A Campaign-Quality Army

Annual Report 2005

RAND ARROYO CENTER

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A Campaign-Quality Army

RAND ARROYO CENTER

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Letter from the Director

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It is hard to remember a time when the U.S. Army faced a wider and more formidable array of threats. Since shortly after 9/11, it has been fighting a determined and adaptive enemy who has proven to be adept at using asymmetric techniques to counter or avoid U.S. military strengths. We expect conflicts of this kind to continue, in various forms, for many years to come, and to be a primary focus of U.S. defense efforts. Yet it is hardly the only challenge. North Korea and its mercurial leader continue to threaten the stability of the Korean peninsula, and may now have nuclear weapons in addition to large conventional forces. China is making substantial progress in turning its forces from a large land-based Army focused on territorial defense into a smaller but much more agile force that can project its power across the Taiwan straits. And Iran seems determined to acquire nuclear weapons, while its meddling in Iraq and Afghanistan may yet provoke a U.S. military response.

Clearly, today's challenges call for an Army that truly embodies "full-spectrum" capabilities and is capable of responding quickly to a range of threats as they emerge around the globe—including in the United States. This is the force the Army seeks when it talks of pursuing "a campaign-quality Army with a joint and expeditionary mindset." The effort could not be more timely or important: hence we have chosen to focus this year's annual report on RAND Arroyo Center's support to the pursuit of a campaign-quality Army. The report describes the results of several research efforts that deal with the issues facing the Army as it makes what arguably might be the most difficult transformation in its 200-year history.

The first essay discusses some issues associated with becoming a full-spectrum force. We now recognize the wars in Iraq and Afghanistan as insurgencies, but our first essay suggests that the kind of insurgency matters in shaping the appropriate response. The essay builds a case for viewing them as among the first examples of networked insurgencies, which operate far differently from traditional ones. In this case, definitions can be crucial because the techniques that work against one type fail utterly when applied to the other. The essay also chronicles an Arroyo effort to help the Army plan so-called stability and support operations, or SASO. Arroyo researchers have developed a user-friendly spreadsheet model to determine the size and composition of forces needed for such operations. The essay concludes with a discussion of homeland security and what it could mean for the Army. After describing a range of plausible events, it proposes different responses and estimates what each might cost.

The second essay takes up the issue of operational tempo and what options the Army might have for responding to the demand of continuing rotations while still affording active and reserve component units reasonable recovery time between deployments. It focuses on the amount of time units spend at home between deployments and the number of combat-ready brigades the Army can field under different levels of operational demand, different Army force structures, and different policies with regard to using the reserve components. It then explores the costs and risks of the policy options the Army has to address the varying levels of demand.

The report next turns to what may be one of the Army's most significant challenges in developing a campaign-quality force: the training and stabilization policies necessary to keep such a force ready to fight under a wide array of circumstances. The essay first addresses the complex question of how the Army should train "full-spectrum" leaders. It turns next to the challenge of producing well-trained units. The Army has proposed a set of enhancements to improve future training for Maneuver Brigade Combat Teams. Arroyo researchers assessed these enhancements as well as others, and identified options the Army might consider to improve future maneuver unit training capabilities. Finally, this essay takes up the issue of unit stability, which

is one approach the Army is taking to boost the readiness and proficiency of its combat units. The essay describes the potential implementation effects of lifecycle manning on two key soldier outcomes: combat performance as measured by unit performance at the National Training Center and soldier well being.

The final essay considers a key enabling capability for the Army's vision of its future: a mobile wireless network, in many ways the sine qua non of the Army's plans for how it will fight in the future. One part of the essay recounts the judgment of network experts on the state of technology and the Army's approach to building its network. A second part addresses the Army's ever-increasing demand for bandwidth, and reports the results of Arroyo's work on what the Army can do to increase the size of the electronic pipes through which it must push its data. Finally, this essay lays out some of the considerations involved in selecting the type of network used and what that selection means for the tradeoff between efficiency and robustness.

The creation of a campaign-quality Army with a joint and expeditionary mindset is a work in progress and will remain so for a number of years. The research described here deals with only a few aspects of that complex process.

Soldiers from the 1st Armored Division patrol Tal Afar, Iraq. Photo courtesy of U.S. Army; photographer Staff Sgt. Aaron Allmon II

As RAND Arroyo Center builds its research agendas in the coming years, it will continue to work closely with its many Army sponsors to identify the other areas where objective analysis can help point the way. ■

The Arroyo Center: Origins and Growth

The Beginning: The Jet Propulsion Laboratory

The origins of RAND Arroyo Center trace back several years before its founding in 1982. Discussions about the Army's need for an external analysis agency had been going on since the mid-1970s among various members of the Army Staff, notably Lieutenant General Edward Meyer, then Deputy Chief of Staff for Operations, Dr. Walter La Berge, the Under Secretary of the Army, and Major General Maxwell Thurman, then head of the Army's Program Analysis office and familiar with the support that the U.S. Air Force was getting from RAND's Project AIR FORCE. Meyer became Chief of Staff in 1979, and in 1981 Thurman became the Army's Vice Chief. Along with James R. Ambrose, who became the Army's Under Secretary in 1981, they started the process that brought the Arroyo Center into being. All were familiar with the relationship between the Air Force and Project AIR FORCE at RAND and thought it would be a good model for the Army—an organization equipped with a range of analytic skills that could do independent and objective research on major Army issues. Credibility of research findings was crucial, and for that reason they concluded that the organization had to stand outside the Army. Hence they chose the management structure of Project AIR FORCE, namely that of a federal contract research center (later called a federally funded research and development center, or "FFRDC").

The Army initially chose to locate its new analysis center at the Jet Propulsion Laboratory (JPL), in the Arroyo Seco (literally, "dry river bed") just north of Pasadena, California. JPL had been founded as an Army laboratory, and although it had been transferred to the National Aeronautical and Space Administration upon its formation in response to the Soviet launch of *Sputnik*, the Army maintained a contract with JPL that could be readily expanded to include the new analysis center. Meanwhile, Mr. Ambrose's earlier experience in the aerospace field had made him familiar with JPL and its managing officials. Accordingly, an official from the Army Study Program Management Office approached the California Institute of Technology, which managed JPL for NASA, about establishing an analysis center patterned after Project AIR FORCE. This center was to be a high-quality, interdisciplinary research and analysis organization that would help the U.S. Army study long-range issues important to its civilian and military leadership.

JPL formed a study group to consider the Army's request in May 1982. A series of discussions between Army officials, including Mr. Ambrose and Walter Hollis, the Deputy Under Secretary of the Army for Operations Research, and JPL and Caltech officials, took place over the summer. The Caltech Board of Trustees approved the concept, and JPL appointed Dr. Martin Goldsmith as manager for what was initially called the Army Analysis Program. The new organization submitted its first annual operating plan to the Army Study Program Management Office in September 1982. The plan addressed the proposed work for fiscal year 1983, which principally entailed organization and program definition but also authorized some limited substantive work. That document, coupled with the transfer of $200,000 to JPL, marked the beginning of what would come to be known as the Arroyo Center. In October, a committee under former JPL director William Pickering was assembled to establish a charter and mode of operation for the Army Analysis Program. In May 1983, the name was changed to the Arroyo Center, and the organization began reporting directly to the Director of JPL. The first director of the Arroyo Center, Richard A. Montgomery, was hired in September 1983, replacing Martin Goldsmith.

From Arroyo Seco to Ocean Avenue

The Army's analytical goals and the philosophy of JPL's managing body, the California Institute of Technology, did not mesh well. Many Caltech faculty members believed that the new organization's policy focus was inappropriate for Caltech, whose expertise was primarily in technical fields. In spite of efforts on the part of Arroyo Center and Caltech leadership to allay such concerns, the faculty voted in January 1984 to have the university divest itself of the Arroyo Center. Army officials considered a number of alternative homes for the center, each deemed to have the requisite experience in operating an interdisciplinary research group. These included SRI International, the New Mexico

State University Physical Science Laboratory, the Aerospace Corporation, and, of course, the RAND Corporation. In September 1984, the U.S. Army Chief of Staff decided to transfer the Arroyo Center to the RAND Corporation, and on February 1, 1985, the Arroyo Center facility at JPL closed its doors. During its tenure at JPL, the Arroyo Center published 27 reports on topics ranging from U.S. policy toward Latin America to the military uses of infrared sensors.

From a research perspective, the transition to RAND was relatively seamless. A handful of the 25 Arroyo researchers transferred from JPL to RAND, bringing with them three Army-approved research projects: Lessons Learned in the Field, Fault Lines in the Warsaw Pact, and Projection of Soviet Forces. Those three projects, coupled with five more developed by the RAND staff, constituted the proposed research plan for 1985 that was presented to the Arroyo Center Policy Committee, the body formed by the Army leadership to oversee the Arroyo Center's research agenda. At the time, the committee had five members: the Vice Chief of Staff, U.S. Army, the Assistant Secretary of the Army (Research, Development and Acquisition), the Commanding General of U.S. Army Training and Doctrine Command, the Commanding General of Army Materiel Command, and the Deputy Chief of Staff, Operations. The Executive Agent for the Arroyo Center was the Director of the Study Program Management Office.

The Early RAND Years

That first research agenda developed at RAND understandably reflected key Cold War concerns, notably how best to defend Europe against attack by Warsaw Pact forces. Yet it included the beginnings of research streams that continue to the present. One of the initial logistics projects, for example, employed the RAND Dyna-METRIC model, originally developed to analyze the movement of spare parts in Air Force maintenance systems, to help the Army find better ways to manage its spare parts. This work eventually grew into the Velocity Management project, which expanded the focus from spare parts to the entire supply and maintenance system and contributed to major changes in how the Army carries out its logistics. This particular project also illustrates the benefit of locating the Arroyo Center at RAND, where Army researchers could take advantage of the experience of their Project AIR FORCE colleagues, as well as colleagues in the rest of RAND's growing number of research centers.

A second major stream of research appears in the work done at the Army's National Training Center (NTC) at Fort Irwin, California. One of the first questions the Army asked Arroyo was whether scientifically valid quantitative research could be done in a field setting. The National Training Center collects an enormous amount of data on the mock battles fought there, but it was not clear whether that information would support valid research findings. Some early work indicated that it could, but also that structured observations in the form of questionnaires, filled out by the observer-controllers who accompany the training units, could provide information not available from routine data collection. These techniques have been in use at the National Training Center ever since, and Arroyo Center researchers working there today employ the techniques developed in those early years.

The Post–Cold War Years

Even before the Berlin Wall came down, Arroyo Center researchers began helping the Army think about a future in which the main focus was not armored warfare on the plains of Europe. With forces of change clearly at work in the Soviet Union, anticipating what that nation might look like in five or ten years became important, and Arroyo researchers turned to such topics as contemporary events in the Soviet Union and the effect of Gorbachev's policies on the political scene. The withdrawal of the Soviet army and the reunification of Germany meant that the Army needed a new strategy to defend Europe. The Arroyo Center helped Army planners think about new strategies for Europe, while also focusing on new emerging national security needs that would require Army forces. Meanwhile, Arroyo's manpower experts helped the Army manage a near 40 percent reduction in strength that began in 1992.

But it was also clear that the United States was destined to play a much different global role, so the Arroyo Center broadened its focus to take in other arenas and types of conflict, including conflicts in the Third World. Some saw Operation Just Cause, which drove the Noriega regime from power in Panama, as a harbinger of other regional contingencies, and Arroyo Center researchers analyzed that operation to determine what it might imply for supporting similar operations. Operations other than war (OOTW) had always been in the Army's repertoire, but they assumed new importance following the Cold War; indeed, some saw them as the Army's primary role and argued for a drastically revamped force structure to deal with them. While recommending against that approach, Arroyo Center researchers nonetheless explored the ramifications of

Many Arroyo researchers work at the RAND Corporation's headquarters in Santa Monica, California.

OOTW, particularly their effect of preparedness for traditional military missions.

As the post–Cold War decade wore on, the Arroyo Center devoted considerable effort to helping the Army resolve two persistent dilemmas. One was created by small but repetitive deployments that seemed to have a disproportionately large effect on the Army's operating tempo and readiness. Arroyo Center research helped the Army understand the complex effects of small deployments and how they might best be managed. The second dilemma was created by what some have called the "barbell" shape of U.S. forces: very capable but heavy forces unable to deploy quickly, and agile light forces able to get to the area of conflict rapidly but lacking punch and staying power. Well before the Army launched its ambitious "transformation" effort in the fall of 1999, Arroyo had begun to suggest ways for the Army to make the light forces more effective without robbing them of their agility.

Arroyo Today

Today, the Army finds itself engaged in active insurgencies in Afghanistan and Iraq. While fighting those conflicts, the Army is absorbing the lessons learned from them on a daily basis, and RAND Arroyo Center is helping in that process. It is engaged in publishing reports on the conflicts themselves, highlighting successes as well as areas for improvement. It is also helping to correct problems identified. For example, some of the logistical processes used to support forces in Iraq during major combat and subsequent operations did not perform as well as expected, and Arroyo researchers have worked closely with logistics organizations inside and outside the Army to modify procedures and practices to solve problems. Furthermore, the need for a continuing presence in Iraq and Afghanistan is causing Arroyo to revisit its research on turbulence and turnover along with that on basing and manning. And the heavy use of reserve components underscores the need to reexamine the balance between the components.

As large as the fighting in Iraq and Afghanistan looms, the Army is facing formidable challenges in other venues as well. The conflicts have reduced the Army's ability to attract high-quality soldiers, and Arroyo is trying to help the Army counter this challenge. Hurricanes Katrina and Rita have raised questions about the nation's ability to respond to natural disasters or a large-scale terrorist event, and Arroyo is helping the Army assess the lessons of this experience, in particular the possibility that the military might have to assume a larger or more immediate role than has been assumed in the past. And, of course, the Army is still transforming itself from a heavy, Cold War force to one better structured, equipped, and trained to deal with a wide spectrum of requirements. Thus, the task facing RAND Arroyo Center is to help the Army come to grips with what is surely one of the most demanding periods of its history.

The Army's need for first-rate research has never been greater. Over the past two decades, RAND Arroyo Center has recruited the research staff, developed the analytic tools, and created the research capital to meet this need, and it looks forward to many more years of helping the Army serve the nation. ■

The Arroyo Center Policy Committee

RAND 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 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 RAND 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 comprises the following individuals.

General Richard A. Cody (Co-chair)
Vice Chief of Staff, U.S. Army

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

Mr. Daniel Denning
(Acting) Assistant Secretary of the Army (Manpower and Reserve Affairs)

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

General William S. Wallace
Commanding General, U.S. Army Training and Doctrine Command

General Benjamin S. Griffin
Commanding General, U.S. Army Materiel Command

General Dan K. McNeill
Commanding General, U.S. Army Forces Command

Lieutenant General Robert W. Wagner
Commanding General, U.S. Army Special Operations Command

Lieutenant General Kevin C. Kiley
Commanding General, U.S. Army Medical Command/ The Surgeon General, U.S. Army

Lieutenant General Franklin L. Hagenbeck
Deputy Chief of Staff, G-1, U.S. Army

Lieutenant General James J. Lovelace
Deputy Chief of Staff, G-3, U.S. Army

Lieutenant General Ann E. Dunwoody
Deputy Chief of Staff, G-4, U.S. Army

Lieutenant General Steven W. Boutelle
Chief Information Officer, G-6, U.S. Army

Lieutenant General David F. Melcher
Deputy Chief of Staff, G-8, U.S. Army

Lieutenant General David W. Barno
Assistant Chief of Staff for Installation Management, U.S. Army

Major General (P) John F. Kimmons
Deputy Chief of Staff, G-2, U.S. Army

Major General N. Ross Thompson III
Director Program Analysis and Evaluation, Executive Agent for the Arroyo Center

Meeting the Challenge of Full-Spectrum Warfare

During the Cold War, the Army planned mainly for major combat and tended to see other operations—so-called operations other than war—as "lesser included contingencies" for a warfighting Army. Although this attitude is often seen as a reaction to the frustrations of the Vietnam conflict, it predates Vietnam by several decades. And it made sense, during the Cold War, when the Army faced a near-overwhelming conventional enemy in the form of massed Soviet forces.

But the Cold War ended over fifteen years ago, and since then the Army's operational menu has varied widely, from major combat in Iraq in 1991 to a humanitarian relief operation in Somalia to political stabilization missions in Bosnia and Kosovo late in the 1990s, and, finally, to the present counterinsurgency campaign in Iraq. With the war on terrorism as a major (but not the only) organizing theme for planning military forces, the Army must expect to face more stabilization and counterinsurgency operations in the future—even as conventional threats like that posed by North Korea remain very real.

With the war on terrorism as a major (but not the only) organizing theme for planning military forces, the Army must expect to face more stabilization and counterinsurgency operations in the future—even as conventional threats like that posed by North Korea remain very real.

Thus, today's campaign-quality Army must be able not only to conduct sustained combat operations of shifting scope but also to operate across the entire spectrum of warfare. This spectrum includes counterinsurgencies, stability and support operations, and homeland defense. RAND Arroyo Center has carried out research in each of these areas to help the Army define what each means in terms of requirements for the force.

Counterinsurgency Operations

The Army's history of waging counterinsurgency operations arguably traces back to the earliest days of the country and the Revolutionary War. Subsequently, it fought the Indian Wars, an insurgency in the Philippines, and, of course, the Vietnam conflict. As much as this history may teach lessons for today's Army in Iraq, the fact is that today's insurgents pose a different kind of threat, one made possible mainly by the very information revolution that the U.S. Army itself seeks to exploit to improve its capabilities: this might be called "network-centric" insurgency.

Iraq: Not a Traditional Insurgency

For over two years, the Army has waged a debilitating counterinsurgency campaign in Iraq, which some have described as a "classical guerrilla-type campaign." The reality is that it is not—which is among the reasons why the insurgency is proving so difficult to defeat and the insurgents themselves so resilient. Definitions matter because they shape how people perceive and, more important, respond to what is being defined. The distinction between the "classical" guerrilla insurgencies of the Cold War era and contemporary network-centric ones is critical. Unlike the classical insurgency modeled on Mao Tse-tung's, the one in Iraq has no center of gravity. Apparently absent from the Iraq insurgency are a clear leader (or leadership),[1] any attempt to seize and actually hold territory, and any single defined or unifying ideology. Rather, what we find in Iraq is the closest manifestation yet of netwar: warfare carried out by flatter, more linear, diffuse, and multidimensional networks rather than the clearly identifiable stovepiped, pyramidal hierarchies and command and control systems that have governed traditional insurgent organizations.

[1] The infamous Abu Musab Zarqawi clearly had pretensions to such a role, as evidenced by the letter he wrote to bin Laden that was seized by U.S. authorities, but he never achieved such a distinction. (See "Full Text of 'Al-Zarqawi Letter,'" http://www.ict.org.il/documents/documentdet.cfm?docid=62.)

The organizational structure of netwar has been characterized as follows:

> *[It] is quite flat. There is no single central leader or commander; the network as a whole (but not necessarily each node) has little to no hierarchy. There may be multiple leaders. Decisionmaking and operations are decentralized and depend on consultative consensus building that allows for local initiative and autonomy. The design is both acephalous (headless) and polycephalous (Hydra-headed)—it has no precise heart or head, although not all nodes may be "created equal."*[2]

This description arguably comes closest to explaining the insurgent phenomenon that has unfolded in Iraq, where secular Ba'athists and other former regime elements increasingly cooperate with religious extremist foreign jihadis along with domestic (Iraqi) jihadis. In this loose, ambiguous, and evanescent environment, constellations of independently organized cells or mere collections of individuals gravitate toward one another to carry out armed attacks, exchange intelligence, trade weapons, or engage in joint training and then disperse, at times never to operate together again. "Here the Ba'athist/Islamic divide does not exist in a practical sense," a senior Coalition Provisional Authority (CPA) official responsible for training the Iraqi police remarked as long ago as February 2004. "I wouldn't have thought it possible as they were so diametrically opposed to each other during the [Saddam Hussein] regime—but it is happening."[3]

Admittedly, it is still too soon to determine whether the features of Iraq's insurgency will be lasting or ephemeral characteristics of postmodern insurgency. But if they gain traction and are indeed revealed to be a harbinger, the implications for how military forces train, equip, and organize to meet this challenge are profound.

A Crucial Test

Admittedly, it is still too soon to determine whether the features of Iraq's insurgency will be lasting or ephemeral characteristics of postmodern insurgency. But if they gain traction and are indeed revealed to be a harbinger, the implications for how military forces train, equip, and organize to meet this challenge are profound. The network-centric insurgency in Iraq thus presents an important test for the Army. Insurgents and terrorists there—and doubtless those observing from both surrounding and distant locations—may already have been encouraged and emboldened by their ability to confront the world's most technologically advanced, best trained, equipped, and led military.

The stakes are high. Whatever the outcome of the current conflict in Iraq, its consequences will likely be felt for years to come. It is important to understand that many of the foreign jihadis fighting in Iraq view the conflict there as a means to an end, not as an end in itself. The road to Tel Aviv, Amman, and perhaps Riyadh runs through Baghdad. These foreign insurgents are not likely to make their last stand in Iraq. Rather, if pressed to the wall, they will disperse and emerge elsewhere. But they will carry with them the invaluable lessons learned in the urban fighting in Iraq, including the use of roadside and vehicular improvised explosive devices, stand-off weapons, remotely detonated bombs, and a panoply of other tactics of the urban guerrilla. Exporting these tactics to the cities of Europe, North Africa, the Middle East, South Asia, and elsewhere could rapidly escalate the death and destruction in countries that have seen little if any organized jihadi violence.

What the Army Needs to Do

Arroyo analysis suggests that the rise of insurgent operations argues for a more coherent and disciplined approach to teaching counterinsurgency (COIN) topics. A review of Army doctrine and formal officer education programs along with interviews with leaders returning from Afghanistan and Iraq has revealed that the Army does not have a coherent COIN doctrine, and without that doctrine, leader training and education for COIN are unlikely to improve dramatically. Analysts also detected a strong bias toward major combat operations, with COIN operations seen as lesser-included operations in doctrine and most education programs. However, there is also good news in the curri-

[2] John Arquilla and David F. Ronfeldt, "The Advent of Netwar," in Arquilla and Ronfeldt (eds.), *In Athena's Camp*, Santa Monica, CA: RAND Corporation, MR-880-OSD/RC, 1997, p. 280.
[3] Email communication with a senior CPA official, Baghdad, Iraq, February 2004.

cula of Special Operations Courses, the Advanced Military Studies program, and the Army's support for Internet-based forums to share COIN lessons and collaborate on COIN problem solving. From these observations, Arroyo researchers have identified seven major implications for Army doctrine, training, education, and organization during the current transformation campaign.

- Continue development of a comprehensive counterinsurgency doctrine that appreciates the network form of organization and provides tactics, techniques, and procedural guidance.
- Develop and maintain a cadre of counterinsurgency specialists to train U.S. forces and advise foreign partners.
- Develop a resident joint and interagency counterinsurgency training program for general-purpose forces.
- Expand formal education efforts to improve COIN and stability and support operations skills.
- Integrate netwar concepts into doctrine and training.
- Emphasize policing and intelligence collection for general-purpose forces.
- Use simulations and gaming technologies to improve COIN skill sets.

The challenge to the Army is formidable. It cannot ignore major combat operations, but neither can it relegate COIN to a "lesser included" status. The key to success lies in harnessing the overwhelming combat force of the Army as part of a comprehensive vision to transform capabilities to deal with irregular and unconventional threats.

Stability and Support Operations

Since 1990, the United States armed forces, primarily the U.S. Army, have led seven major postconflict stability and reconstruction operations and participated in a dozen others. The pace and scope of these operations have grown since 2001, as the United States has increased its use of force against international terrorist groups. Adjusting to this shift in focus has been one of the primary challenges facing the Department of Defense, and planning and executing stability operations by the Army has posed a major challenge.

Army Field Manual (FM) 3-0, *Operations*, describes stability and support operations (SASO) as one of four major types that the Army must conduct, and FM 3-07, *Stability Operations and Support Operations*, expands on FM 3-0 by discussing the distinct challenges of stability operations together with doctrinal foundations that facilitate meeting them. This conceptual manual provides the analytical tools needed to evaluate a stability operation or a support operation. However, it does not deal with one of the more difficult problems facing the Army: determining the requirements for SASO. These difficulties arise because the nature of the SASO can vary dramatically depending on the country involved and the nature of the tasks that a unit has to accomplish.

From these observations, Arroyo researchers have identified seven major implications for Army doctrine, training, education, and organization during the current transformation campaign.

The Force Estimator Model

To help calculate SASO force requirements, RAND Arroyo Center has developed a user-friendly model that runs on widely available computers and software. The intent underpinning its development is to give the Army force planner a flexible and credible tool that can quickly compute force requirements and then vary them to see which attributes are most sensitive in the specific situation.

The model contains a wealth of data in the form of planning factors, an extensive list of Army units by standard requirements code (SRC), and country data taken from the CIA *World Factbook*. The latter are provided as a reference for those analysts who need specific pieces of information about a country, e.g., population.

The tasks associated with SASO are the most critical component of the model; they drive the requirements. These tasks fall into two categories: force employment and support functions. Force employment tasks include security (controlling enemy assets, creating a secure environment, and dealing with unexpected events), humanitarian aid, repairing or rebuilding critical infrastructure, and providing special forces. Support functions include command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR), logistics, and support.

Many of the tasks have subtasks. For example, controlling enemy assets has four subtasks: demobilization, demilitarization, sensitive site protection, and battlefield cleanup. Each task requires the planner to provide certain inputs, and once this has been done, the model will calculate the units required to carry out that task and report the results by SRC. Figure

1 is an example of how the planner would calculate the troops required to demobilize an enemy force. The model requires the planner to enter information about the number of enemy prisoners of war and how many new or refurbished prisoner of war camps would be needed, and the number of prisoners that must be moved each day. Once the inputs are provided, the model calculates requirements to the SRC level of detail, as indicated in the lower left-hand portion of Figure 1.

The model has a series of screens for each force employment or support task. Once all are filled out, the model calculates the overall requirements for the scenario. The planner can then alter any of the entered data and recalculate the requirements. The model has a postprocessing capability that enables planners to compare the results of scenarios.

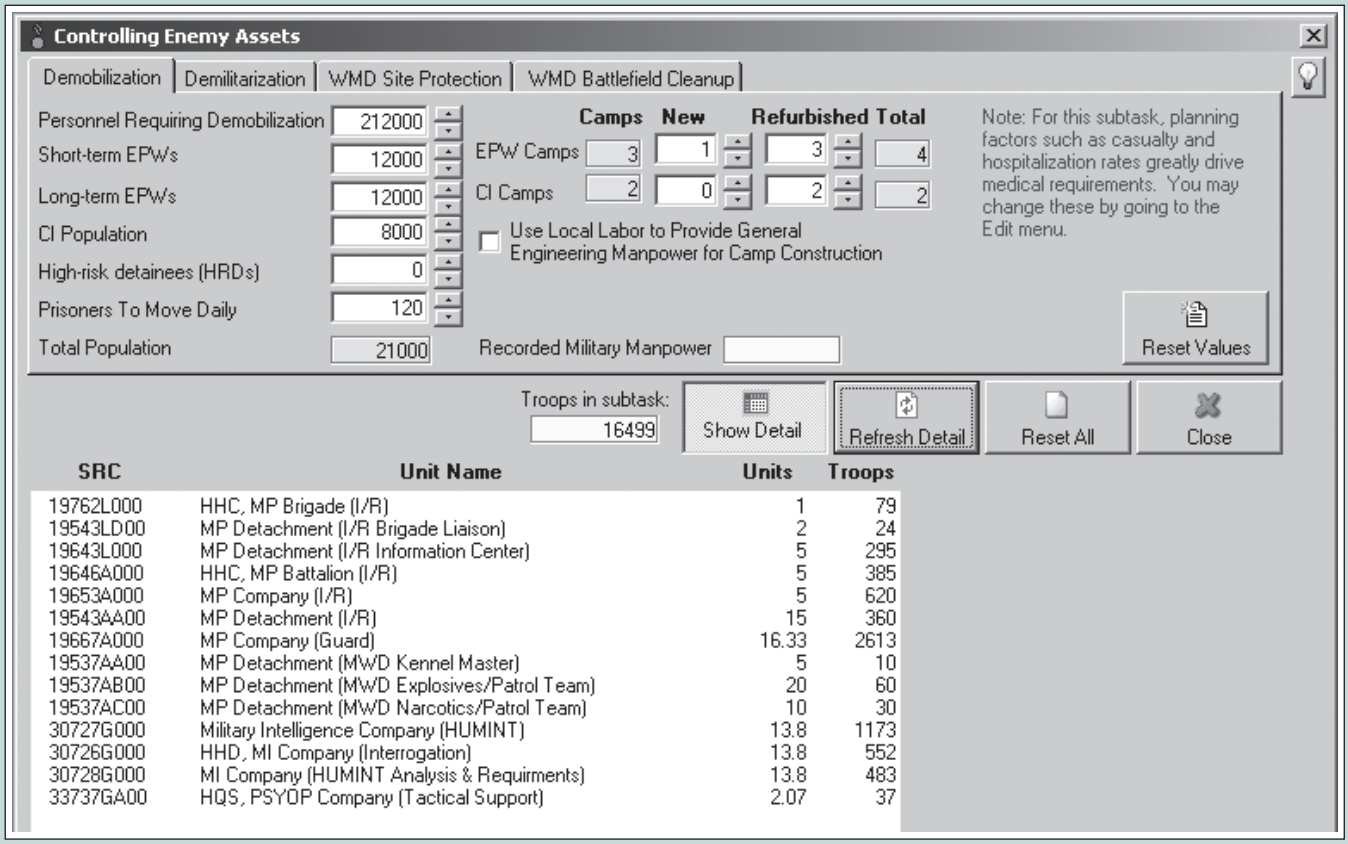
The model offers several advantages. It provides planners a quick way to estimate SASO requirements and to vary parameters to identify the most demanding requirements. More important, the model gives planners a clear audit trail between tasks and requirements. Finally, the model is easy to change, so as experience in SASO grows, the Army can modify the planning factors to produce more accurate requirements. The model has won ready acceptance among Army planners and can be downloaded from a password-protected web site (http://www.rand.org/ard/).

Homeland Defense

The September 11 terrorist attacks vaulted homeland security to a top national priority.[4] Since then, many civilian organizations have been improving their capabilities to respond to such attacks. The role of the U.S. military, especially the Army, is to make up for any shortfalls in civilian

[4] Even before the September 11 attacks, Arroyo research had indicated that it was likely adversaries would attempt attacks on the homeland as an asymmetric strategy to counter the overwhelming superiority of U.S. forces in direct combat. See Richard Brennan, *Protecting the Homeland: Insights from Army Wargames*, Santa Monica, CA: RAND Corporation, MR-1490-A, 2002.

Figure 1. Calculating Demobilization Requirements



capabilities. The Army has already taken steps to enhance its ability to respond in this area. For example, it has made some of its active and reserve units available more rapidly. The question is whether it should do more to hedge against the risk of not being adequately prepared. A group of RAND Arroyo Center researchers explored ways that the active and reserve components of the Army could respond to that risk today. The results of the analysis appear in *Army Forces for Homeland Security*.

What Should the Army Hedge Against and How?

The considerable uncertainty in the nature of the threat to the homeland and the capabilities that local communities and states can generate to meet them seriously complicates the Army's task in determining its likely role in this realm. To determine what the Army might plan for, Arroyo researchers posed five possibilities against which the Army might want to hedge. These hypothetical but plausible possibilities could pose a serious risk to the country should they occur. To illustrate possible responses, Arroyo researchers developed ways that the Army could prepare *today* by conducting specialized training, improving responsiveness, or by augmenting capabilities.

Possibility 1: The National Guard is inadequately prepared because of its focus on conventional warfare.

Army response 1: Improve National Guard homeland security capabilities by providing funds and facilitating the sharing of state assets. Department of Defense (DoD) funding would be provided for training that enhances a state's homeland security capability. Legislative changes would facilitate the use of one state's soldiers in another state by making laws uniform and extending legal protections to guardsmen performing homeland security.

Possibility 2: Active component is not available soon enough or trained well enough to respond to a large-scale domestic emergency.

Army response 2: Dedicate a brigade (3,600 soldiers) for rapid reaction rotating between the active component and the National Guard. The brigade would have an exclusive homeland security mission and thus be always available and well trained in homeland security tasks. Some elements of the brigade would always be on a higher alert status.

Possibility 3: Law enforcement combined with existing Army counterterrorism capabilities cannot meet demands of future terrorist attacks.

Army response 3: Create a rapidly deployable and dedicated combating terrorism force (6,200 soldiers) in the active component. This force would be designed to augment civilian law enforcement efforts quickly with highly trained, specialized forces that can protect key installations, assist in the event of civil disturbances, track terrorists and their weapons, and carry out other anti- and counterterrorism operations.

Possibility 4: Active component cannot respond adequately to large-scale domestic emergencies because of significant forces deployed overseas.

Army response 4: Give National Guard primary responsibility for homeland security activities by creating dedicated rapid-response civil support battalions (8,900 soldiers). This response would create ten new organizations, civil support battalions containing about 900 soldiers, in ten regions across the country. It would provide the heart of the National Guard homeland security capability with special training. The civil support battalions could draw on other Guard capabilities as required. Members would agree to remain on special alert status.

Possibility 5: Army Reserve units critical for homeland security are not available because they are deployed overseas, not ready soon enough, or prohibited by law from conducting all missions.

Army response 5: Dedicate a pool of Army Reserve units exclusively to the homeland security mission (7,500 soldiers). Many of the types of support units needed in past Army disaster relief operations are located primarily in the Army Reserve and will likely remain there, even given the Army's plans for augmenting support units in the active force. The forces would be located in different parts of the United States to facilitate responding to homeland security contingencies anywhere in the country. Although the reservists would not be on active duty, they would be notified of their priority homeland security status and would be on call for a more rapid activation (e.g., under 7 days).

These responses would offer a range of benefits, from providing more responsive, better-trained units for homeland security to improving the overseas readiness of active component units.

What Are the Costs?

The Army would take these actions immediately if they did not cost anything. But they do. The financial costs are of two types: startup and sustaining. In some cases startup

Table 1. Benefits and Costs of Army Options

Response	Benefits				How Accomplished		Costs ($ millions)	
	More Responsive	Available	Specially Trained	AC Oversees Readiness	Force Structure	Planning	Startup	Sustaining
Army National Guard training			★			★	0	20
Active component/Army National Guard homeland security ready brigade	★	★	★			★	0	200
Active component combating terrorism force	★	★	★		★		1,000–1,400	
Army National Guard primary homeland security responsibility	★	★	★	★	★		400–600	
Dedicate rapid U.S. Army Reserve units	★	★	★	★		★	0	0

costs are negligible, but some entail substantial costs. Table 1 lays out the potential benefits, how they are gained, and the estimated costs.

What Should the Army Do About Homeland Defense?

Without being able to predict the future and in the face of certain costs but uncertain benefits, the choice for the nation is what sort of homeland security risks it is willing to assume. Based on their analysis, Arroyo researchers concluded that a multifaceted hedging strategy could make sense for the Army. They recommend that the Army take the following actions:

First, given the National Guard's responsibility and availability to respond to domestic emergencies, the Army should support legislation that would make it possible for DoD to fund homeland security training activities and for the National Guard to share its resources more easily across state borders.

Second, given the possibility that units in all components of the Army may be unavailable because of overseas deployments and the need already acknowledged by DoD for units in all of the Army's components to be ready and on alert, the Army should take the additional step of dedicating some forces to homeland security emergencies and training them appropriately.

The diverse nature of these operations underscores the challenge of building an Army that can operate across the full spectrum of operations. What is abundantly clear is that the response to the demands of truly full-spectrum warfare cannot be one of business as usual.

Third, because the prospective capabilities and deficiencies of civilian organizations are uncertain, the Army should hedge again by dedicating a mix of forces for homeland security with some units trained in specialized law enforcement capabilities.

Fourth, any dedicated units should be drawn from the National Guard to permit the active Army and supporting Army Reserve units to be available for deployments overseas and to capitalize on the Guard's historical experiences in domestic emergencies and links to state and local emergency responders.

Conclusion

The diverse nature of these operations underscores the challenge of building an Army that can operate across the full spectrum of operations. What is abundantly clear is that the response to the demands of truly full-spectrum warfare cannot be one of business as usual. These operations require a wide range of capabilities and the doctrine, equipment, and training to employ them effectively. To become effective across the spectrum will require sweeping change, which is always difficult for large organizations to make. ■

Army Stretched Thin

There's No Easy Way Out for the Nation

The United States faces an enormous challenge in having to provide military forces for sustained overseas operations while protecting the American homeland and standing ready for other crises that may require rapid response. Driven by the wars in Iraq and Afghanistan, the increased operational tempo of the last four years has led to lengthier and more-frequent deployments of soldiers and units across the entire U.S. Army, putting stress on both its active and reserve components.

What emerges from the analysis is a picture of the difficult tradeoffs the Army faces today.

Today, the bulk of the active-duty Army is either in Iraq, returning from Iraq, or preparing to go to Iraq. The formerly part-time soldiers in the National Guard now account for about 40 percent of the brigades deployed to Iraq and Afghanistan. And since the war began in Iraq two years ago, the length of a standard mobilization for reserve units there has risen well above the one-year goal that was originally intended.

These events have placed a growing strain on the U.S. Army as it seeks to train its soldiers and to maintain a pool of units ready to respond rapidly to new contingencies. This situation confronts the nation with urgent questions about the proper size of the Army's active and reserve forces, about the optimum number and types of combat units needed to sustain high levels of overseas deployments while maintaining readiness for other missions, and about the effects on soldiers and units stretched thin by the repeated, rapid rotations.

RAND Arroyo Center has examined various ways in which the Army might respond to the current and future demands upon its forces. It has also gauged the likely long-term effects of several policy options on Army combat brigades. The options utilize brigades from the active component (AC) and reserve component (RC) operating under either a standard rotational schedule or an intensified one. (The RC includes both the U.S. Army Reserve and the National Guard, although only the National Guard has combat brigades.)

As illustrated on pp. 20–21, what emerges from the analysis is a picture of the difficult tradeoffs the Army faces today, assuming a world in which high levels of overseas rotations continue. Those tradeoffs could augur major changes in the future size, structure, cost, and management of the active and reserve forces. The challenge is daunting. There is no viable option free of substantial risks, sacrifices, or both.

Rough, But Ready?

The Arroyo analysis focused on two outcome measures that characterize the Army's ability to fulfill its missions over time: (1) "time at home" between deployments for active-duty brigades, and (2) the number of "ready" active-duty brigades.

Time at home is important because of its broad ramifications for unit training and soldier well-being, recruitment, and retention. The number of ready units is a metric for assessing the nation's defense posture and the Army's ability to respond rapidly to new threats.

These two outcome measures depend on several factors that could vary simultaneously:

- **Size of the operational requirement:** Arroyo analyzed a range of requirements, from 8 brigades to 20 brigades required at any given time. As a point of reference, the Army's requirements have grown over the past couple of years from 12 brigades to 17 brigades in Iraq and Afghanistan alone.
- **Army force size and structure:** Arroyo examined the effects of different operational requirements on the baseline force (pre-2004) and the planned (or "transformed") force, which is expected to be in place by 2007 in the AC and 2010 in the RC. Also examined were the effects of relying on a future force that might include an expanded AC or might have a different mix of RC units than currently planned.
- **Utilization policies:** Arroyo compared variations in the frequency of reserve unit mobilizations and in the amount of preparation time given to the units before deploying. Under current policy, the goal is for reserve units to be mobilized for a maximum of one year out

of every six. Given the need for training during this year of mobilization, it was assumed that reserve units would train for six months and deploy for six months. Researchers modified this policy hypothetically to allow for more intensive use of the reserves in all three respects, such as mobilizing the reserves one year out of every *five* years, training them for only three months of that year, and extending their deployments to *nine* months.

The analysis also accounted for the three types of combat brigades now being planned by the Army in its transformed force: heavy, medium, and infantry. Heavy brigades have armored vehicles for maximum protection and firepower. Medium brigades have wheeled vehicles for mobility and versatility. Infantry brigades typically lack an extensive complement of ground vehicles. The classification is important because the different types of units are specialized for particular combat missions and environments, and there are limitations on the extent to which the units can substitute for one another.

The analysis assumed that heavy and medium brigades could substitute for one another. Therefore, they were combined into a category called "heavy-medium" brigades. On the other hand, it was generally assumed that infantry units could not do the job of heavy-medium units, though cases were considered in which unit types were interchangeable in meeting the overseas requirements.

Few Options

The analysis began by considering what would happen if the U.S. Army relied solely on its supply of active-duty brigades. The in-theater requirement was weighted toward heavy-medium brigades, in line with the emphasis currently placed on deploying these types of brigades to Iraq and Afghanistan. For political reasons, certain brigades were subtracted from the pool of available rotating brigades. One brigade was subtracted from the pre-2004 force, assigning it to Korea. Two brigades were subtracted from the transformed force, assigning one to Korea and one to Europe.

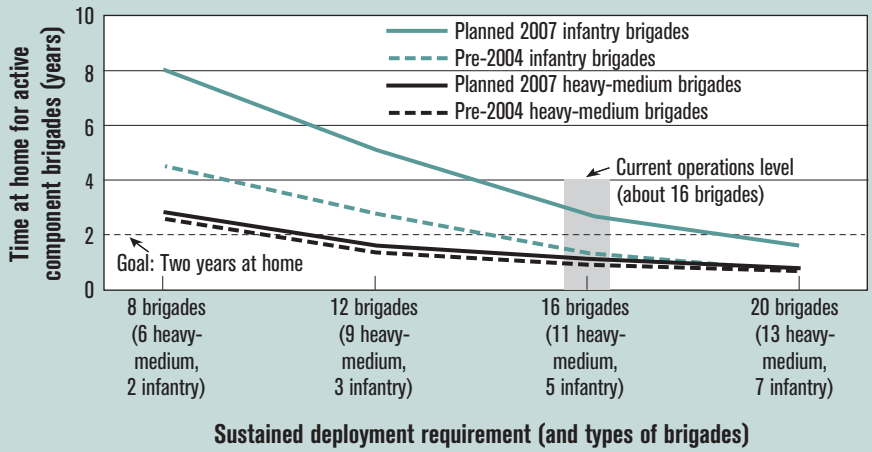
Figure 2 shows the results for the pre-2004 force of 32 rotating active-duty brigades and for the post-transformation force of 41 rotating active-duty brigades. In both cases, the inventory of heavy-medium brigades falls under considerable stress when sustained deployment requirements exceed 10 combat brigades. The burden on heavy-medium brigades is eased only slightly by the Army's plans for transformation, because those plans call for the addition of mostly infantry brigades.

At larger requirements (12 through 20 brigades), the time at home for heavy-medium brigades drops to less than two years. Two years of time at home is a well-established Army goal for refreshing, refitting, retraining, and thus "readying" units between subsequent deployments.

Some improvement could be made by permitting units of any type to substitute for one another, such as sending infantry units in place of heavy-medium units. This change would equalize the strain across all Army units. As the requirements rise above 14 combat brigades, however, both the heavy-medium and infantry units would begin to spend less than two years at home. At these high levels of demands, the nation would be left with few brigades primed and ready for other needs.

The burden is eased only slightly by the Army's plans for transformation.

Figure 2. Active-Duty Army Readiness Suffers Greatly When Sustained Deployment Requirements Exceed 10 Brigades



NOTE: We assume deployments of only active-duty brigades, no reserve brigades.

Arroyo researchers next examined the potential of using the reserve brigades to extend the time at home for the active brigades and thereby to increase the number of ready active brigades. They stipulated the use of the entire post-transformation supply of 11 heavy-medium reserve brigades to fulfill a sustained deployment requirement of 16 brigades, of which 11 are specified to be heavy-medium.

Figure 3 shows the results for time at home for the active-duty heavy-medium brigades. Their time at home remains substantially below two years no matter how hard the reserves are pushed. It was initially assumed that the Army would mobilize the reserves for one year out of every six, in line with DoD policy. The researchers then investigated a series of modified RC policies, such as more frequent mobilizations (one year out of every five, four, or three) and reduced preparation times (with longer deployments). These modifications were found to be somewhat helpful but still insufficient, even in combination, to bring the time at home for AC heavy-medium brigades up to the two-year threshold.

To meet its goal of two years at home for all AC brigades between deployments, therefore, the Army would need to take further steps. One possible approach would be to increase the number of AC and/or RC heavy-medium units beyond those in the Army's transformation plan—a costly but conceivable solution.

Time at home for the active-duty heavy-medium brigades remains substantially below two years no matter how hard the reserves are pushed.

Another approach would be to use infantry and heavy-medium brigades interchangeably *and* to use all AC and RC brigades interchangeably. In this case, though, the nation would have to accept the appreciable risks of assuming that any type of brigade could accomplish any type of mission and that each of the reserve brigades would be equal in capability to the active brigades.

Many Risks

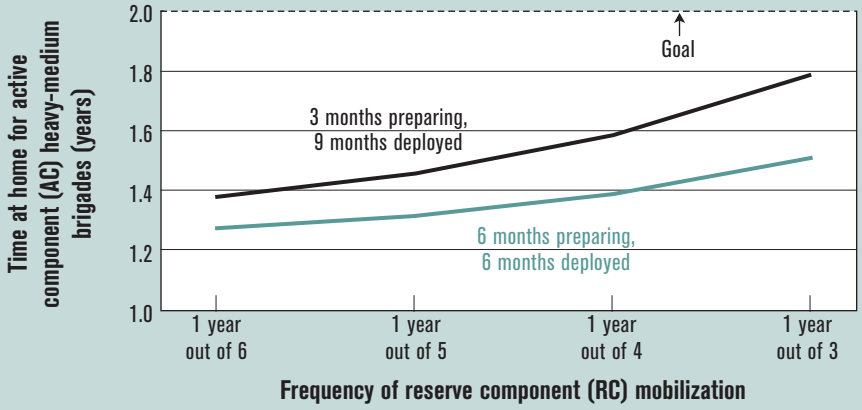
Each policy alternative involves significant costs, risks, or both. Arroyo has posited a series of future conditions that raise progressively tougher questions for the nation. Where possible, Arroyo has proposed how the Army might adapt to meet the immediate requirements and to sustain its forces over the longer term. But in most of the cases, the future conditions would present the Army—and the nation—with notable risks of one kind or another.

Suppose, initially, that overseas rotation requirements drop back to 10 brigades. All AC units would have at least two years at home between deployments. The Army would have a full stock of more than 20 ready combat brigades, of which at least 11 would be heavy-medium brigades.

The question for the nation is whether policymakers are comfortable basing future Army planning on this rosy scenario of consistently lower levels of overseas rotational requirements. This assumption could be plausible if the current requirements in Iraq and Afghanistan are viewed as an aberration or something to be endured for only a short time now or periodically in the future.

Alternatively: What if high overseas rotation requirements—of 14 to 20 brigades—continue for some time? The Army would experience serious problems with active-unit readiness. The nation would have few, if any, ready AC brigades to turn to in a crisis. Transforming the Army as planned would alleviate the strain a bit. But transformation would be largely in the future, would bring its own uncertainties, and could not meet the full demand for rotational forces by itself.

Figure 3. Even Extreme Utilization of Army Reserves Wouldn't Give Active-Duty Heavy-Medium Brigades Two Years at Home



NOTE: We assume 41 transformed rotating AC brigades, 11 transformed rotating RC brigades, and a sustained deployment requirement of 16 brigades, including 11 heavy-medium and 5 infantry.

The nation could decide to live with low levels of active-unit readiness—*if* it assumed that the Army would only rarely need to respond quickly to contingencies with large numbers of forces, either overseas or at home. This course presumes that international or domestic contingencies would not require the Army to do much beyond supporting its current level of overseas rotations.

What if the risks are too high for the Army to plan for low levels of contingency requirements? There are two possible adaptations. First, the Army could turn to the reserves and plan to utilize them at reasonable rates, such as mobilizing RC brigades for one year out of every six. But RC units would still cover only a modest portion of the total requirement for overseas forces.

Second, the Army could assume that any AC or RC unit could perform the mission demanded by any contingency. This course would carry considerable risk if a theater environment were not benign or if a mission required armored protection or ground mobility. To date, the Army has hedged against these risks by deploying predominantly heavy-medium forces to Iraq. And even if full flexibility were possible among all types of units, AC time at home would still dip below two years if the total overseas rotational requirements were to increase beyond about 17 brigades.

What if it is too risky to assume that AC and RC infantry and heavy-medium brigades can substitute for one another in future missions? There appear to be only two realistic options. One is for the Army to forgo its transformation plans to convert some of its RC heavy-medium units to infantry units. This option would also require the Army to find the financial resources to make all 25 of its existing RC heavy-medium units equal in readiness to AC heavy-medium brigades.

Alternatively, the Army could add more AC heavy-medium brigades. This could be accomplished either by adding units or by changing the mix of units in the transformation plan. This option would require many billions of dollars beyond the current plan and would take years to achieve.

To decide among these options will require the nation to confront a number of tradeoffs. The tradeoffs pertain to the Army's reliance on the AC versus the RC; the risks to the nation if the Army has few ready units for new contingencies; the training required of Army units for different types of operations; and the resources available for the AC, the RC, or both.

Arroyo's analysis suggests that none of the tradeoffs will be easy. No single policy is likely to meet all goals. Each option involves sacrificing something important or incurring substantial costs. ■

No Single Policy Is Likely to Meet All Army Goals, Given Current Rate of Sustained Operations

The U.S. Army has borne the brunt of sustained military operations over the past four years. The wars in Iraq and Afghanistan have led to lengthier and more-frequent deployments of soldiers across the entire Army, including both its active and reserve components. The deployments have placed growing stress on the Army as it seeks to train its personnel and to maintain a pool of units ready to respond rapidly to new contingencies.

We identified two key measures of the Army's ability to fulfill its missions: (1) total "time at home" between deployments of active-duty brigades, and (2) the number of "ready" brigades. The table shows that the Army has become stretched thin according to both criteria—and that each option that could mitigate the problems comes with its own downside. The table outlines the risks and likely outcomes of seven policy options for the Army's active-duty, "heavy-medium" brigades (units organized around armored or wheeled vehicles). All seven options presume a continuation of the current rate of sustained operations over the long term.

Option A places sole responsibility for overseas rotational deployments on the active component (AC). This policy would allow only a year at home between yearlong deployments and shrink the number of ready AC heavy-medium brigades to just 2 out of a grand total of 25.

Option	Policy U.S. Army Personnel Mix of Active Component (AC) and Reserve Component (RC) Brigades for Overseas Operations	Risks	Resources Additional Heavy-Medium Brigades (above and beyond planned AC) RC New AC	RC Utilization Years at Home Year Mobilized: Months Preparing Months Deployed
A	Use planned (transformed) AC only; no use of RC	AC units at home only for short time; few ready brigades	0 (planned AC only)	Not applicable
B	Use planned (transformed) RC per current utilization policy	AC units at home only for short time; few ready brigades	11	1 2 3 4 5 6 6/6
C	Use planned RC more intensively than in current utilization policy	Assumes more-frequent RC use and improved preparation time; results still fall short of goal	11	1 2 3 4 5 3/9
D	Keep current RC heavy-medium brigades and use per current policy	Financial costs of keeping 25 heavy RC brigades and transforming them	25	1 2 3 4 5 6 6/6
E	Keep current RC heavy-medium brigades *and* use more intensively	Requires major investments *plus* frequent RC use *plus* shortened preparation	25	1 2 3 4 5 3/9
F	Permit flexibility in all unit types; use planned RC per current policy	Works well only if AC and RC are interchangeable and if armored protection is not important	34	1 2 3 4 5 6 6/6
G	Add new AC heavy-medium brigades or shift units from infantry	Meets operational goals but entails substantial financial costs to nation	11 7	1 2 3 4 5 6 6/6

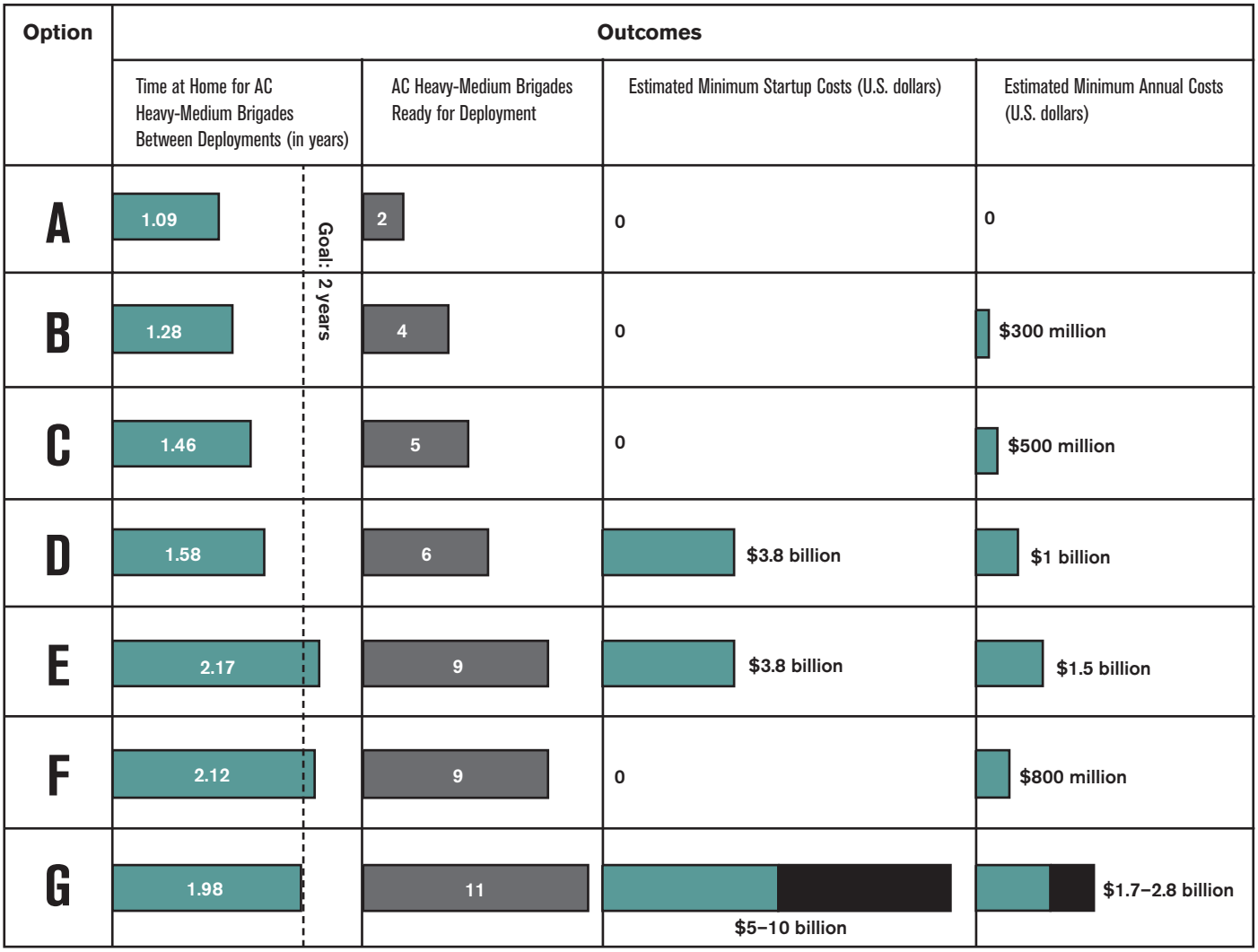
Assumptions: Sustained requirement of 16 overseas brigades, 11 of which must be heavy-medium brigades, from a total of 41 rotating AC transformed brigades (23 heavy-medium) and variable RC brigades. RAND cost estimates are approximate and should be viewed as minimums. Cost estimates are expressed in 2005 U.S. dollars.

The next four options rely on the reserve component (RC) in increasingly intensive, costly, and risky ways. Of these four, only Option E, which is the most drastic option, appears to meet the goals. Option E would alter the Army's plans for transformation by doubling the supply of RC heavy-medium brigades available for deployment abroad, deploy them more frequently than currently planned, and cost billions more.

Option F might appear to meet the goals at relatively little expense, but this option could pose appreciable risks on the battlefield. By permitting maximum flexibility in using AC and RC units interchangeably *and* infantry and heavy-medium units interchangeably, Option F could create a situation in which the Army might have the wrong type of units in theater if tensions rose or the situation deteriorated.

Option G calls for either adding seven new AC heavy-medium brigades or shifting the planned mix of AC units away from infantry brigades toward costlier heavy-medium brigades. This option would ease the Army's burdens and risks considerably, but only at great expense to the nation.

What emerges in stark relief is the dilemma faced by the Army today—and the complexity of making decisions that could help lengthen the time at home between deployments for AC brigades and increase the number of ready brigades available to respond quickly to new threats. ■



Training and Leading a Campaign-Quality Army

A campaign-quality Army is one that can quickly deploy to meet the wide range of possible operational requirements of the National Military Strategy and the operational plans that implement it. It requires a pool of ready units, and leaders who can quickly adapt to the actual operational conditions their units will face. In the context of the wide range of possible and ongoing operational missions, two significant challenges faced by today's Army are educating and developing leaders and designing and implementing effective unit training programs.

This article discusses recent RAND Arroyo Center research designed to support these objectives and the Army's readiness goals more generally. The first study discussed focuses on the education, development, and preparation of officers, while the second identifies options for improving unit training. A third study illustrates how units' ability to meet readiness goals can be facilitated through lifecycle manning, under which the personnel in many brigade-sized units will be stabilized for 36 months.

Developing Leaders

The needs of a campaign-quality Army have prompted questions about how best to prepare future leaders for the new demands they will inevitably face. To help the Army understand this issue, Arroyo researchers examined how recent changes in the operational environment might have affected leadership requirements and how these in turn would affect the way the Army educates, develops, and prepares its leaders.

Something Old, Something New

Nothing in Arroyo's research challenged the long-standing foundations that have underpinned Army leadership. Old and well-tested character traits and values remain the basis for effective leadership. But the research also found that the widely varied operational challenges that today's Army faces demand increased emphasis on new skills and experience.

The Army's long-standing formulation of leadership has always rested on three critical pillars:

- **What a leader must *be*:** the values that form character (e.g., loyalty, duty, respect) as well as the mental, physical, and emotional attributes needed to support these values;
- **What a leader must *know*:** areas of knowledge ranging from very general (e.g., interpersonal, conceptual) to very specific areas of expertise and skill over a range of disciplines;
- **What a leader must *do*:** the kinds of actions leaders must take to make their organizations accomplish their tasks and function effectively (i.e., influencing, operating, and improving the units and systems under their control).

Leaders not aligned with these fundamental pillars of leadership will fail, notwithstanding their fine technical or operational skills, because their subordinates will not follow them. Beyond this foundation, challenges posed by the new operational environment call for somewhat more emphasis on certain kinds of leadership skills and background. This can be for one of—or a combination of—three reasons: the skill is more important, more complex, or required at lower echelons of leadership.

Specific operational skills. This list includes but is not limited to facility in joint and combined operations, dealing with civilian populations, providing force protection, conducting operations in urban or restricted terrain, understanding the enemy situation, using technology for situational awareness, integrating coalition forces, and interacting with media.

Intellectual and cognitive abilities. Leaders increasingly need to be able to make decisions quickly,

Old and well-tested character traits and values remain the basis for effective leadership. But the research also found that the widely varied operational challenges that today's Army faces demand increased emphasis on new skills and experience.

in unfamiliar situations, and amid greater ambiguity and uncertainty than leaders faced in the past. In such circumstances, leaders may have to shortcut the traditional but time-consuming decisionmaking processes taught in school. They also need to know how to learn; they must become confident that they can acquire new skills and knowledge quickly when needed.

Breadth of knowledge and perspective. Leaders need a broad base of experience and background knowledge to inform their decisions. Familiarity with a wide range of possible operational situations—and with external institutions and cultures (e.g., other services, joint commands, government agencies, foreign governmental and nongovernmental actors)—will provide officers with a wider array of knowledge to draw on in evaluating possible courses of action.

The Army Needs to Broaden Its Efforts to Develop Well-Prepared Leaders

To meet the challenges posed by the operating environment, future leaders will need more preparation and experience. The study found that it would be possible within the current position structure for the Army to ensure that officers get a significant amount of tactical and technical experience through repeated operational assignments. However, creating this degree of depth in experience could easily come at the expense of breadth. The Army will therefore need to ensure that its officers acquire the needed breadth of experience. The most promising course may be to supplement the development of leaders' operational expertise in settings outside traditional unit assignments.

Other venues will also be needed to develop key areas of knowledge and skill. Intellectual and cognitive skills for decisionmaking (e.g., pattern recognition, ability to gain situational understanding) can be developed in academic, institutional settings and then applied in operational environments using simulations or practical exercises. Achieving greater breadth of knowledge and perspective among officers will require contact with external institutions, i.e., greater exposure of officers to graduate education and broadening assignments outside the Army.

The Army also needs to do more to develop leaders who are well prepared to meet future challenges and to learn continually and adapt to new circumstances. Options the Army might pursue include the following.

Learning modules and exercises. This includes developing educational modules designed to build competence and confidence in rapid decisionmaking skills as well as practical exercise tools to provide a wider array of challenges for use both in education modules and in field environments. The Army should also capitalize on distributed learning capabilities to support pre-deployment (or post-deployment) familiarization as well as self-study programs.

Dedicated learning time and increased opportunities for education. Officers require dedicated learning time, in both academic and unit settings, to develop and broaden their skills. As a practical matter, this means affording more officers opportunities for advanced civil schooling as well as adding more breadth to professional military education. The Army might also consider setting aside dedicated positions specifically for the purpose of broadening officers who would not normally be designated for such positions, e.g., an assignment in another government agency or an operational billet.

Longer careers and more officers. Most of these alternatives for leaders become more feasible if officers have more time to spend in each assignment and at each level. Moreover, it seems likely that many of these initiatives could be taken only with a larger base of officers to work with. The latter would require major structural changes and resource investments, and thus would require a long-term planning horizon. At a minimum, the Army should assess whether it is possible to satisfy modern requirements for breadth and depth within the current officer inventory and force structure.

In the context of a wide range of possible and ongoing operational missions, it is critical to design and implement effective unit training programs.

Improving Unit Training

Trained and ready units, particularly combat units, are the foundation of a campaign-quality Army. In the context of a wide range of possible and ongoing operational missions, it is critical to design and implement effective unit training programs.

To meet this challenge, the Army has proposed a set of training system enhancements to improve future training for Maneuver Brigade Combat Teams (MBCTs), which will in time include those equipped with Future Combat

Systems (FCS) technologies. In support of these efforts, Arroyo researchers assessed a range of planned enhancements and identified options the Army might consider to improve future maneuver unit training capabilities.

The enhancements evaluated include options for improving live, virtual, and constructive training events and for increasing the amount of training manpower available to support unit training. These enhancements were evaluated in terms of their ability to improve the quality, quantity, and adaptability of future training, as defined in Table 2.

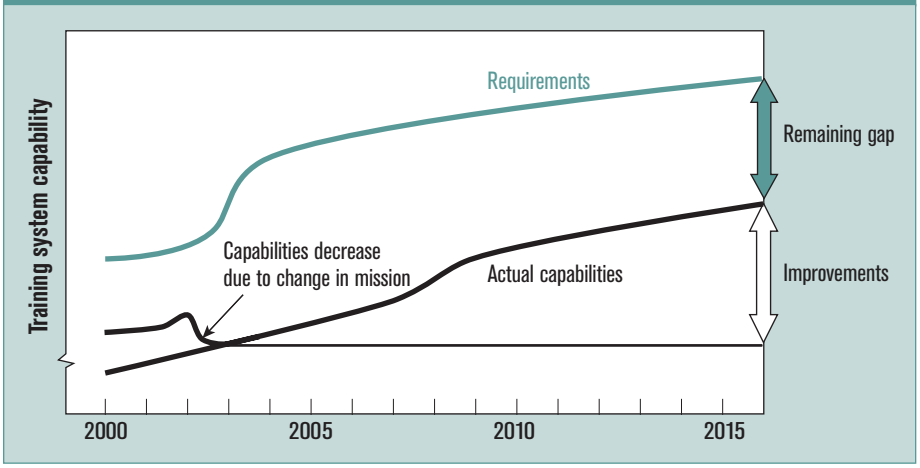
There Is a Gap Between Future Training Requirements and What the System Is Set to Provide

The study found that while planned enhancements will improve unit training, the capability achieved may still fall short of what will be needed to meet future training requirements in 2016. Figure 4 is a notional illustration of this finding. It shows the anticipated increase in training system requirements over time (the top line), as well as Arroyo's assessment of what currently planned enhancements will be able to achieve (the lower line). A "gap" between achievements and requirements already existed in 2000, when the Army was thought of as facing a threat largely related to major theater war. In 2002, requirements began to increase as the true implications of the contemporary operating environment (COE) emerged, while achievements (the lowest line) initially went down because of the increased importance of stability operations and support operations (SOSO), a mission the training system was not initially geared to address on the increased scale required. Over time, the Army has been closing the gap, due both to adaptations made by unit leaders and trainers and to training system improvements. The analysis suggests that these improvements should continue out to the 2016 timeline. However, a training gap will likely remain because of the anticipated continuing growth in requirements.

Table 2. Definition of Training Enhancement Measures

Training Measure	Definition
Quality	The potential of the enhancement to increase the desired training effect, as determined by improved training event realism, complexity, and feedback
Quantity	The potential of the enhancement to increase the number and duration of training events, or the number of soldiers and leaders trained
Adaptability	The potential of the enhancement to allow training events to be adapted to a wide range of missions, enemies, and conditions

Figure 4. Notional Illustration of Changes in the Army Training System Capability over Time



Enhancements Focus on the Quality of Training, Less on Quantity and Adaptability

The study found that, in the 2016 timeframe, planned enhancements show the best potential for improving training quality. Of particular importance are enhancements designed to improve live training at the Army's maneuver combat training centers (CTCs) as well as at unit home stations. Live enhancements include improved Tactical Engagement Simulation Systems (TESS); targetry, ranges, and facilities; and instrumentation. Other enhancements will improve the capabilities of virtual and especially constructive simulations to support leader training.

Current planned enhancements show less potential for increasing training quantity. The research showed that the key constraint is unit leaders' time, and no initiatives reduce this constraint in any major way. A potential exception is lifecycle manning—which, by decreasing personnel turnover, could reduce the need for sustainment training. However, the benefits of lifecycle manning will depend in part on the degree to which positional stability (a soldier stays in not only the same unit, but the same job) can be achieved. The study also found that the benefits of embed-

ded training (which will incorporate training capabilities into operational equipment), while potentially important for individual and crew training, will be limited for higher-echelon live and virtual training in the 2016 timeframe. Finally, while the study found great potential to increase the quantity of constructive-supported leader training, these events will continue to be manpower-intensive and time-consuming to support.

Of special significance for a campaign-quality Army is the study's finding that current planned enhancements do not focus enough on improving the adaptability of training to a wide range of missions, enemies, and conditions. As a result, unit leaders and staff will continue to be responsible for most of the work needed to adapt training. The time needed for unit leaders and staff to plan, execute, and learn from training events will remain significant.

One problem affecting many of the enhancements is that they tend to focus disproportionately on technologies relative to training support manpower. While improved technologies are necessary, the timelines for developing those technologies are typically quite long, and many will not be available in the 2016 timeframe. An increased emphasis on manpower, in contrast, offers the potential for both near-term and longer-term improvement.

To support improved unit stability, the Army is shifting from an individual replacement system, under which soldiers rotate into and out of units on an individual basis, to a system of lifecycle manning, which stabilizes an entire unit for 36 months.

Greater Oversight and an Increased Emphasis on Manpower Will Be Needed

In a period of reduced investments in training enhancements, the study recommends a number of measures to monitor and manage improvement initiatives more closely, including the implementation of quality, quantity, and adaptability metrics. The study also recommends that the Army rebalance the training strategy to place an increased emphasis on training manpower. Increased manpower can make a greater number of events possible and support increased quality and adaptability of training.

A key area for investment is constructive-supported training for battle command, which is defined as "the exercise of command in operations against a thinking enemy." Constructive exercises could be effectively used to increase the number of training opportunities, if the quality of realism in these simulations can be improved and if they are supported by adequate manpower. A key resource for battle command training is the Battle Command Training Center (BCTC), which is designed to train new digital operators and maintainers, provide for their sustainment training, and support leader training exercises from team through BCT level. To ensure that the BCTC attains its full potential, the Army will need to ensure that sufficient manpower resources remain available.

Improving Unit Stability

A campaign-quality Army must attain and maintain high levels of readiness, and units' ability to meet readiness goals can be facilitated through continuity in training, personnel stabilization, and quality leadership. To support improved unit stability, the Army is shifting from an individual replacement system, under which soldiers rotate into and out of units on an individual basis, to a system of lifecycle manning, which, as discussed in the previous section, stabilizes an entire unit for 36 months. That is, the unit will be manned, trained, deployed, and will return from deployment while largely keeping all personnel in place.

Arroyo researchers recently examined the potential implementation effects of lifecycle manning on two key soldier outcomes: combat performance and soldier well-being.

Higher Levels of Personnel Stabilization Among Junior Enlisted Personnel Were Associated with Higher Performance of Collective Skills

To understand the effects of lifecycle manning on combat performance, researchers compared new stability measures they developed using Army personnel data with RAND Arroyo Center's extensive database of CTC training proficiency outcomes. This database provided unit training proficiency data for 66 active component maneuver battalions at the National Training Center (NTC). For purposes of this analysis, researchers used the data to associate varying degrees of personnel turnover with the unit's proficiency on collective combat skills. Observed entry measures—those first achieved by the unit—served as a measure of how well the unit was prepared before being affected by the

CTC experience. This is an important distinction, because it was also found that the effect of the training experience tended to make all units better (as would be expected) regardless of the degree of stability they had before going to the NTC. The analysis indicated that high levels of personnel turnover, such as existed in the Army during the 1990s, affected maneuver company and platoon proficiency at the NTC, particularly for junior enlisted personnel. For example, Figure 5 shows maneuver execution results for companies with low junior enlisted personnel turbulence (left column) and high turbulence (right column). Companies with low junior enlisted turbulence tended to score higher on execution skills upon entry to the NTC. Similar results were found for company planning, preparation and continuous operations (such as force protection) skills, and for platoon planning and execution. However, as related above, in almost all cases these proficiency differences were no longer apparent at the NTC best score, at which on average all battalions, companies, and platoons did well despite pre-NTC turbulence.

These results illustrate the positive training effect of a CTC rotation. Since the scores for the different stability groups equalize after a training rotation, the CTC can be thought to have an intervention effect that could in some cases offset initial effects of personnel turbulence.

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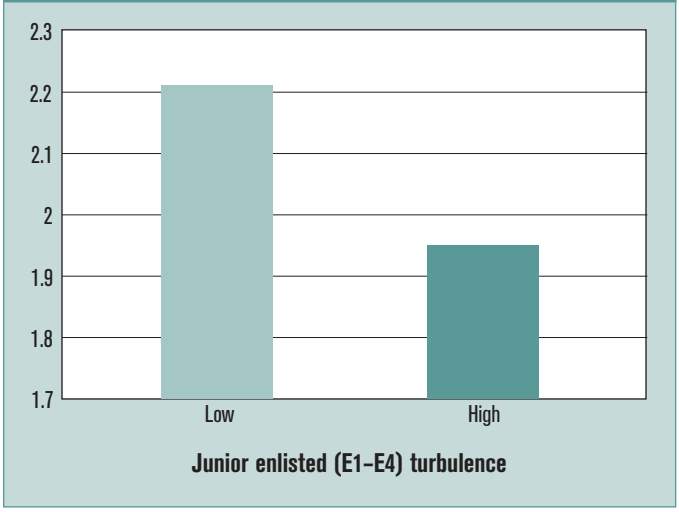
The results also suggest the potential benefits of lifecycle manning. Since units historically had high turnover within three months after an NTC rotation, it was likely that the collective gains acquired were being lost through personnel turbulence. Life-cycle manning can be expected to ameliorate this loss, since battalions would stay intact after an NTC rotation. In addition, the higher scores on entry for junior enlisted personnel with higher stability suggest that whether or not a unit was able to attend a CTC before deploying, stability might help the unit be more prepared.

Figure 5. Maneuver Company Execution Skills by Turbulence Groups: First Score



Positive Relationships Were Found Between Stability and Some Soldier Outcomes Among Junior Enlisted Personnel

Arroyo's examination of soldier self-reported survey data collected by the Army Research Institute found generally high levels of satisfaction among soldiers and officers across all metrics used in the analysis. However, some of the most notable effects of stabilization were found among junior enlisted personnel. Junior personnel who were in their jobs longer reported higher levels of job satisfaction and greater confidence in their skills.

It is also important to note that junior enlisted personnel in their work groups longer tended to report that they would be *less* inclined to recommend the Army to others and also tended to report lower morale than those in the first six months of being in their work group. This may mean that overall satisfaction with the Army goes down for enlisted personnel with time in position despite greater confidence and satisfaction with their jobs. This result may be a by-product of a current cultural expectation to change jobs frequently—that is, soldiers expect to move and may feel something has gone wrong with their career paths if they are not moving frequently. It should also be noted that this group is the only group that contains first-term soldiers. With the systemic change that lifecycle manning will bring, it may be that this effect, if it is a cultural artifact, could gradually disappear. The Army may benefit from knowing whether this finding persists given current operating conditions.

The Army May Want to Focus Lifecycle Manning Efforts on Junior Enlisted Personnel

Should full stabilization carry with it some less desirable effects such as difficulty in managing officer or noncommissioned officer career development, the Army still has options. Because junior enlisted personnel constitute the majority of personnel in a maneuver brigade, and stabilizing them is associated with higher job satisfaction and feelings of preparedness as well as higher levels of platoon and company training proficiency, the Army might reasonably focus its efforts on stabilizing this group. Stabilizing this group would mean reducing turbulence among the largest group of Army personnel in combat units. Moreover, these results suggest that the Army is likely to see improvements in combat proficiency with increased stability of junior enlisted personnel.

An emphasis on stabilizing junior personnel might also have a positive outcome for senior leaders. When a battalion has high turnover among its junior enlisted ranks, battalion leadership must devote considerable care, attention, and resources to orienting and training this group. To the extent that lifecycle manning can reduce personnel turbulence, it might allow battalion staff to spend less time on basic issues and thus more time on higher-order training.

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Conclusion

Although the Army faces many challenges in training and maintaining a campaign-quality force, it has options for improving the training and development of soldiers at all levels—from senior leaders to junior enlisted personnel. Key to these efforts will be expanded learning opportunities for leaders and providing manpower support to improve the quality, quantity, and adaptability of unit training. An emphasis on stabilizing soldiers through lifecycle manning can potentially further enhance combat proficiency and support other training benefits. ■

A Network for Future Forces

Modernization is crucial to the Army's efforts to transform itself into a campaign-quality Army, and the Future Combat Systems (FCS) is the centerpiece of the modernization effort. The FCS is a collection of 18 systems, coordinated and integrated by an overarching network. However, the network, or perhaps more accurately the network of networks, is the sine qua non of the FCS, because without it the Army will be unable to harness the capabilities of the component systems. It is also arguably the most complicated aspect of the Army's tactical networking needs. RAND Arroyo Center has been helping the Army analyze its communications needs for over a decade, initially focusing on the integration of digital systems and more recently on the development of the network. Its more recent analysis has focused on the challenges of building a network, the amount of bandwidth needed, considerations of what type of network the Army should consider, and analysis of potential network nodes.

In an age where cell phones are ubiquitous and people routinely exchange email or surf the Internet via wireless devices, it is easy to overlook the challenges of establishing a tactical net for combat forces. But imagine an Internet where not only the individual users move, but so do the servers and routers, over rough terrain in all kinds of weather.

Building a Network of Networks

In an age where cell phones are ubiquitous and people routinely exchange email or surf the Internet via wireless devices, it is easy to overlook the challenges of establishing a tactical net for combat forces. But imagine an Internet where not only the individual users move, but so do the servers and routers, over rough terrain in all kinds of weather. And then imagine setting this network up in a matter of hours or minutes. Add to that the challenge of sending and receiving signals without having line of sight between antennas and then put into the mix an enemy who is trying to jam the signals. This is the challenge facing the Army as it attempts to construct a network that will transmit information seamlessly to thousands of mobile users.

Can It Be Done?

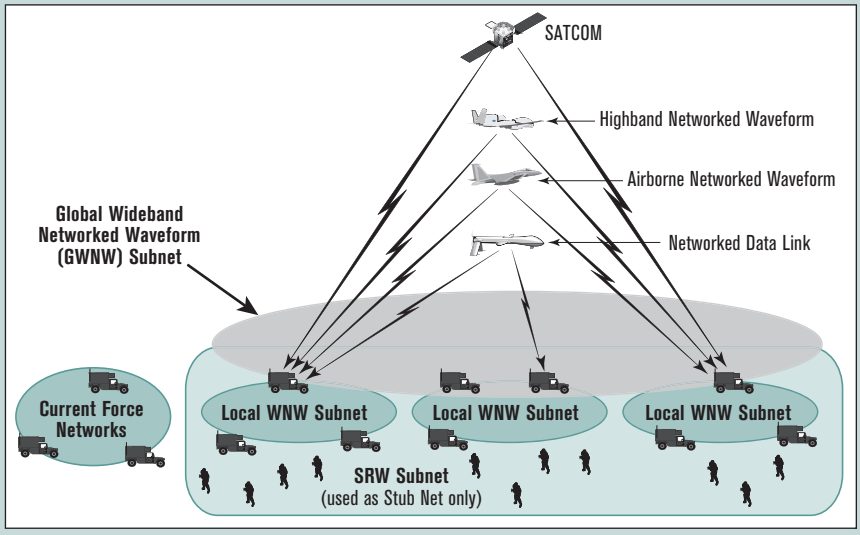
A fair question is whether the advanced network the Army envisions—indeed is counting on—is even feasible. Setting up a small mobile network falls well within the art of the possible. But scaling a small network of a few dozen nodes to one that contains thousands of nodes poses immense challenges. To explore this topic, RAND Arroyo Center hosted a Science of Networks conference[5] attended by experts in state-of-the-art wireless mobile networks. Emerging from the conference were four overarching conclusions that highlight both the Army's challenge in developing the FCS's MANET (Mobile Ad Hoc Network) and some thoughts about how to meet the challenge.

First, the science (i.e., theory) of wireless mobile networks is relatively immature, i.e., the analytical understanding of them remains limited. Real-world factors, such as the desire for a low probability of intercept and resistance to jamming, only compound the analytic issues. As critical as it is to develop the science of networks, however, the Army's timeframe for developing the FCS means that much of the work on its network will have to proceed without the benefit of a theoretically provable path to success.

A second conclusion that emerged is that the relatively small mobile, wireless networks of today do not scale well to large size (e.g., hundreds or thousands of nodes passing substantial amounts of data). As a result, current plans for the FCS's MANET reflect clusters of smaller networks bridged together via airborne and space-based nodes to extend the networking reach to beyond line of sight as shown in Figure 6. Reflecting the first conclusion above, this approach to the network highlights the clear

[5] http://www.rand.org/ard/projects/netconf.html.

Figure 6. Mobile Ad Hoc Network



need to gain a better understanding of how the layers of networks interact to ensure that the Army's overall network remains stable and reliable in all operating conditions.[6]

Third, conference participants concluded that Army networks must be designed through a series of experiments. This means considering, evaluating, and modifying different network configurations through simulation and prototyping in representative scenarios. This kind of approach is often necessary with complex, unprecedented systems (think of the Apollo program's Lunar Lander). A flexible, validated, large-scale simulation and prototype network hardware and software, all needed for experimentation, will be difficult and expensive to develop, but also indispensable. The FCS program is developing the simulations and network prototypes in parallel, so there is no way at present to demonstrate that the FCS network will be sufficiently effective or responsive to battlefield conditions and requirements.

Finally, and as suggested already, while the FCS program is using a development approach like that suggested in the third conclusion above, there is no guarantee that it will result in a satisfactory network design. Thus, the success of the single most critical component of the FCS remains an open question.

The Way Ahead

Given its ambitious timeframe, FCS network development will continue down its established path, but Arroyo research suggests that mitigation efforts should also proceed. In particular, the immaturity of network science must be addressed. Here, there are likely to be continued opportunities to work with the private sector and academic institutions on basic and applied research concerning network theory and practice.

More immediately, the Army needs, today, a technology roadmap for developing an effective network assessment capability. This roadmap should lay out a timeline and identify the resources needed to meet the following objectives.

1. Develop measures of effectiveness and measures of performance for the network that are situation-appropriate and include both the usual technical metrics (latency, throughput, power, and reliability) as well as operational metrics (the network's ability to adapt to mission, environment, scale, and threat). Also critical is the issue of integrating new equipment and technology into existing networks, and the Army's ability to do this effectively requires appropriate metrics.

2. Identify the most promising evolutionary and revolutionary protocols and processes for optimizing network performance across multiple network layers so that they may be included in the simulations. These may include cross-layer optimization procedures, game-theoretic methods, and fluid-flow models, along with innovative replacements for current transmission control protocol/internet protocol systems. The ability of the protocols and procedures to scale to large numbers of mobile nodes should be the key consideration in deciding which options to include.

3. Develop a sequence of increasingly demanding and realistic scenarios for examining and comparing network options. These scenarios should be based on a systematic and quantitative evaluation of the Army's future operating

[6] Typically, a reference to "network layers" refers to the Open System Interconnection model, which defines a networking framework for implementing protocols in seven layers: physical, data link, network, transport, session, presentation, and application. Control passes from one layer to the next, starting at the application layer (the top layer) and proceeding to the physical (the bottom layer). See http://www.webopedia.com/quick_ref/OSI_Layers.asp.

environments. From this analysis the next step is the development of simple, open-terrain, small-scale situations using fixed messaging. Scenarios should then evolve to more complex, large-scale engagements with reactive forces that change locations, behaviors, and messaging dynamics in response to the quality of information coming through the network.

4. Evolve a flexible, transparent, and challenging simulation environment for network development and assessment in parallel with and using the results of the scenario development described above. This may be organized in a crawl, walk, and run sequence.

Crawl. To begin, the simulation environment would represent only such aspects as approximate terrain representation, mobile nodes, active entities, and largely preprogrammed messages. The primary role of this baseline capability is to validate, verify, and accredit network behavior with field tests, historical data, high-resolution simulations, and other criteria, including internal checks of reasonableness. The environment should have a tracing and explanation capability to enable subject matter experts to examine the dynamics of messaging. Existing models based on OPNET, QUALNET, and other simulations may be appropriate for this stage.

Walk. The environment is extended to larger-scale engagements, loss of nodes, a "dirty" environment, some urban characteristics, and a wide range of messages and priorities. A range of protocols and algorithms should be introduced and tested to determine the flexibility of the environment.

Run. Until simulations can realistically mimic human decisionmaking in combat, it will be necessary to use human-in-the-loop simulations that include realistic network response to the information flow and the effect of human activity on that flow. The latency, inaccuracy, or overload produced by the network will result in different, sometimes unpredictable responses by the commanders and changing loads on the network. This complex adaptive system will challenge any new protocol or routine and so is the true test of its robustness. Any simulation and conclusions reached using simulation must be validated given the inability of state-of-the-art simulation to represent accurately networks in general and MANET networks intended for military combat use in particular. Such validation must compare the results obtained from physical experiments and comparable simulations, paying careful attention to issues associated with scaling, intercept probability, jamming, human factors, network ad hoc interruption and reconfiguration, etc.

Bandwidth

The network design is a crucial consideration, but there are related issues to contend with. Equally daunting, from a technical and operational viewpoint, is the issue of bandwidth. Bandwidth constitutes the "pipes" that make up the transport portion of the network and through which flow the bits of information; the wider the pipe, the more information can flow. When the amount of information exceeds what the pipe can carry, clogs occur and communications slow down. As the Army moves from a segmented communications system to a networked one, bandwidth assumes increasing importance. This is because in a segmented system, communications are limited to vertical channels. As the information flows up or down, each node in the net has the ability to control the volume and direction of flow. In a networked system, communications move both horizontally and vertically. Control of information flow is much less restrictive. Unlike segmented systems where each node can further restrict information flow up or down, networked communications systems can release information to multiple nodes, each of which may decide to continue forwarding the information. This less restrictive information flow requires considerably more bandwidth. The move to networked communications systems has the Army concerned about whether it has enough bandwidth available to meet the operational requirements of the future force.

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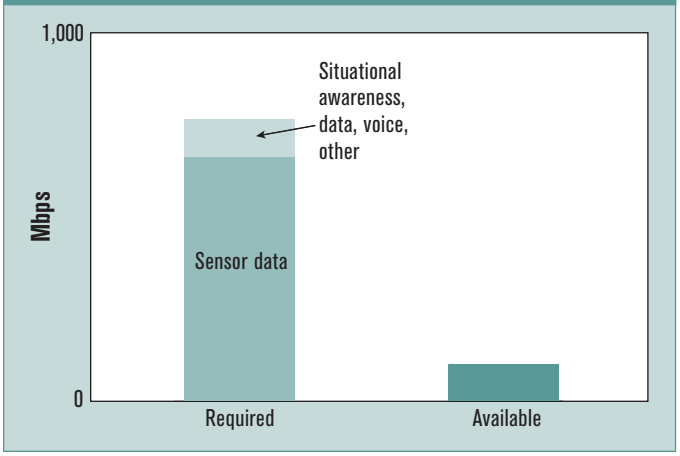
Bandwidth: Demand and Supply

Demand for bandwidth has increased exponentially. Operation Noble Anvil, the 1999 U.S. operation in Kosovo, required nearly two and a half times the bandwidth used in 1991 during Operation Desert Storm, a much

larger operation. By late 2001, Operation Enduring Freedom in Afghanistan marked the largest military use of bandwidth, exceeding that used in Desert Storm by a factor of seven. Most recently, by one estimate Operation Iraqi Freedom required roughly ten times the bandwidth of Desert Storm.[7]

It is likely that demand for bandwidth will continue to grow, with the result that it will soon outstrip supply. Based on currently stated requirements for a future brigade-sized unit, Figure 7 shows peak bandwidth requirements compared with the anticipated availability.[8] As it is, commercial demands are already competing with the military for any available spectrum. Limited access to the spectrum makes it difficult for Army units to train as they will fight, and by some estimates, not enough spectrum is available to support a brigade-sized exercise. Unless sufficient bandwidth is found or more efficient methods of using available bandwidth are identified, Army plans will require substantial reevaluation.

Figure 7. Initial Estimates Suggest Future Requirements (Demand) Will Exceed Existing Supply



Army Options and Actions

In broad terms, the Army's options to address the bandwidth problem are few: (1) get the most out of the hardware and software, i.e., use improved radios and antennas and make better use of allocated spectrum; (2) get the most out of the network's architectural options, e.g., employ hierarchical schemes using elevated nodes such as unmanned aerial vehicles; and (3) constrain demand—that is, look for ways to hold capacity demands to only what is absolutely needed. For example, the Army could limit sensor proliferation and the use of video.

In priority, Arroyo researchers recommend that the Army take the following actions.

Reassess Information Demands and Needs

As a first order of business, the Army must understand what drives its information demands. Only scant data exist on the details of actual demand, and relatively little analysis has been conducted of the necessity and the value of proposed information flows at each of the various echelons. Furthermore, because demand is not the same as need, the Army must reassess its tactical information requirements. More experimentation is needed to determine how various information demands contribute to mission success.

Change the Application Structure

Applications determine the volume and timing of much of the information flow. Adjusting applications demands, say by compressing them, can radically decrease bandwidth requirements. For example, compressing voice transmissions can save bandwidth: uncompressed digitized voice transmissions typically require 64 kbps (kilobytes per second) in a public switched phone network, but compression can lower the demand to 2.5 kbps and still deliver acceptable voice quality.[9] Analyzing and fusing raw sensor data locally will also reduce the demand for bandwidth. However, explicit performance assessments must be conducted to maintain quality with respect to data fusion and compression.

Manage Operational Demands to Meet Needs

The priority afforded a given user of a network will vary depending on the situation. During a battle, operational traffic should have priority, but logistics traffic may be more important during a repair, refuel, and rearm phase. Changing information needs mean that commanders must manage the network actively to ensure that the most important communications get priority and to smooth flow through the network.

[7] Andrew Bridges, "Pentagon Turns to Commercial Satellites to Ease War Data Squeeze," Associated Press, March 27, 2003.

[8] The estimate of anticipated supply is based primarily on spectrum available today or expected to be available in the near term in the United States.

[9] The bandwidth demand of voice transmissions is small compared with that of sensor data, but it is useful for illustrating the effect of compression.

Increase Efficiency of Network Routing

Army communications are increasingly network-based and must be addressed from a network perspective. The Communication and Electronics Research, Development and Engineering Center (CERDEC), the Defense Advanced Research Projects Agency (DARPA), and commercial industry are attempting to increase capacity through more efficient network routing. These techniques take advantage of knowledge of the network state to improve routing efficiency.

Increase Capacities of Links

Spectrum reuse is key to achieving as much capacity as possible. One technology that enables reuse is that of directional antennas. These can increase capacity substantially because they transmit and receive in a focused, point-to-point manner, allowing a number of communications links to use the same frequency allocation without interfering with each other. Developed to their full potential, directional antennas could ameliorate the inherent capacity limitations of large numbers of radios sharing a frequency channel.

Fully dynamic spectrum management has even greater spectrum reuse potential because it does away with the need for static channel/frequency assignments. Dynamic spectrum management finds and uses available frequencies that are not being otherwise used at a particular time. DARPA is developing technologies that enable dynamic access to the radio frequency spectrum, and this important technology concept needs to receive continued support.

Although the network will appear to the Army users as a single, transparent network, it will actually be many networks that interact to form a global information grid.

Overall Assessment and Recommendations

Bandwidth is increasingly a limited resource that needs to be actively managed. Although new technologies will greatly increase capacity, other new technologies and unchecked user demand for bandwidth will probably outpace capacity growth. The challenge then is to meet the right users' needs at the right time. To achieve this, Arroyo researchers recommended, first, that the Army treat bandwidth needs as an operational resource to be allocated by commanders and staffs much in the way that other resources, such as close air support, are allocated. Second, the Army should continue to invest in a number of technologies that have the potential to increase capacity. These technology efforts should be managed and synchronized by a single agency for efficiency and coordination and to create an overall information architecture. Third, the Army should develop and refine better assessment tools to balance the complex tradeoffs that will be required. Last, the Army needs to work closely with the DoD to avoid duplication and to take advantage of DoD-wide capabilities. This is especially important with respect to the DoD efforts to maintain and perhaps acquire new spectral allocations.

Network Architecture: Efficiency and Robustness

The discussion above sketches out some of the technical challenges confronting the Army in its efforts to move to a network-centric force. As part of the transformation, it must also decide *what type* of network it wants to implement. Network type becomes important because of the tradeoffs between robustness and efficiency.

Although the network will appear to the Army users as a single, transparent network, it will actually be many networks that interact to form a global information grid. Recent Arroyo research explored some of the issues the Army must grapple with as it makes decisions about network architectures.

Considerable research into network structures has been carried out in recent years, and it contains instructive lessons that could benefit the Army in its efforts to design a network. Networks are composed of nodes, which in a military network are the command vehicles, soldiers, sensors, and other producers or users of information. Nodes are linked if they can exchange information. Networks have been characterized in different ways, and one way is by their connectivity—the number of connections one node has to others.

Efficiency and Robustness of Types of Networks

Let us consider two types of networks: fully connected and hub. A fully connected network is shown in Figure 8. In this case, all nodes are connected to all other nodes. Each node has the same number of connections and so the same *degree of connectivity*. A fully connected network has multiple paths between any pair of origin-destination nodes. Therefore, such a network, for any number of nodes, theoretically reduces the likelihood that any node or group of nodes could be left isolated (disconnected from the network). We

Figure 8. Fully Connected Network

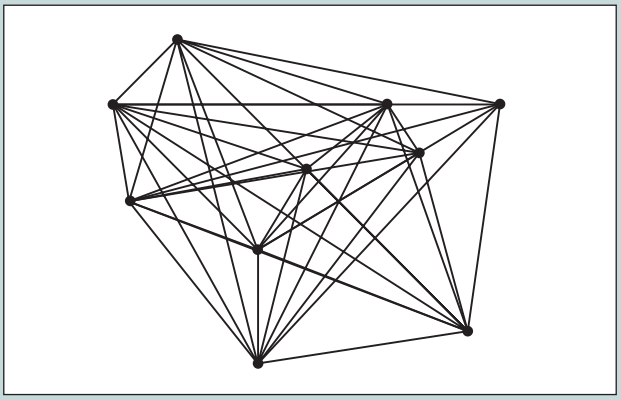
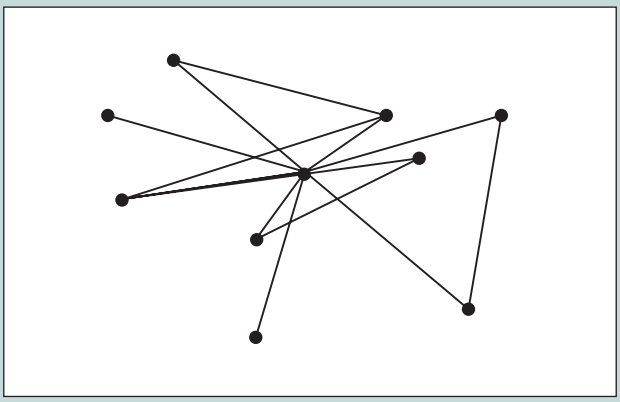


Figure 9. Hub Network



can therefore say that such a network is relatively robust compared with a less connected network type.

But robustness comes at the price of efficiency, e.g., a large overhead that could potentially use a lot of bandwidth just to maintain the large number of routes through the various links. This problem is not large when the network is small because there are only a few routes to maintain, but it is a concern when a network has many nodes. In a communications network, a route (for a message's path) is usable only if it is known to network nodes. This is usually done by the "probing" messages exchanged throughout the network that give each node some information on the existence of nearby neighbors. These messages are considered "overhead," and they increase the quantity of information flowing through the net. But routing protocols, which identify usable paths for data messages, depend on the information from such messaging. Clever design and use of routing protocols can help to minimize the level of traffic taken up to maintain the routes on any size of network. But for large mobile networks with dynamically changing routing options, the overhead tends to get quite significant, especially for large, fully connected networks.

Figure 9 shows a hub network. In this case, a few nodes have very high connectivity, but most nodes have low connectivity. If failures are random, the hub is no more likely to fail than any other node, and given laws of probability, it is arguable that random node failure will have little effect on the ability to pass messages because there is only a small probability that the hub nodes would fail. For this reason, we can say that the hub network is very robust against random node failure.

The distribution of connectivity throughout such a network follows what is called a power law distribution. This could mean that the few nodes with high connectivity process a disproportionate amount of the message traffic. As a result, the hub nodes are important to the integrity of the network and hence provide high-value targets for attack. Thus, such networks are not robust against targeted node attack.

Clever design and use of routing protocols can help to minimize the level of traffic taken up to maintain the routes on any size of network. But for large mobile networks with dynamically changing routing options, the overhead tends to get quite significant, especially for large, fully connected networks.

From an efficiency standpoint, the nature of the network structure limits the routing options and conceivably the overhead messaging. Furthermore, messages between two nodes that require relay and that can use the hub node(s) need fewer "hops," by definition. This adds to network efficiency. In summary, such node types are relatively efficient but not always robust.

Advantaged Nodes

Maintaining a fully connected network (or networks of other degrees of

connectivity) is easier said than done in some venues. First, the connectedness of a network is mostly a function of the scenario (terrain, environment, etc.). In fact, most of the practical spectrum allocated to today's tactical military communication radios require line of sight between the antennas of the transceivers to connect. As a result of the fixed transmission range of radios and the varying degrees of signal attenuation experienced in complex terrain, maintaining any degree of connectivity may necessitate "advantaged" nodes, i.e., those with a high degree of connectivity, achieved perhaps by being airborne in the form of a high-altitude airship or an unmanned aerial vehicle (UAV). Of course, relying on a small set of advantaged nodes is not robust. In such situations, the ability of all nodes to connect with any other is less important than the ability of all nodes to connect with a set of advantaged ones. As shown in Figure 10, hybrid options that blend characteristics of efficient networks with those of robust networks can be considered and perhaps dictated by the terrain.

By way of analyzing network robustness, Arroyo researchers constructed a hypothetical network and examined its performance after node failures caused by the targeted attacks of an intelligent enemy and those that were merely random.

Analysis

By way of analyzing network robustness, Arroyo researchers constructed a hypothetical network and examined its performance after node failures caused by the targeted attacks of an intelligent enemy and those that were merely random. The network analyzed appears in Figure 11. It comprises eight ground nodes, one ground hub, and two airborne hubs. Robustness is measured by the percentage of messages that reached their destination.

The network appeared to be quite robust due to the large numbers of connections linking each node. These multiple connections provide significant link redundancy between any two nodes, so the loss of random nodes can be mitigated by rerouting communications. In fact, the network was indeed found to be quite robust to random node failure. Even with the removal of six nodes, over 75 percent of messages continued to pass through the network. With the removal of four nodes, fully 98 percent of communications went through successfully.

However, the network still has vulnerabilities. If an enemy were smart enough to identify critical nodes, he could attack them and greatly reduce the network's ability to process messages. For example, many concepts for the Army's future network include airborne nodes in UAVs acting as hubs. Given the high attrition rates of UAVs in recent operations due to both enemy action and technical problems, it is not impossible that we could lose a significant number of airborne nodes. They could be replaced, but

Figure 10. Networks Tradeoff Robustness and Efficiency

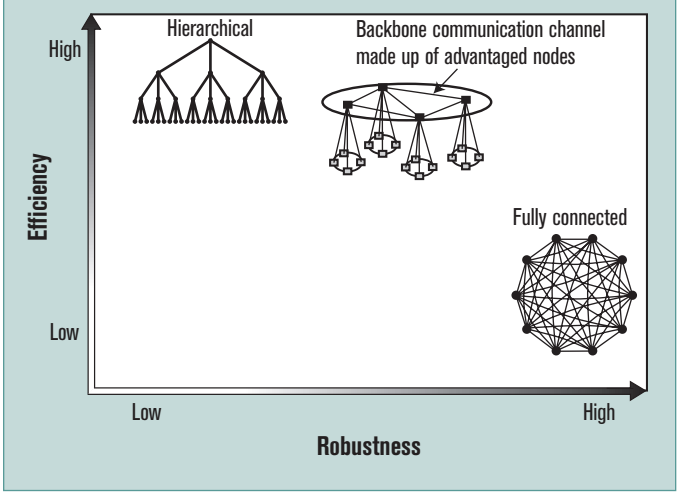
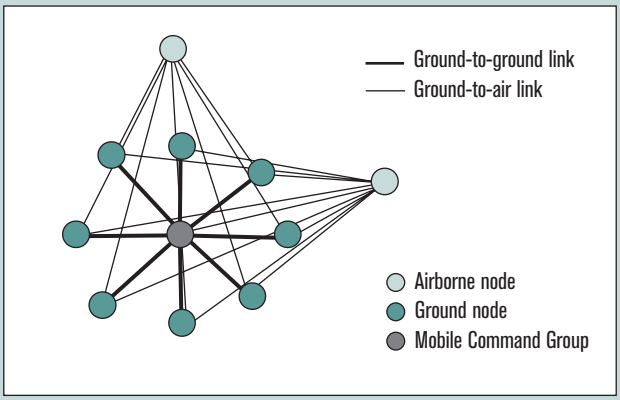


Figure 11. Hypothetical Tactical Network



while this took place the communications network could be much less effective. If the enemy identified and took out the three hub nodes shown in Figure 11, the network collapsed; no messages got through.

Arroyo researchers carried out additional excursions to assess the effects of node loss on the network's ability to process messages. That analysis showed that the loss of airborne links has more effect on connectivity than does the loss of ground-to-ground links. These findings have important network implications because potential adversaries will likely be aware of the importance of airborne nodes to operational success of the ground units and will target them accordingly.[10] Adding satellites as part of the network can help with robustness because they are less vulnerable than UAVs, but they can be jammed.

Conclusions

All tactical networks make tradeoffs between robustness and efficiency. Robustness requires redundancy, but the latter always entails reduced efficiency because of the overhead required to get the redundancy. Reduced efficiency also implies a greater need for bandwidth, and increasing the supply of bandwidth is not easy. Furthermore, as the analysis described here shows, certain parts of the network can be attacked with great effect. The Army needs to take a holistic approach to network design so that robustness, efficiency, and vulnerability issues can be assessed from an entire network perspective. Treating these issues only at the subnetwork level will miss important interrelationships that, if ignored, may result in an ineffective network. ■

[10] For a discussion of one potential airborne node, see Lewis Jamison, Geoffrey S. Sommer, Isaac R. Porche III, *High-Altitude Airships for the Future Force Army*, Santa Monica, CA: RAND Corporation, TR-234-A, 2005.

Publications

This section lists and abstracts RAND Arroyo Center research published since the last Annual Report. *All publications may be obtained from RAND's Distribution Services: telephone 310.451.7002; fax 310.451.6915; email order@rand.org. Additionally, all publications may be viewed in their entirety on RAND's web site, http://www.rand.org.*

The Effect of Equipment Age on Spare Parts Cost: A Study of M1 Tanks

Carol E. Fan, Eric Peltz, Lisa Colabella

TR-286-A

As the average ages of Army weapon systems increase, it has been assumed that age increases maintenance costs. However, it has proved difficult to quantify and estimate the actual effect of equipment age on costs. This study examines the relationship between equipment age and spare part costs for M1 Abrams tanks by using part requisition data. The authors also examine the issue of adaptive practices by comparing actual part expenditures to an exchange price-based valuation of part demands.

High-Altitude Airships for the Future Force Army

Lewis Jamison, Geoffrey S. Sommer, Isaac R. Porche III

TR-234-A

Across the services, there is an increasing demand for overhead communications capacity. New, lighter-than-air vehicles that operate at very high altitudes have an obvious attraction for planners of surveillance and communication missions; the ability to see to a more distant horizon results in greatly expanded surveillance. This report informs the U.S. Army about the usefulness and limitations of high-altitude airships (HAA) in the role of platforms for communications and surveillance suites in theater battlespace. Potentially, HAA may provide communications satellite capabilities for the WIN-T network that are less expensive than satellites and may support a Global Hawk–like surveillance package. HAA performance issues include engine power, envelope strength and permeability, solar-cell power, fuel-cell capacity, weather, launch and recovery, and air defense survivability.

How Should the Army Use Contractors on the Battlefield? Assessing Comparative Risk in Sourcing Decisions

Frank Camm, Victoria A. Greenfield

MG-296-A

Can the Army improve the way it measures the risks of using civilian contractors in combat? This report proposes a method for comparing the "residual risks" of using military and contract sources to perform specific support activities on the battlefield. It applies the Army's standard approach to risk assessment, which identifies sources of risk, or "threat"; the risks the threats present; the opportunities to mitigate these risks; and the risk that remains—the residual risk—when the Army chooses a particular course of action to mitigate risks. The approach offers an orderly way to translate relative inherent capabilities of military and contract sources, terms of applicable status-of-forces agreements, and threats at any particular place and time on the battlefield into a comparison of the residual risks associated with military outcomes, the safety of contract personnel, resource costs, and other policy factors of greatest importance outside a particular contingency setting.

Implementation of the Asthma Practice Guidelines in the Medical Department: Process and Effects

Donna O. Farley, Shan Cretin, Georges Vernez, Suzanne Pieklik, Elaine Quiter, J. Scott Ashwood, Wenli Tu

MG-319-A

RAND researchers worked to implement clinical practice guidelines in treatment of three common ailments (asthma, diabetes, and low back pain). This report is an evaluation of the asthma practice guideline demonstration. It documents the extent to which intended actions were implemented, assesses short-term effects on clinical practices, and measures the quality and limitations of available data for monitoring practice improvements and clinical outcomes. The authors found that although the implementation scored some notable successes, resource limitations and organizational barriers curbed overall progress. They conclude that allowing for flexibility, monitoring the facilities consistently, and training providers thoroughly are the keys to implementing the practice guidelines. They also concluded that patient education needed improvement.

Implementation of the Diabetes Practice Guideline in the Army Medical Department: Final Evaluation

Donna O. Farley, Georges Vernez, Kathryn J. Dolter, Suzanne Pieklik, Wenli Tu, J. Scott Ashwood, Shan Cretin

MG-277-A

In partnership with the Army Medical Department (AMEDD), RAND researchers have been working to implement clinical practice guidelines in treatment of three common ailments: diabetes, asthma, and low back pain. This report evaluates the diabetes practice guideline demonstration. It documents the extent to which intended actions were implemented, assesses short-term effects on clinical practices, and measures the quality and limitations of available data for monitoring practice improvements and clinical outcomes. The authors found that although the implementation scored some notable successes, resource limitations and organizational barriers curbed overall progress. They conclude that allowing for flexibility, providing adequate resources, and learning from experience are the keys to implementing practice guidelines throughout AMEDD.

Improving the Army's Management of Reparable Spare Parts

John R. Folkeson, Marygail K. Brauner

MG-205-A

This report addresses initial efforts to expand the Army's logistics process improvement efforts initiative by applying an integrative approach to improving the responsiveness, reliability, and efficiency of the Army's national-level inventory management and depot-level component repair processes. The goal of these processes is to repair sufficient assets to replenish serviceable inventories to meet the needs of requirements determined to support equipment readiness. The examination of the reparable-management process identified three key issues that need to be addressed: (1) the impact of uncertainty and variability in customer demands on long-term planning forecasts; (2) the need for increased emphasis on near-term replanning for execution; and (3) the inability of repair responsiveness to meet changing requirements. The report recommends that a pilot effort be undertaken to develop and test alternative approaches to the implementation of improvement initiatives.

Increasing Participation in Army Continuing Education: eArmyU and Effects of Possible Program Changes

Bruce R. Orvis, Laurie L. McDonald, Barbara Raymond, Felicia Wu

MG-293-A

The eArmyU continuing education program allows enlisted soldiers to earn college credits while on active duty. This study sought to determine how to make eArmyU available to more individuals while controlling program costs. Historically, the primary cost of eArmyU had been attributed to the laptop computer provided through the program. This study examined the effects of the existing eArmyU program and of removing the laptop or other provisions on outcomes including soldiers' participation in the program, retention, duty performance, and quality of life. Those especially likely to enroll in eArmyU include African Americans, females, AFQT Category I–IIIA soldiers, married soldiers, soldiers with dependents, and senior soldiers. The fully funded laptop is an important element underlying soldiers' participation in eArmyU; without it, eArmyU participation rates and the retention benefits of eArmyU are likely to decline significantly. Personnel records indicate that the current eArmyU program is associated with increased retention: eArmyU participants have one year longer to their ETS date than demographically similar nonparticipants and 25 to 30 percent of participants extend or reenlist to participate. Study recommendations include ways to achieve the goals of increasing enlisted access to education opportunities, constraining eArmyU costs, and limiting soldiers' risk of recoupment.

Making Better Use of Bandwidth

John F. Pane, Leland Joe

TR-216-A

Recent operations in Afghanistan and Iraq have demonstrated the Army's increasing reliance on communications, making it important to find ways in which the Army might better use bandwidth. This report discusses how existing data compression and network management techniques could be used in the near to medium term to improve performance. These techniques will not solve the bandwidth bottleneck but will contribute to better performance with minimal impact on existing networks. The authors recommend that the Army incorporate compression and network acceleration technologies into future systems, identify where Army-specific tailoring could improve commercial data compression technologies, and develop an experimental plan to determine acceptable compression-related losses in quality and to train users.

Measuring Essential Communications, Fusion, Intelligence, Surveillance, and Reconnaissance Characteristics of the Army Future Combat Systems

Dan Gonzales, Louis R. Moore, Lance Menthe, Paul Elrick, Christopher Horn, Christopher Pernin, Michael S. Tseng, Ari Houser

MG-266-A

The Army's Future Combat Systems (FCS) vehicles will be lightly armored, so FCS-equipped units will depend on the information advantage provided by networked battle command and intelligence systems to detect, identify, and target adversaries at extended non-line-of-sight (NLOS) ranges. This report uses new analysis techniques and simulation models to examine the contribution of command, control, communications, intelligence, surveillance, and reconnaissance (C3ISR) systems to the potential performance of the FCS. It also explores the effects of alternative sensor fusion. The authors identify essential C3ISR capabilities, discuss key tradeoffs, and map next steps to optimize FCS performance and to enable Army future forces to defeat the enemy at NLOS ranges.

Medical Risk in the Future Force Unit of Action: Results of Army Medical Department Transformation Workshop IV

David E. Johnson, Gary Cecchine

TR-253-A

This report analyzes and discusses the workshop results of Army Medical Department (AMEDD) Transformation Workshop (ATW) IV. This workshop continued the assessment, begun in ATWs I–III, of the medical risks associated with emerging Army operational concepts and the capacity of the AMEDD to mitigate these risks. The principal purpose of ATW IV was to begin the process of providing casualty demand estimates that will need to be addressed by the health service support system at echelons above the Unit of Action (UA). AMEDD subject matter experts supported the workshop and examined the ability of an envisioned UA medical structure to support future force combat operations in a 12-hour combat simulation.

Proposed Missions and Organization of the U.S. Army Research, Development and Engineering Command

Bruce Held, Amado Cordova, Elliot Axelband, Anny Wong, Shelley Wiseman

DB-465-A

The Army consolidated the research and development (R&D) organizations in Army Materiel Command under one commander. This report documents one aspect of RAND Arroyo Center's support during the establishment of RDECOM. Arroyo identified four major missions for RDECOM: (1) Provide responsive technical support to current and U.S. Joint Forces Command operations, (2) provide effective technical support to Army acquisition programs, (3) provide the technical vision for the Army of the future, and (4) attend to the planning, management, and oversight of Army R&D and science and technology (S&T) work. These four missions provide a context for RDECOM's organizational design, and Arroyo researchers recommended the adoption of a matrix structure. Within it, RDECOM's current laboratories and R&D centers provide the personnel and facilities for accomplishing RDECOM's missions. Mission accomplishment, however, is managed and resourced by the RDECOM commander, working through a number of deputy commanding generals (DCGs). This report thus examines alternative organizational designs with either two or three DCGs.

Reexamining Military Acquisition Reform: Are We There Yet?

Christopher Hanks, Elliot Axelband, Shuna Lindsay, Rehan Malik, Brett Steele

MG-291-A

The Department of Defense undertook 63 distinct acquisition reform (AR) initiatives between 1989 and 2002. Based on interviews with industry and Army Program Management personnel, researchers report that industry and Army Program Management personnel acknowledge that some good has come from some AR initiatives, but they argue that many serious structural and cultural impediments that hinder the ability of the acquisition process to deliver desired outcomes in terms of cost, schedule, and performance still remain.

Risk Management and Performance in the Balkans Support Contract

Victoria A. Greenfield, Frank Camm

MG-282-A

Is the Army getting what it needs and managing risks appropriately in its combat service support contracts? This report uses the Army's Balkans Support Contract and a continuous risk-management framework to answer these questions. On the basis of this case study, the authors conclude that the Army has been getting what it needs, though it might, at times, be bearing too much cost-related risk, and that few risks arise directly from the use of contractors. They also see a need for more training for the Army's contracting personnel to better plan, coordinate, and manage contracts.

Something Old, Something New: Army Leader Development in a Dynamic Environment

Henry A. Leonard, J. Michael Polich, Jeffrey Peterson, Ronald E. Sortor, S. Craig Moore

MG-281-A

Changes in the world over the past two decades have created a dynamic situation—volatile, unpredictable, and novel in many respects—making the conduct of military operations more complex and varied than in the past. This report examines the nature of demands on Army officers in the contemporary operating environment and their implications for developing leaders. This research arose from concerns about both the current operational environment and a closely related development, the Army's ongoing transformation of its structure, technologies, and operating techniques. How will the Army prepare its future leaders for the new demands that will inevitably be placed on them? The report describes analysis and findings on three major topics: the general attributes and intellectual qualities required by leaders in the modern environment; specific operational skills and depth the new environment requires; and the extent to which career paths can provide a foundation of operational experience while still meeting other demands on the officer corps. Although the report concentrates on changes in leader skills needed to keep pace with the evolving operating environment, it also reemphasizes that the Army should continue to acquire and develop leaders with the character traits and values that have always been the underpinning of effective leadership. Beyond that essential base of leadership, the findings imply that considerably more needs to be done to prepare leaders to meet the challenges of the contemporary environment and to continually learn and adapt to new circumstances.

Steeling the Mind: Combat Stress Reactions and Their Implications for Urban Warfare

Todd C. Helmus, Russell W. Glenn

MG-191-A

Combat stress casualties are not necessarily higher in city operations than in operations on other types of terrain. Commanders and NCOs in the U.S. military should develop the necessary skills to treat and prevent stress casualties and understand their implications for urban operations. Consequently, the authors provide an overview of combat stress reaction (CSR) in the form of a review of its known precipitants, its battlefield treatment, and the preventive steps commanders can take to limit its extent and severity. The authors interviewed participants in former urban operations and reviewed historical and contemporary documents, many of which suggest that urban operations are inordinately stressful and that the risk of CSR may be high. But historical data from the battles of Brest, Manila, and Hue, as well as others, show no evidence of increased rates of stress casualties. The authors also review treatment and prevention steps from the perspective of military operations on urbanized terrain.

Stretched Thin: Army Forces for Sustained Operations

Lynn Davis, J. Michael Polich, William M. Hix, Michael Greenberg, Stephen Brady, Ronald E. Sortor

MG-362-A

The United States faces difficult tradeoffs in responding to the calls now being made on Army forces for overseas operations in Iraq and Afghanistan. This report describes the effects of large-scale deployments on the Army's ability to provide ready forces for other contingencies, to ensure that its soldiers are trained for warfighting and stability operations, and to preserve the quality of life for its soldiers and families. The authors found that the Army's plans for transforming its active and reserve brigades and employing its reserves at reasonable rates ameliorate the stresses but still leave shortfalls. Steps available to improve the situation all involve significant risks or costs. Unless these overseas requirements recede considerably, the nation is faced with an Army stretched thin, with no quick fix or straightforward solution.

Sustainment of Army Forces in Operation Iraqi Freedom: Battlefield Logistics and Effects on Operations

Eric Peltz, John M. Halliday, Marc L. Robbins, Kenneth J. Girardini

MG-344-A

The major combat operations of Operation Iraqi Freedom (OIF) have been judged from virtually all quarters as a remarkable success, although accompanied by some perceptions that this success was achieved in the face of severe logistics problems. This monograph examines the facts behind these perceptions, describing how Army forces were sustained during Operation Iraqi Freedom, analyzing how well this support performed, and discussing the effects on operations with an emphasis on the period from the start of ground combat to the fall of Baghdad. The findings should be of interest throughout the Army as well as the broader Department of Defense supply chain, deployment planning, and force development communities. The findings have implications for the design of the logistics system, logistics process improvement efforts, future force design and warfighting concepts, and the acquisition of equipment such as vehicles as well as logistics information systems.

Sustainment of Army Forces in Operation Iraqi Freedom: Major Findings and Recommendations

Eric Peltz, Marc L. Robbins, Kenneth J. Girardini, Rick Eden, John M. Halliday, Jeffrey Angers

MG-342-A

By virtually every account, the major combat operations of Operation Iraqi Freedom that toppled Saddam Hussein's regime in the spring of 2003 were a remarkable success. Yet there is a general belief within the Army and the broader defense community, supported by RAND Arroyo Center's analysis, that this success was achieved despite logistics problems that hampered materiel sustainment. However, moving beyond the initial impressions that emerged quickly following operations, Arroyo's research has indicated that forces and sustainment capabilities were sufficiently robust to overcome the problems and effectively execute missions. This monograph describes how well the Department of Defense logistics system supported Army forces in Operation Iraqi Freedom, documents the major reasons for shortfalls in performance, provides recommendations for improvement, and points to questions raised with respect to the design of future forces.

Transformation and the Army School System

Michael G. Shanley, James Crowley, Matthew W. Lewis, Ralph Masi, Susan Straus, Kristin Leuschner, Steven Hartman, Sue Stockly

MG-328-A

Army Transformation and wider operational demands are placing increased demands on Army training and The Army School System (TASS), which is responsible for the vast majority of institutional training in both the active component (AC) and reserve component (RC). This report identifies policies and options for increasing TASS's contribution to Army readiness while improving the integration of the AC and RC training systems. The study recommends, first, that TASS adopt private sector practices, organizational models, and technologies to improve its approach for developing interactive media instruction training (a key form of future training). The study also recommends that TASS expand its training delivery options by developing a more effective local training system to conduct selected courses and support other unit training needs. Finally, TASS should seek to leverage available training resources to improve integration of AC-RC training institutions and provide additional training options.

Unexploded Ordnance Cleanup Costs: Implications of Alternative Protocols

Jacqueline MacDonald, Carmen Mendez

MG-244-RC

Cleanup of unexploded ordnance (UXO) at former weapons ranges has become one of the most costly environmental problems the military faces. This study examines cost estimation for UXO remediation conducted at closed military installations, the difficulties of accurately estimating cleanup costs, and the major effects that different cleanup requirements and methods can have on cost. It assesses previous estimates of UXO cleanup costs and evaluates the strengths and limitations of the military's preferred cost-estimation tool, the remedial Action Cost Engineering Requirements (RACER) software package. Using a modified method of implementing RACER, the study shows how costs change depending on which cleanup protocol is followed. The results show that the choice of cleanup protocol has major cost implications. ■

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