
Marygail K. Brauner, Bruce R. Orvis, Beth J. Asch
MR-902-A/OSD

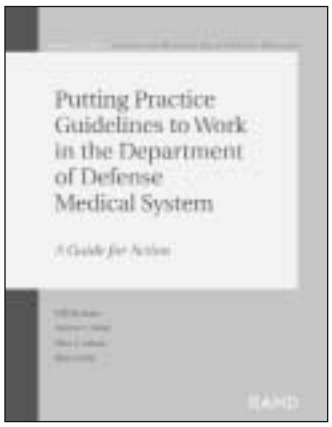
Based on indications of increased difficulty in meeting recruiting goals, in spring 1994 the Army Chief of Staff and the Deputy Secretary of Defense asked RAND to examine recent trends in the recruiting market and to assess their implications for meeting accession requirements. An initial examination of the 1994 market concluded that the pool of interested high-quality young men was adequate to meet DoD needs but that the system appeared to be less effective in tapping into this supply of potential enlistees. The longer-term analysis, reported here, confirms the reduced effectiveness of recruiting, and also finds that the significant increase in FY97's accessions required to sustain the postdrawdown force, coupled with a decline in youth's interest in military service, translates into a possible supply shortage. The decline in recruiting productivity is most likely due to a number of factors, and until these are addressed, meeting accession goals will require more recruiting resources or different management practices. The researchers offer two short-term actions for consideration: (1) increase recruiting resources, and (2) reduce the requirement for high-quality non-prior-service male accessions by recruiting more women, accepting more prior-service accessions, or changing the quality goals. Longer-term actions should aim at enhancing the cost-effectiveness of recruiting in the postdrawdown environment. This could include: rethinking recruiting management and the cost benefit of alternative recruit quality levels; considering more marketing strategies and enlistment options, particularly ones that would improve the military's ability to recruit persons interested in attending college; and optimizing the match between monthly accession goals and training infrastructure costs.



Preparing the U.S. Army for Homeland Security: Concepts, Issues, and Options
Eric V. Larson, John E. Peters
MR-1251-A

Although it is generally agreed that "homeland defense" is an emerging mission area for the Department of Defense, there is as yet little agreement on many key issues, including the definition of homeland defense, the task areas to be included, probabilities and magnitudes of the threats in each task area, the desired performance levels and capabilities, the most effective concepts for providing these capabilities, or the budgets that will be needed. This research defines homeland defense and argues that it should be made up of five main task areas: domestic preparedness against weapons of mass destruction, continuity of government, continuity of operations, border and coastal defense, and national missile defense. The authors suggest an analytic methodology and illustrate it. The authors assess Army doctrine, organizations, training, leadership, materiel, and soldier systems for each task area, and provide illustrative planning vignettes that the Army and Department of Defense can use. Finally, it is argued that a long-term adaptive framework is needed for developing homeland defense policies and programs, and that additional resources should only be allocated as the threat increases and the cost-effectiveness of policy alternatives becomes better understood.

Putting Practice Guidelines to Work in the DoD Medical System: A Guide for Action
Will Nicholas, Donna O. Farley, Mary Vaiana, Shan Cretin
MR-1267-A



The challenges of implementing evidence-based practice guidelines in clinical settings have been widely recognized in the health care field. This implementation guide is designed as a "how-to" procedure for managers and clinicians in the military health system who seek practical techniques to help them integrate evidence-based practice guidelines into the medical care processes at their medical facilities. The guide will be of particular use because its content is based on both published research on clinical guideline implementation and more than two years of experience with guideline implementation during the Army Medical Department/RAND Guideline Implementation project. In this project, three regional demonstrations were conducted to test methods for implementing three different guidelines, with participation of eleven Army medical facilities. Lessons learned from the project have been incorporated into the information provided in this guide as well as in field note examples highlighted throughout the document.

Thinking Small: Technologies That Can Reduce Logistics Demand
Calvin Shipbaugh
RP-888

In support of the Logistics Integration Agency's efforts to identify the most important technological innovations contributing to the Revolution in Military Logistics, this paper describes three areas of emerging miniaturization technologies that could support a dramatic reduction in logistical demands and improve the performance of logistics processes. As the Army fields future weapon systems, miniaturization technologies will permit design and support options that reduce logistics demands while offering additional opportunities for logistics process improvement. Near-term applications of microelectromechanical system devices will lead to a range of improvements such as enhanced efficiency of weapon and transportation systems, reduced waste and spoilage of materiel, and lower rates of system failure. As the use of tiny microsensors and microprocessors spreads, the U.S. military could become an integrated information network of individual Web sites in a netted theater. Longer-term military applications of molecular nanotechnologies are expected to bring further improvement in areas such as power sources, biomedicine, and virtual manufacturing. By planning for, supporting, and exploiting these technologically driven synergies between demand reduction and logistics process improvement, the Army will be well positioned to achieve a full revolution in military logistics.

Using Venture Capital to Improve Army Research and Development
Bruce Held, Ike Chang
IP-199

The U.S. Army is having difficulty balancing its need for new technologies with the resources available to develop them. Since it is unlikely that the Army will devote substantially greater resources to its research and development, the Army must find better methods for developing the technologies needed to stage its revolution in military affairs while keeping current equipment relevant and affordable. This issue paper introduces the idea that the Army should fund some of its technology development through a private venture capital organization. The concept exploits venture capital's efficiency in developing technology, its access to the growing commercial technology sector, its capacity to respond with agility to changing technology, and its ability to leverage additional resources throughout the development cycle. The authors propose that the Army set up a venture capital fund as a not-for-profit corporation that makes equity investments in early-stage companies developing technologies that are important to the Army but also have potential to find commercial markets in the longer term. The use of a venture capital model for development of relevant advanced technologies could significantly help the Army achieve the acquisition reform goal of affordably acquiring the leading-edge technologies it needs. ■

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