

## Annual Report 2000

### National Defense Research Institute

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National Defense Research Institute

CLIENTS	POLICY CENTER		
	Acquisition and Technology	Forces and Resources	International Security and Defense
<b>DEPARTMENT OF DEFENSE</b>			
<b>Assistant Secretary of Defense</b> (Command, Control, Communications, and Intelligence)	▲		●
<b>Defense Finance and Accounting Service</b>		■	
<b>Defense Information Systems Agency</b>	▲		
<b>Defense Intelligence Agency</b>	▲	■	●
<b>Deputy Secretary of Defense</b> Office of the Special Assistant for Gulf War Illnesses		■	
<b>Director of Net Assessment</b>			●
<b>Joint Staff</b>			●
<b>National Security Agency</b>	▲		●
<b>Under Secretary of Defense for Acquisition, Technology, and Logistics</b>			
Ballistic Missile Defense Organization	▲		
Defense Advanced Research Projects Agency	▲		
Defense Threat Reduction Agency	▲		●
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Deputy Under Secretary of Defense for Installations		■	
<b>Under Secretary of Defense (Comptroller)</b>			
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<b>Under Secretary of Defense for Personnel and Readiness</b>			
Assistant Secretary of Defense for Health Affairs		■	
Assistant Secretary of Defense for Force Management Policy		■	
Assistant Secretary of Defense for Reserve Affairs		■	●
Deputy Under Secretary for Defense Program Integration		■	
TRICARE Management Activity		■	
<b>Under Secretary of Defense for Policy</b>			
Assistant Secretary of Defense for International Security Affairs			●
Assistant Secretary of Defense for Special Operations and Low-Intensity Conflict			●
Assistant Secretary of Defense for Strategy and Threat Reduction			●
<b>Unified Commands</b>			
U.S. Joint Forces Command			●
U.S. Pacific Command		■	●
U.S. Transportation Command		■	
<b>U.S. Marine Corps</b>			
		■	
<b>U.S. Navy</b>			
	▲	■	●
<b>OTHER</b>			
<b>Department of Energy</b>			●
<b>Department of State</b>			●
<b>National Intelligence Council</b>	▲		

## National Defense Research Institute

As the October 2000 suicide bombing of the *USS Cole* reminds us, the Department of Defense (DoD) confronts a security environment that is fraught with danger. Although U.S. military forces have no conventional peer, terrorists, rogue states, narcotics traffickers, and others continue to probe the vulnerabilities of the United States and its allies and seek opportunities to undermine U.S. interests.

Creative but disciplined research and analysis can help the DoD better formulate policy for this environment. At the National Defense Research Institute (NDRI), we strive to help defense policymakers recognize, plan for, and manage change and uncertainty. Such is the essence of policy analysis today, difficult as it may be. In the defense arena, questions have not only become more complicated and intertwined—such as how best to transform U.S. forces to overcome future adversaries or how to recruit and manage military personnel with new sets of skills—they also tend to morph into new problems and challenges on very short timescales.

Given these challenges, and the potential for partisan discord on a host of issues, the DoD needs a research capability that is clearly seen as objective in its approach. In this vein, the Institute’s research has been used to address some of the most difficult problems facing the DoD.

Throughout this past year, NDRI continued to focus on the main elements of our nation’s defense plans: *strategy, technology, people, and the relationships among them*. We did so by providing a broad spectrum of support to our clients: we evaluated new policy options; defined and suggested how to implement current policies; and maintained a base of knowledge, theory, and methods. In this regard, we continued and refined the primary function of this Institute—to perform research on complex national defense problems, where multidisciplinary capability, objectivity, and an explicit national-interest charter are essential. At the same time,

RAND is a nonprofit institution that helps improve policy and decisionmaking through research and analysis.

clients turned to NDRI to provide special analytic support, informed by its long-term research.

For more than 15 years, this Institute has developed a special relationship with the DoD. Today, key elements of this relationship include

- ▲ a governance arrangement whereby an Advisory Board—comprising officials from the Institute’s major sponsors—guides the Institute’s long-term research agenda and approves an annual research program;
- ▲ a core research capability offering a reservoir of expertise on a full range of defense issues;
- ▲ a versatile research staff able to respond quickly to changes in research priorities and to provide short-term assistance on time-critical policy issues;
- ▲ a series of programs to disseminate research within DoD and more broadly throughout the defense community.

This annual report documents NDRI’s core activities in 2000 and highlights selected research results. It is by no means exhaustive. These contributions continued RAND’s legacy of reach and relevance in support of the nation’s security.



**Jeffrey A. Isaacson**  
Director  
National Defense Research Institute

**T**

he National Defense Research Institute (NDRI)

is a federally funded research and development center at RAND that provides studies and analyses to policy-makers in the Office of the Secretary of Defense (OSD), the Joint Staff, the Unified Commands, the defense agencies, and other clients. It brings science, analytical rigor, and an understanding of world and national security affairs to the study and choice of policy.

NDRI in calendar year 2000 operated through three centers, whose research corresponds closely with the responsibilities of three of the undersecretaries in the OSD—Policy; Acquisition, Technology, and Logistics; and Personnel and Readiness—who are principal clients of NDRI.

NDRI’s centers supported clients in a number of different ways in 2000—framing new policies; defining and suggesting how to implement current policies; maintaining a base of knowledge, theory, and

methods; and providing other analytic and technical support. In this regard, the primary function of this Institute is research on policy, strategy, and complex problems, where multidisciplinary capability, objectivity, independence, and an explicit national-interest charter are essential.

## NDRI’s Research Centers in 2000

▲ The **International Security and Defense Policy Center** explored how the security environment is changing; how those new conditions affect U.S. interests; and what policies, strategies, and terms of U.S. engagement are needed to shape the environment and protect those interests.

▲ The **Acquisition and Technology Policy Center** addressed opportunities and challenges presented by advances in technology, in particular those enabled by the information revolution. It analyzes ways to preserve U.S. military advantages as economically as possible.

▲ The **Forces and Resources Policy Center** analyzed issues affecting the people who make up our forces, on the forces needed to carry out U.S. military strategies, and on the optimum use of resources. It focuses on policy options that help ensure that the United States is able to attract and retain high-quality military personnel in this new era.

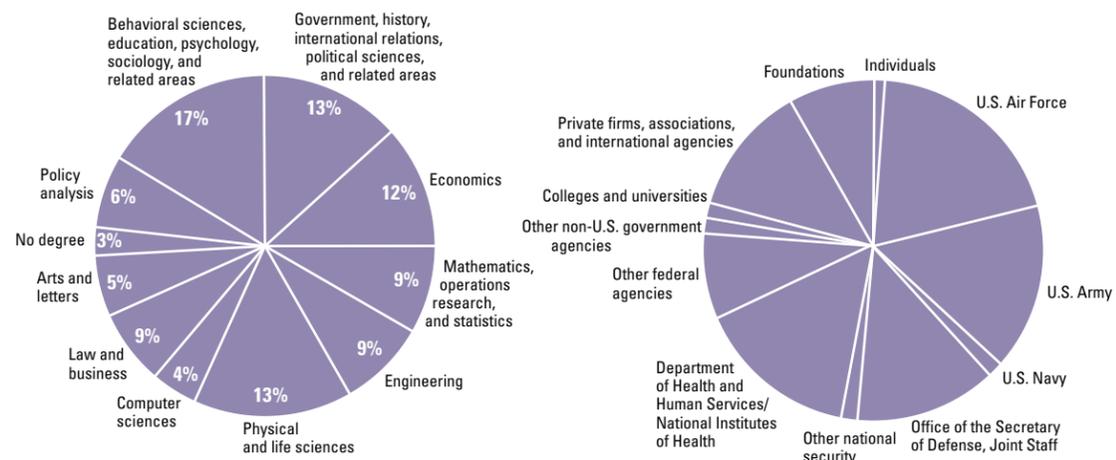
## NDRI’s Three Policy Centers



## Disciplines

## FY2000 Research Activity

\$143.9 million



### RAND's Multidisciplinary Staff Provide Breadth and Depth to Research Activities

#### The RAND Environment

NDRI is part of RAND, a private, nonprofit institution founded in 1948 in Santa Monica, California. RAND's mission is to help improve policy and decisionmaking through research and analysis. Since its early days, RAND has studied the most pressing public policy problems of the day, producing in-depth, objective policy analyses, basic and applied research, and analytic tools used in government, academia, and the private sector.

Today, RAND analyses assist public policymakers at all levels and the public at large in efforts to strengthen the nation's economy, maintain its security, and improve the quality of life of its citizens. RAND helps clients analyze choices and developments in many areas, including national defense, education and training, health care, criminal and civil justice, labor

and population, science and technology, community development, international relations, and regional studies. RAND also offers several advanced training programs, including the RAND Graduate School's doctoral program in policy analysis and its intensive advanced defense analysis seminars geared toward mid-career decisionmakers.

At any time, NDRI can call on RAND's two other DoD federally funded research and development centers for additional analytical resources. Project AIR FORCE, the oldest studies and analysis organization at RAND, has helped U.S. leaders determine the size, shape, and missions of the U.S. Air Force. RAND's Arroyo Center has addressed mid- and long-range policy questions for the U.S. Army.

NDRI also draws upon research talent from throughout the organization. RAND employs some 700 research professionals, nearly 80 percent of whom hold advanced degrees, most commonly the doctorate.

Staff disciplines include economics, mathematics and statistics, medicine, law, business, physical sciences, engineering, social sciences, arts and letters, and computer science. RAND possesses analytical depth in psychology, sociology, and demography, all of which NDRI harnesses in conducting studies of personnel issues, for example. RAND Health, one of the world's preeminent health care policy research organizations, brings crucial insight into questions connected with the provision and management of military medical services. RAND's Science and Technology Policy Institute investigates national policies regarding scientific and technical education, research and development, and regulatory practices that inhibit or promote technology and investments. Numerous other RAND

research centers provide specialists with skills that prove particularly useful when investigating policy issues. These specialists are in areas such as

- ▲ surveys, statistical analysis, and information systems
- ▲ computer modeling and simulations
- ▲ scenario design, analysis, and testing

RAND's international programs—comprising the Center for Asia-Pacific Policy, the Center for Middle East Public Policy, and the Center for Russia and Eurasia—provide NDRI with sources of additional research talent on security, economic, political-social, and other matters in key regions of the world. Work on allied defense issues done through RAND's independently chartered European subsidiary, RAND Europe, provides perspective that is relevant to both national security and non-national security work.

RAND research is supported by a broad range of sources, from charitable foundations to combinations of private firms. The largest share of support comes from agencies of the U.S. government. RAND also conducts projects for foreign governments, when such work supports U.S. interests. In addition, RAND pursues some research using funds from its own endowment.

Today, RAND analyses assist public policymakers at all levels and the public at large in efforts to strengthen the nation's economy, maintain its security, and improve the quality of life of its citizens.



**T**he International Security and Defense Policy Center (ISDP) is the

organization within NDRI chartered to analyze the effects of international political, strategic, economic, and technological changes and to assist U.S. national security decisionmakers in developing policies to deal with those developments. Its research agenda in 2000 focused on emerging challenges that continue to recast U.S. national security policy: the proliferation of weapons of mass destruction and other technologies, the pervasiveness of information and its effect on military strategy and operations, and the emergence of new threats to the United States at home and to its forces and allies abroad.



As spelled out below, four themes guided ISDP's research in 2000:

## International Engagement

Helping U.S. defense policymakers understand the willingness and capabilities of NATO allies to share in Europe's defense costs and to operate within and beyond European borders was a major focus of ISDP in 2000. The Center continued to assist the Joint Staff in evaluating challenges that Pentagon planners face in developing and implementing theater engagement plans in and around Europe, and provided DoD with direct assessments of Georgia's emerging national security needs and options.

## Understanding Emerging Threats

ISDP investigated how U.S. interests may be threatened by mass casualty weapons, by the proliferation of technology, by the United States' increasing reliance on information systems, and by terrorists and other nonstate actors. The Center helped DoD policymakers evaluate U.S. capabilities to monitor and detect other states' nuclear tests. It investigated U.S. capabilities to operate in urban environments. On the information front, ISDP analysts examined China's information security strategy and infrastructure, the degree to which terrorist groups have become information- and network-savvy, the use of deception in cyber and information environments, and the methods that OSD can use to most efficiently process and employ satellite imagery and other space-based intelligence. And the Center assessed the capabilities of nonstate actors' from several perspectives: their ability to deliver combat and public health services and their access to black- and gray-market sources of small/light arms, explosives, and other equipment.

## Defining New Defense Strategies

ISDP research explored how to formulate U.S. defense strategy to shape the international environment, address emerging threats to U.S. interests, and accommodate new technologies and tactics. The Center continued evaluating strategies that commanders in U.S. Central Command and in U.S. Forces, Korea could consider to counter the proliferation of mass casualty weapons in their respective theaters. Center analysts directly supported the Commander-in-Chief, U.S. Joint Forces Command in developing joint warfighting studies and experiments. The Center provided the Department of State with time-sensitive advice on the changing role of nuclear arms in U.S. security strategy. And it helped U.S. policymakers understand how state and nonstate actors are using perception operations that take advantage of new information technologies and what options Washington has to deal with adversaries' burgeoning information capabilities.

## Defense Planning

In 2000, ISDP supported DoD across a broad spectrum of planning efforts. Working with NDRI's Forces and Resources Policy Center, ISDP provided analytic support to a congressionally mandated panel assessing the United States' ability to respond to domestic acts of terrorism involving the use of weapons of mass destruction. It helped the Joint Staff prepare for the 2001 Quadrennial Defense Review by identifying issues that might dominate the discussion and developing tools to assess alternative U.S. force structures. Center analysts helped the Commander-in-Chief, Pacific Fleet explore the implications of alternative reorganization paths that he was considering. And the Center continued to provide analytic support to the DoD's joint integrated computer modeling effort.

The military application of emerging technologies for communications and information processing is likely to change the way military force is managed and applied. One possible change is the reemergence of a doctrine based on swarming, whereby military units organized as networks use dispersed yet integrated operations. NDRI analyzed 10 swarming cases throughout history—from Scythian horse archers against a Macedonian phalanx supported by light cavalry in 329 B.C. to Somalis surrounding U.S. commandos in a peacekeeping operation in 1993—to explore the future utility of swarming in U.S. doctrine.

For the purposes of this study, a swarming case was any historical example in which the scheme of maneuver involved the convergent attack of several (or more) semiautonomous (or autonomous) units on a target force in some particular place. Most examples of military swarming are tactical “massed swarm” cases from the ancient world and the Middle Ages, wherein a swarming army begins as a single massed body, then disassembles and conducts a convergent attack. Other swarming examples are “dispersed swarm” cases, such as those drawn from the history of guerrilla warfare, wherein the swarming army is initially dispersed but then converges on the battlefield without ever forming a single mass.

## Historical Findings

At least three factors appear to play a role in whether swarming is successful: elusiveness (either through mobility or concealment), a longer range of firepower (standoff capability), and superior situational awareness. The combination of these three key advantages appears to have a synergistic effect. Swarming offers several tactical advantages, including the following:

- ▲ When a swarming army attacks a defender from all sides, the swarming appears to have an unnerving psychological effect, and it creates killing zones.
- ▲ Deceptive swarmer tactics such as feigned retreats and ambushes are very successful against undisciplined opponents.
- ▲ It can sever the nonswarming army’s lines of communication.
- ▲ Networks are better at fighting other networks.
- ▲ It gives the ability to choose the time and place of battle.

Swarming has not always worked, however. Swarmers were sometimes incapable of a quick knockout blow. Their mobility and/or concealment depended on terrain. Often, logistics posed a significant challenge to them. And their attacks on fixed defenses yielded mixed results.

**Battlefield Dispersion from Antiquity to the Present**

Area Occupied by Deployed Force, 100,000 Strong	Antiquity	Napoleonic Wars	U.S. Civil War	World War I	World War II	1973 Arab-Israeli War	Gulf War
Square kilometers	1	20.12	25.75	248	2,750	4,000	213,000
Front (km)	6.67	8.05	8.58	14	48	57	400
Depth (km)	0.15	2.5	3	17	57	70	533
Men per square km	100,000	4,790	3,883	404	36	25	2.34
Square meters per man	10	200	257.5	2,475	27,500	40,000	426,400

## Is a Swarming Doctrine Feasible?

Ultimately, a swarming doctrine’s feasibility will depend on the benefits emerging from the information and communications revolutions. Many benefits are already being realized. Eventually, the computers and wireless radios that are currently being installed on every vehicle, plane, and ship will communicate digitally with each other across interoperable battle command and control systems. Sensors and shooters will share a near-real-time common picture of the battlefield. Several governmental research and development efforts that have been pursued in recent years may be relevant to a discussion of swarming, including the U.S. Army’s Army XXI and Army After Next (AAN) work and the Marine Corps’ Urban Warrior program.

The occasional limitation of swarmers in the past—an inability to deliver a knockout blow quickly—may be overcome in the future by joint, indirect fire assets such as fighter/bombers, C-130 and helicopter gunships, the multiple-launch rocket system (MLRS)-fired Army Tactical Missile System (ATACMS), offshore Naval fire support, and even space-based kinetic-energy weapons. The command and control limitations of the past may be erased by the advent of future wireless communication systems—such as mobile mesh networks—capable of supporting a tactical Internet anywhere in the world.

Given the radical force-structure changes a swarming doctrine would require, this NDRI study recommended that a portion of the U.S. light or medium force adopt swarming as an operational concept, if swarming proves to be feasible during field experiments. History suggests that swarming armies were successful when they were able to elude their opponent, possessed standoff firepower, and enjoyed

superior situational awareness. It is reasonable to assume that swarming can work again if future forces enjoy these same advantages. Ongoing technological development suggests that light Army units may soon enjoy them.

As with any tactic or strategy, swarming will not work against all types of opponents in all situations. NDRI suggested that network organizations that use a dispersed formation to swarm are more relevant than AirLand Battle divisions for four particular missions:

- ▲ *Power projection missions.* The mobile yet lethal nature of the swarm unit lends itself well to the missions of light expeditionary forces—such as the “Halt Phase” mission—because swarm units are light enough to be air-transported and mobile enough to remain elusive.
- ▲ *Dispersed operations.* Dispersion of swarming units on the battlefield will reduce their vulnerability to weapons of mass destruction and improve their ability to rapidly counter enemy forces who themselves have spread out in response to allied air superiority.
- ▲ *Counterinsurgency operations.* A highly mobile network of nodes can detect dismounted enemy personnel more effectively than can standard U.S. reconnaissance assets.
- ▲ *Peace operations.* Swarm units have the advantage over hierarchical divisions when organized for peace operations, an ability to shape the environment, and an ability to minimize command problems on urban terrain.

For more information, see *Swarming on the Battlefield: Past, Present, and Future*, Sean J. A. Edwards, MR-1100-OSD, 2000.

Successful coercion, a cornerstone of an effective foreign policy, depends on the proper application of military force. However, the United States often fails to coerce successfully despite its overwhelming military power. To help understand this problem, NDRI assessed eight attempts to coerce Iraq since the end of the Gulf War in 1991. These efforts illustrate Baghdad's strengths and weaknesses and highlight lessons about limits on the U.S. ability to bring its full power to bear when coercing foes.

## An Analytic Framework

Coercion is the use of threatened force, including the limited use of actual force to back up the threat, to induce an adversary to behave differently than it otherwise would. Coercion is typically broken down into two categories: deterrence (stopping an undesired action from occurring) and compellence (reversing an undesired action). In practice, however, distinguishing between these two is difficult. NDRI drew on both these categories to inform its overall conclusions about coercion.

Coercion is dynamic. Just as the United States tries to shape Iraq's behavior, so too does Iraq try to reduce the pressure imposed on it. Adversaries typically try to counter-coerce the United States, inflicting military, political, or diplomatic costs to force the United States to drop its threats. At the same time, coercive success is often difficult to measure. The same action can have both positive and negative effects, particularly when long-term ramifications are taken into account.

## Coercion's Mixed Track Record

The eight U.S. attempts to coerce Iraq or to deter hostile Iraqi actions that NDRI studied are outlined in the accompanying tables, overlaid against Iraqi and U.S. objectives. These attempts have had a mixed track record.

As the tables suggest, the containment of Iraq has generally succeeded. A robust regional

### Saddam's Primary Objectives

by Case	Oppose Kurdish Safe Haven	Oppose Shi'a Safe Haven	Refuse to Accept UNSCOM Inspections (1991-1992)	Initiate 1993 UNSCOM/NFZ Standoff	Initiate 1994 Border Buildup	1996 Incursion into the North	Initiate 1997-1998 UNSCOM Standoff	Initiate December 1998 Strike
Rebuild conventional forces								
Maintain NBC arsenal		X	X			X	X	
End diplomatic isolation						X		
End sanctions		X	X			X	X	
Improve regional influence (threats or accomplishments)				X				
Improve prestige at home	X	X		X	X	X	X	X
Strengthen control over Iraq	X	X			X			

presence, a rapid surge capacity, and a willingness to use limited force probably have convinced Saddam that regional aggression will not succeed. Iraq is far weaker than it was in 1990, both in relative and absolute terms. Iraq's regional influence, while increased from 1991, remains limited.

On the other hand, stopping Iraq's nuclear, biological, and chemical (NBC) programs has proven far more difficult. Iraq probably has not attained a nuclear weapons capability, and progress on its biological and chemical programs has probably halted. But the broader U.S. goals of discovering the extent of Iraq's programs, destroying them, and preventing Iraq from reconstituting them in the future have not been met.

Maximal U.S. goals regarding regime change were not met. Efforts to change the regime—by encouraging Iraqi elites to support a coup or the Iraqi populace to overthrow Saddam—probably are farther from success than at any time this decade.

## Iraq's Vulnerabilities and Countermoves

The various U.S. attempts to coerce Iraq reveal that Saddam is most likely to give in when his power base is effectively threatened. Maintaining the support and loyalty of key tribes, Baath party

### U.S. Objectives That Affected the Use of Force

by Case	Establish Kurdish Safe Haven	Establish Shi'a Safe Haven	Force Acceptance of UNSCOM Inspections (1991-1992)	1992-1993 UNSCOM/NFZ Standoff	1994 Border Buildup	1996 Incursion into the North	1997-1998 UNSCOM Standoff	December 1998 Strike
Keep Iraqi conventional forces weak								X
Halt Iraqi NBC programs		X	X				X	X
Remove Saddam from power	X <sup>a</sup>							X
Protect subjugated Iraqi peoples	X	X				X		
Ensure security of Gulf allies (from immediate threat)		X		X				
Minimize U.S. casualties <sup>b</sup>						X		
Maintain sanctions							X	
Prevent destabilization of allies	X			X	X	X	X	X
Maintain Iraq's diplomatic isolation					X	X		

<sup>a</sup>Removing Saddam did not motivate creation of the northern protective zone, but, once created, this zone was exploited for anti-Saddam activities.

<sup>b</sup>Minimizing U.S. casualties is a high priority for any U.S. military operation. This is listed as a category here for cases when the political leadership sought to prevent any casualties, even if it severely constrained operations.

officials, military officers, and other elites is Saddam's overriding concern. Note, however, that Saddam does not respond passively to U.S. attempts to target his vulnerabilities and press his regime. Rather, he tries to exploit U.S. weaknesses whenever possible and take countermeasures—exploiting domestic suffering, complying incompletely with demands, trying to fracture coalitions, and repressing dissent—to minimize U.S. pressure. These countermeasures (most notably attempts to fracture coalitions) have at times failed or even backfired, but Saddam has frequently managed to offset U.S. coercive pressure.

## Implications for Coercion

The Iraqi experience is rich with general lessons for coercing major regional powers in critical

regions. When designing coercive strategies, policymakers must pay particular attention to the following issues:

- ▲ *Recognizing adversary "centers of gravity."* When planning a coercive strategy, policymakers should strive to identify the target's "center of gravity"—that which, if destroyed, would cause the enemy's resistance to collapse. For Iraq, this appears to be Saddam's relationship with his power base.
- ▲ *Recognizing the dynamic nature of coercion.* Coercion is a process, not an event. Planning must acknowledge that just as the United States is (or should be) performing a "center of gravity" analysis on the adversary, the adversary is likely doing the same on the United States or the coalition aligned against it.
- ▲ *Understanding what cannot be affected.* The United States can affect only the level of pain it inflicts, not an adversary's willingness to accept it.
- ▲ *Improving long-term planning.* Policymakers and analysts did not anticipate Saddam's survival, and U.S. policy suffered as a result. In future confrontations, the United States should conduct more low-probability, high-impact analysis and "red team" measures to explore the range of possible outcomes and make U.S. policy more robust.
- ▲ *Recognizing self-imposed limits.* The attempts to coerce Iraq reveal the degree to which self-imposed constraints, especially those generated by political and diplomatic concerns, limit the quantity and type of force the United States can threaten or use.

For more information, see *Confronting Iraq: U.S. Policy and the Use of Force Since the Gulf War*, Daniel L. Byman, Matthew C. Waxman, MR-1146-OSD, 2000.

In this study, NDRI and its sister research center at RAND, the Arroyo Center, proposed a new way of viewing one of the most complex challenges facing U.S. armed forces today: operating in urban environments. Whereas there is no lack of confidence among tacticians when debating doctrine for fighting on open terrain, discussions of how to deal with combat and noncombat missions in villages, towns, and cities inspire far less confidence.

Urban undertakings today pose far greater challenges than even just a few decades ago. The region around Seoul, South Korea, exemplifies the problem. Not quite 50 years ago, Seoul was virtually an entity unto itself, separated from neighboring small cities or towns by expanses of rice paddies and lightly occupied terrain. Today, the city is awash in a much larger metropolitan area. Seoul and Incheon have seemingly merged. More people now live and work in a square kilometer. More vehicles pack the same downtown area; more offices, apartments, and commercial enterprises fill a unit of space.

This high density leads directly to a magnified density in time. More infrastructure, people, and activity in less space mean that situations can change more rapidly. A greater number of events can occur in a given period. More decisions per unit of time are demanded of military leaders. The effect is one of time and space compression. In such settings, military commanders have less time to analyze situations and alternatives, position logistical support properly, and maintain the initiative.

### Density's Tactical and Operational Challenges

Traditional forms of maneuver may be impossible: The high density of buildings, vehicles, and the like reduces the space available, restricts the ability to see other members of a unit, and complicates command and control. High civilian population density, moreover, means that individuals suddenly dashing from a doorway or alley could be innocent noncombatants seeking safety, or armed adversaries. The density of structures and other vision-blocking obstacles compounds the problem, for the potential target often appears suddenly and at very close range. Such densities overload warriors' abilities to monitor situations, complicate their target identification, and reduce their engagement to almost instantaneous acts.

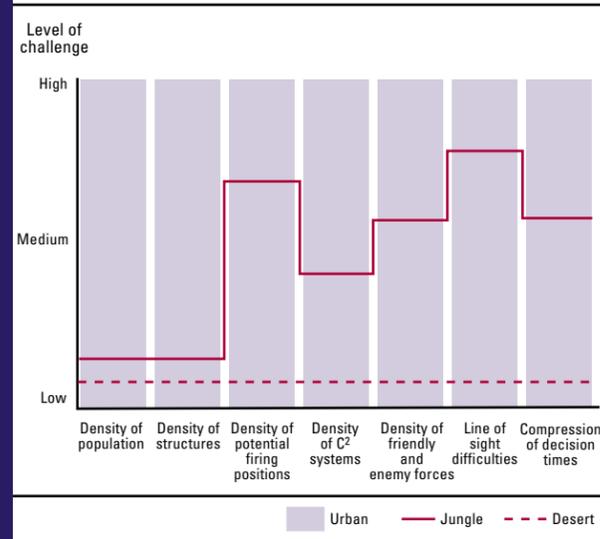
Density poses similar complications at operational levels. A single urban area can become a "resource magnet" that demands seemingly more than its fair share of manpower and other assets. Operational-level commanders have to decide how much of their limited combat power and supplies to dedicate to built-up areas in theater where their forces are more concentrated and therefore potentially more vulnerable.

### Five Approaches to Density

While these complications are significant, they are not insurmountable. This research identified five overlapping approaches that U.S. commanders may be able to employ to overcome the challenge of density.

- ▲ *Match density with density.* Commanders can attempt to neutralize density's effects by increasing the size of their forces or other resources dedicated to the mission. Given sufficient manpower, for example, an attacking

### The Challenge of Military Operations in Urban Areas



unit can augment its strength so as to have sufficient men to cover every possible enemy firing position and approach route.

- ▲ *Effectively reduce densities.* Commanders can reduce the number of threatening enemy firing positions by maximizing underground and building-to-building movement; employing booby traps, chemicals, or other lethal and nonlethal munitions; or avoiding particularly dense concentrations of windows, doorways, and the like. Emerging robotic capabilities offer considerable promise in this regard.
- ▲ *Maintain selected densities.* Commanders can work to cut off or isolate their urban foes. In World War II, Zhukov defeated Manstein's efforts to maintain substantial contact with Stalingrad; only then did Paulus surrender his Sixth Army. In 1968, the 1st Cavalry Division

de facto isolated Hue's communist defenders by overrunning the headquarters supervising the operation (despite that headquarters not being located within the city).

- ▲ *Address density asymmetrically.* Urban combat effectively neutralizes the superior power of U.S. armed forces in many ways. But that does not mean that their competitive edge should be considered lost. Superior discipline, training, combined arms, and leadership will continue to be influential, if not decisive. Much urban sprawl consists of structures that are well dispersed and suffer limited if any shielding by adjacent obstacles. Indirect, aviation, or fixed-wing air fire support is in many cases feasible. Urban densities may complicate the employment of such support, but proper planning, map analysis, visual reconnaissance, and training can ensure that friendly force fire support superiority is not unnecessarily diminished.
- ▲ *Capitalize on urban densities.* The same factors that disrupt U.S. forces can overwhelm the enemy. The density of activity in a city is a natural cloak for surreptitious actions. Changes in routine are less likely to be noticed as urban routine is itself often in constant flux. Density can provide the innovative commander with flexibility; for example, a force moving along a street can divide at an intersection, puzzling an enemy attempting to determine intent, only to use many other routes to reconsolidate at a designated time and location.

For more information, see *Heavy Matter: Urban Operations' Density of Challenges*, Russell W. Glenn, MR-1239-JS/A, 2000.



**T**he Acquisition and Technology Policy Center (ATP) is the organization

within NDRI that addresses issues of accelerating technological change in the context of the revolution in world politics and the transformation of the U.S. military establishment. Its research agenda in 2000 reflected the fact that technological advances simultaneously hinder and help U.S. defense policy. On the one hand, new technologies may expose U.S. forces and interests to new challenges, threats, and dangers. At the same time, technology developments and innovative concepts of operation may allow U.S. forces to accomplish new roles and missions—to project power rapidly from the air, from the sea, and on the ground when needed worldwide; wage war from afar with minimal U.S. casualties and collateral damage; counter potential terrorist actions both in the United States and abroad; and engage effectively in urban combat and peacekeeping operations.

Six themes, which are discussed below, comprised the blueprint of ATP's research agenda in 2000.

### Conflict in the Information Age

ATP explored in 2000 how conflict in the information age will affect traditional military engagements and how it could lead to new forms of hostilities. ATP analysts provided support to OSD's

effort to craft an Information Superiority Investment Strategy, explored information superiority concepts connected with early halt missions, assessed how digital communications improve command and control in ground operations, and evaluated the role of decep-



tion in defending active networks. The Center continued to conduct exercises for U.S. and allied defense policymakers on ways to protect critical information systems and infrastructures from hostile attacks. On behalf of the National Intelligence Council, the Center examined the course of the information revolution in various regions and countries over the next 10 to 20 years. Still other ATP analysts provided analytic support to the congressionally mandated Independent Commission on the National Imagery and Mapping Agency.

### Understanding the Effect of New Technologies on Future Military Operations

ATP continued to investigate military operations in light of advances in technology. The Center helped the Defense Advanced Research Projects Agency (DARPA) evaluate research and development activities related to using controlled biological and biomimetic systems for future military applications. It also helped DARPA assess technologies to locate, identify, and engage fleeting targets and to identify humans at a distance. Center analysts helped the Defense Threat Reduction Agency examine how U.S. nuclear test monitoring capabilities might need to change in the future. Other ATP researchers analyzed system interoperability issues connected with ballistic missile defenses.

### Assessing Force Modernization Options

ATP in 2000 continued to identify the priorities of force modernization. Center researchers helped craft a concept of operations for the NR-2 submarine, a nuclear-powered, deep submergence, research and engineering vessel that the U.S. Navy is developing. Another ATP research team explored how different aircraft carrier funding profiles would effect Newport News Shipbuilding's carrier construction, overhaul, and maintenance costs. And the Center helped the Navy and OSD evaluate naval force structure options, acquisition and modernization strategies, and budget issues.

### Maintaining Core Defense Technology and Production Bases

Much of the U.S. defense technology and production base lies in the private sector, and over the past two decades many crucial industries have merged, restructured, or reduced their operations. The Center has for several years helped the DoD explore how to leverage off of these developments and identify where its unique needs require different solutions. In 2000, ATP researchers assessed how alternative production scenarios would affect the E-2C Hawkeye industrial base.

ATP researchers, along with researchers in the Forces and Resources Policy Center helped identify future core equities, alternative organizations, and transition plans for the Naval Sea Systems Command (NAVSEA). The Center also assisted the Navy and the U.S. Maritime Administration in evaluating options for ships designated for final disposal.

### Assessing New Acquisition Strategies

ATP researchers in 2000 helped defense policymakers think through how to streamline the acquisition process and put in motion meaningful acquisition reform. At the direction of the Secretary of Defense, the Center explored options to inject competition into various production phases of the Joint Strike Fighter. Center researchers also evaluated options that the Navy could consider to reduce the cost of its latest special operations forces vessel, the Advanced SEAL Delivery System.

### Application of New Modeling and Simulation Approaches

ATP continued to help DoD create a more flexible, robust simulation and modeling environment in 2000. The Center helped the Defense Information Systems Agency assess how command, control, communications, computers, surveillance, and reconnaissance capabilities influence joint military operations. And it helped DoD analyze how best to represent U.S. information superiority in computer simulations.

NDRI in 2000 helped the Defense Department identify ways to inject competition into the Joint Strike Fighter (JSF) production program. The JSF program is a joint endeavor by the United States and the United Kingdom to develop and deploy a family of common and affordable strike aircraft to meet the operational needs of the Air Force, Navy, and Marine Corps, as well as the United Kingdom and other U.S. allies.

The JSF will be one of the largest acquisition projects in history, worth some \$300 billion (then-year dollars), and the only new major fighter aircraft program planned for the next 30 years. Over the next several decades these aircraft are slated to replace all F-16s, A-10s, AV-8Bs, and Harriers in U.S. and UK inventories and to augment the Navy's F/A-18E/Fs. U.S. and UK forces plan to have some 3,000 of these jet fighters by 2026. The Pentagon expects that additional sales to U.S. allies could approach 3,000 aircraft.

The DoD in 1996 named the Boeing Company and the Lockheed Martin Corporation as the JSF's two finalist prime contractor competitors. Since then, each has been engaged in concept demonstration efforts, flown test vehicles, and pursued other preliminary development efforts—all in hopes of winning the JSF development and production contract, to be awarded in Fall 2001. But as Boeing's and Lockheed Martin's efforts have unfolded, senior DoD officials and members of Congress have voiced concerns that awarding the JSF to one company will effectively leave the United States

with a single fighter aircraft manufacturer. That could lead, some worry, to a situation in which the United States might be paying more for weapons systems or purchasing less technologically sophisticated platforms than it would under more robust competition.

The DoD turned to NDRI for help in exploring and identifying opportunities and options to introduce competition during the production phase of the JSF. Using quantitative and qualitative measures, NDRI examined the chances that the Pentagon would save overall JSF program costs if it pursued several alternative competition paths. In our quantitative analysis, we developed a "breakeven" model to gauge the likelihood that the Pentagon would recoup its costs if it invested in a second JSF producer. We augmented these quantitative data with extensive discussions with both contractor teams and the Joint Strike Fighter Program Office staff regarding the feasibility and desirability of various competition strategies. This qualitative analysis allowed us to assess whether the prospect of saving overall costs via a particular competition path was reasonable. We also examined the Pentagon's experience with introducing competition in 63 weapons system procurement programs between 1960 and 1990.

Our examination of the DoD's past experience suggested that second producers of electronics have been more likely to generate savings

### Fraction of 63 DoD Competitive Production Programs Achieving Savings

Savings Achieved (%)	Missiles and Ships	Electronics
>0	7/10	9/10
>10	5/10	8/10
>20	3/10	6/10
>30	1/10	5/10
>40	Nil	3/10

in production costs than have second producers of missiles and ships. Half of the DoD programs involving competitively produced electronics that we looked at reduced overall costs by 30 percent, but only 1 in 10 competitive missile and ship production efforts did so.

But such a 30 percent cost reduction is just the level of savings the DoD would need to achieve if it were to bring a second competitor into the JSF program. Our break-even analysis suggests that such a second competitor would need to offer the DoD this level of savings across a range of JSF elements—forward, center, and aft fuselage; landing gear; ejection seat; wing; edges; tail; and mission systems. Based on past DoD experience with missiles and ships, we found that such savings from competition would be difficult, if not impossible, for the JSF program to achieve in the near term.

All these areas would be equally unpromising in the far term, with the exception of mission systems—the eyes, ears, and brain of the JSF. Many of the mission system's computer and electronic technologies are evolving rapidly, and several major upgrades in mission systems

during the life of the JSF are likely. We suggest that the DoD investigate the establishment of a "shadow" industry team that would begin developing system architectures and component technologies that would be tailored to the JSF. This shadow team would not compete on the first avionics suite configuration, but would focus on technological advancement, cost reduction, and any new mission requirements that might emerge. Our findings have two policy implications:

- ▲ *Policymakers should stick with the winner-take-all strategy for near-term development and production of the JSF.* Despite the potential advantages that might accrue, establishing a competitive production line for part or all of the JSF would require a front-end investment, together with increases in recurring costs, that probably would not be recovered through price reductions that may result from competitive forces.
- ▲ *Policymakers should consider funding a potential future competitor that would be capable of developing and manufacturing the next major upgrade of the mission system equipment.* This strategy would ensure that future managers have the option of a competitive second source, one that might not otherwise be available.

For more information, see

*Assessing Competitive Strategies for the Joint Strike Fighter: Opportunities and Options*, John Birkler, John C. Graser, Mark C. Arena, Cynthia R. Cook, Gordon Lee, Mark Lorell, Giles Smith, Fred Timson, Obaid Younossi, Jon G. Grossman, MR-1362-OSD/JSF, 2001.

In many military interventions to deter or thwart an invader entering a country friendly to the United States, U.S. policymakers would benefit greatly from being able to employ a joint task force that would combine long-range fires from aircraft and missiles with maneuver forces on the ground. Given likely U.S. capabilities, future aggressors will have incentives to act with little actionable warning and to maneuver as fast as possible to occupy cities, capture key installations, and reduce their vulnerability to U.S. responses. The United States should therefore be prepared to disrupt an invader within the first days of invasion, and to thwart the invasion altogether within perhaps a week.

In this research, NDRI explored concepts for achieving first-week ground-force capabilities in joint-task-force operations. We found, significantly, that a first version of such capability could be achieved in the mid term by using existing airlift and ship-based prepositioning and by rethinking how best to use those precious assets. By reconceptualizing how it uses Marine Corps Prepositioning Force Squadrons and Army Afloat Prepositioning sets, the DoD could within five years have initial capabilities to deploy infantry forces in three to four days and mechanized forces in a week.

But given such a mobility capability, what operational concept and force structure would make sense if early actions are essential? Our analysis suggests a force with three components (detailed sizes and configurations are illustrative):

- ▲ An early allied-support force with a few hundred personnel that could in crisis greatly leverage allied forces already in place. This force may need to bring with it significant equipment for reconnaissance, surveillance, and communications.

- ▲ A light mobile-infantry force with 3,000–5,000 personnel organized into two types of units: 500-person light, mobile, air-deliverable fighting units with multiple missions such as defending critical facilities and launching missile attacks; and 50–80-person infantry units that would operate forward (in some cases behind enemy lines) and—through networking—be able to direct long-range fires and conduct ambush operations.

- ▲ A light/medium-weight mechanized force with 3,000–5,000 personnel in five or six agile tactical units capable, for example, of anti-armor missions against enemy forces already weakened by long-range fires and ambushes. It would draw on Air Force and Navy long-range precision fires, but would have some of its own (“organic”) long-range missiles, shorter-range indirect fires, line-of-sight weapons, and attack helicopters.

These agile, dispersed insertion forces appear attractive over a range of circumstances and scenarios. In simulation, their distributed operation and tactical mobility allowed a high level of survivability and lethality—assuming U.S. information dominance, which would be essential to their survival. In particular, they were quite successful in ambushing enemy forward-combat armored units and combat-service support vehicles. Moreover, given organic indirect precision fires, the combination of such forces and long-range precision fires was much more effective than long-range fires alone.

The value of our postulated early ground forces depends on the scenario. The following table shows results for the Persian Gulf scenarios. It shows that the combined use of long-range fires and maneuver forces could have a substantial effect strategically—holding penetra-

### Potential Value of Rapidly Deployable Ground Force for Defense of Kuwait and Saudi Arabia

Deepest Iraqi Penetration <i>(Median from test set of scenarios, followed by a range covering 75 percent of cases)</i>				
Tactical Warning (Days)	Without New Ground Component Median Outcome	Ground Component Range of Outcomes	With New Ground Component Median Outcome	Ground Component Range of Outcomes
0	Key oil facilities (~500 km)	Gulf coast to Dhahran (~350–580 km)	Gulf coast (~400 km)	Northern Saudi Arabia to key oil facilities (~220–550 km)
5	Gulf coast (~480 km)	Northern Saudi Arabia to Dhahran (~320–580 km)	Northern Saudi Arabia (~200 km)	Kuwait to Gulf coast (~100–380 km)
10	Gulf coast (~400 km)	Northern Saudi Arabia to Dhahran (~200–550 km)	Northern Saudi Arabia (~100 km)	Kuwait to northern Saudi Arabia (~75–350 km)

tions to Kuwait or northern Saudi Arabia in many cases, and reducing the likelihood of penetrations as far as the Gulf coast, much less to the principal oil facilities.

A joint-task-force approach combining long-range fires with a rapid deployment ground force consisting of an early allied-support force, a light mobile-infantry force, and a light mechanized force has a great deal of potential as the front end of a larger campaign. This would be true for major wars and for certain kinds of small-scale contingencies. Indeed, the potential is so great that we recommend vigorous efforts, including service and joint experiments, to establish a more reliable empirical base. These should include more stressful field experiments to characterize and assess: the leverage achievable by connecting defended allies to U.S. C<sup>4</sup>ISR systems; the effectiveness and survivability of small teams used at the front or in the enemy’s rear area; and the nuts and bolts of inserting, extracting, and sup-

porting such operations with C<sup>4</sup>ISR, fires, and logistics.

We believe that that the United States should seek initial versions of an operational first-week ground-force capability within five years. This will require changes in the use of strategic mobility, doctrine, and program priorities. A top priority should be “zero basing” the use of current ship-based prepositioning assets (and airlift) to enable a near- to mid-term version of the advanced joint task force. Initial forces would be heavier and less capable than technology will make possible in the longer term, but much can be done within five years. Establishing such a near- to mid-term goal would be liberating to military innovators, who have been hampered by an excessive emphasis on the distant technology of super-light forces and advanced lift. Moreover, such a rapid effort would be an excellent way to invigorate DoD’s effort to “transform U.S. forces” for future needs.

For more information, see

*Ground Forces for a Rapidly Employable Joint Task Force: First-Week Capabilities for Short-Warning Conflicts*, Eugene C. Gritton, Paul K. Davis, Randall Steeb, John Matsumura, MR-1152-OSD/A, 2000.

NDRI in 2000 explored options that the Department of Defense can explore to streamline and rationalize the way it acquires innovative new weapons systems. Today's defense environment is placing growing pressure on defense policy-makers to be nimble and adaptive, particularly with respect to acquisition systems and processes.

This NDRI research suggested that the characteristics of novel systems are so different from traditional systems that "tinkering" with the present process will be an inadequate solution. Instead, the DoD should consider a new approach, one that intertwines and integrates strategy, process, and organization.

### DoD Needs a New Strategy to Deal with Novel Systems

As shown in the figure, novel systems differ from traditional legacy systems in significant ways:

- ▲ Their design is so new, in overall concept or use of emerging technologies, that the development outcomes (mainly capability and cost) cannot be confidently predicted on the basis of studies alone.
- ▲ Their operational employment has not been clearly defined and demonstrated and is therefore subject to substantial uncertainties and change.
- ▲ Their eventual production run size and operational life span are uncertain.
- ▲ Their key uncertainties can be resolved only through development and test of a demonstrator or prototype, at a cost that is commensurate with the potential value of the system.

The acquisition strategy that the DoD has used for traditional legacy systems likely will not work for acquiring novel systems.

### DoD Needs a New Acquisition Process to Accommodate Novel Systems

Acquisition policies in place today were basically designed to deliver new systems that were ready to be produced at high rates and that could be operated with full support in the field. Such a process has been appropriate when the quantities to be produced have been large and where the systems have been expected to be operational for many years. But these processes are unfriendly and inappropriate when policymakers need to manage new concepts that are both urgent and uncertain. New, innovative system concepts inherently pose many uncertainties for development outcomes (cost and performance of the system, and operational effectiveness in the field).

Legacy Systems	→		Novel Systems
Characteristics			
Extension	Design	New	
Established	Operational Employment	In Formulation	
Predictable	Outcomes	Uncertain	
Large	Production Run	Uncertain	
Long	Operational Life	Uncertain	
<b>Novel Systems Have Different Characteristics</b>			

As a result, the most efficient way to develop novel systems is to identify a "second acquisition path." Such a second path would

- ▲ emphasize flexibility of the process,
- ▲ include an overt willingness to accept some risks in return for faster fielding of the product, and
- ▲ field systems early and refine them later based on field experience.

The last element is the most radical, poses the most challenging problems of implementation, and contains potentially the most powerful tactic for moving an innovative new-system concept to early operational capability. The concept of "experimental" operational units, designed to receive and operate systems that are not quite technically mature and that are not fully provisioned with support and training aids, lies outside the traditional major defense acquisition program (MDAP) acquisition policy. The "field demonstration" phase of the Advanced Concept Technology Demonstration (ACTD) process suggests that this approach can work for novel systems where the system configuration and the operational concept are likely to evolve as early operational experience is accumulated.

### DoD Needs a New Organization to Accommodate Novel Systems

Fundamental changes in acquisition strategy and process will change the nature of tasks to be managed and how the OSD should be organized to perform these functions. This NDRI research suggested that an organization containing the following functional responsibilities would be appropriate. First, a **Science and Technology Office** would have responsibility for identifying new technologies and seeing that selected ones mature, especially those identified in the Concept Formulation and Development Office. Second, a new **Concept Formulation and Development Office** would have the charter to formulate, evaluate, and define concepts in each mission area. For selected concepts offering significant improvements in capability, this office would do the detailed end-to-end planning; take into account problems of engineering and support, e.g., joint command and logistics support; and provide oversight management to the ongoing Concept Demonstration programs. Finally, an **Acquisition Office** would oversee the final acquisition of platforms and systems.

For more information, see *An Acquisition Strategy, Process, and Organization for Innovative Systems*, John Birkler, Giles Smith, Glenn A. Kent, Robert V. Johnson, MR-1098-OSD, 2000.



**T**he Forces and Resources Policy Center (FRP) researches issues

affecting U.S. military personnel, forces needed to execute U.S. military strategies, and ways the DoD can use resources optimally. Since the late 1980s, FRP has helped DoD think through personnel and resource implications of the post-Cold War defense drawdown, the emergence of new security challenges, and the rapid progress of technology.

In 2000, the FRP continued to analyze these issues along five interconnected themes outlined below.

### Ensuring the Supply of High-Quality Personnel

As the military services move into the information age, attracting steady supplies of skilled, smart recruits has become paramount. Not only must each branch compete with the private sector for high-quality enlistees; because more youths are attending colleges and universities, the services also will have to develop policies that allow them to penetrate

this market. FRP researchers in 2000 helped OSD policymakers explore options for recruiting college-

bound youths, evaluate the effectiveness of newly designed recruiting stations, and examine demographic trends that affect recruiting conducted by the National Guard and Reserves.



### Bettering the Quality of Life for Uniformed Personnel and Their Families

OSD has for several years turned to FRP to assess policies and practices designed to directly improve military quality of life. The single largest determinant of an individual's quality of life is his or her compensation. The Center extended its significant body of work on compensation and analyzed a range of compensation issues in support of the 9th Quadrennial Review of Military Compensation. In 2000, the Center also examined metrics that the DoD can use to assess quality of life in different military communities.

### Determining and Meeting Manpower Requirements

The aging of the civilian workforce has raised concerns about the retention of intellectually experienced human capital in the DoD. At the same time, evidence that uniformed service people, especially those in high-tech occupations, are increasingly more difficult to retain, has triggered questions about the optimal experience profile of the force. FRP helped DoD in 2000 to examine whether its existing officer personnel management practices are appropriate for the defense environment it will face in the 21st century. It looked at whether women have been fully integrated into military occupations that previously were closed on the basis of gender. FRP analysts continued the Center's research into issues connected with managing civilian DoD employees, and they helped the Chancellor for Education and Professional Development explore ways to measure and improve the quality of DoD's professional education courses. Other FRP analysts evaluated how the Navy could make tactical training more effective by using different combinations of live, simulated, and classroom exercises. The Center began a multiphase project to estimate how many and what kinds of personnel the Navy will need to service ships in port in the future. And, as noted in the ISDP discussion above, the Center provided support to a congressionally mandated panel assessing the ability

of U.S. authorities to respond to terrorists wielding weapons of mass destruction on American soil.

### Optimizing the Military's Infrastructure

FRP in 2000 helped DoD explore new ways to organize its components and new approaches to planning and operations. The Center helped the DoD analyze whether military installations are structured to support forces in the future. In the logistics area, FRP analysts explored how logistics providers could use proven process-improvement methods to more effectively supply and support U.S. forces based at home and abroad, looked at steps the Navy could take to improve its supply chain to Trident submarines, and helped OSD investigate how it could accelerate logistics improvements. The Center helped analyze how the Defense Finance and Accounting Service could improve its service, and it provided ongoing support to an OSD analysis of the implications for DoD of corporate mergers involving companies in the defense industrial base. And as mentioned above, the Center—working with ATP—helped NAVSEA analyze its core equities and alternative organizational structures.

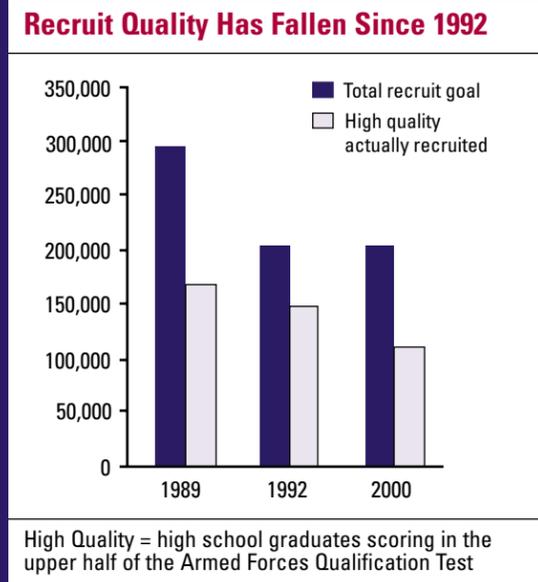
### Improving the Military Medical System

With the largest health care operation in the United States, the DoD faces a myriad of medical management issues. FRP in 2000 helped analyze the structure and costs of the DoD medical system and laid out alternative organizational structures. It began or continued evaluations of three demonstrations within TRICARE, the system that provides health care to military members, dependents, and retirees. FRP surveyed clinicians to begin an assessment of their experiences with a pharmaceutical formulary. And FRP continued helping the Special Assistant for Gulf War Illnesses to summarize and evaluate baseline scientific and medical information about a number of possible causes of illnesses among Gulf War veterans.

As part of an effort to help the DoD prepare for the next Quadrennial Review of Military Compensation, NDRI has investigated whether military compensation is adequate to recruit and retain high-quality personnel. The project has found that the military faces a large and growing problem: intensified competition with the private sector for well-educated, high-aptitude youth. This private-sector challenge extends beyond the difficulties the military faces in trying to recruit and retain personnel when the national economy is booming. High returns to higher education have induced an increasing proportion of youth to seek higher education. In response, the military must develop new strategies and methods to attract, retain, and motivate them. This research—which has involved inquiries into educational benefits, 401k-type plans, post-service earnings, family and spouse incomes, and the structure of enlisted and officer compensation—takes the view that the military must be prepared to consider substantial, if not radical, revisions of its compensation structure, along with broad changes to career paths and personnel management policies.

## How Has the Recruiting Market Changed?

During the past 20 years, the percentage of youths who enroll in college within 12 months of graduating from high school has risen substantially. In 1980, approximately one in two high school graduates enrolled in college within a year of receiving their diplomas; by 1997 two of three graduates did so. This increase in college enrollment has fundamentally changed the market for new military recruits. Today, more high-aptitude youths are likely to enroll in college, depleting



the very pool of people who, because they score well on military qualification tests, typically have performed better in military training and on mission-essential tasks.

This growth in college enrollment has been accompanied by—and probably responded to—the increases in returns to a college education. Since the early 1980s, the wages of those with only some college (no four-year degree) have risen relative to the wages of high school graduates; the wages of those with four or more years of college have risen more significantly.

## How Well Does Military Compensation Compare with Civilian Compensation?

In FY 2000 (FY00), regular military compensation (RMC)—basic pay, basic allowance for subsistence, and tax advantages due to these allowances not being taxable—appeared to compare fairly well with the civilian pay of high school graduates but not as well for those with

some college. Over much of the military career, RMC approximately equals the 70th percentile civilian wage of high school graduates. For military personnel with some college, RMC is only just above the 50th percentile wage level of their civilian counterparts.

Both the selectivity and the rigors of military service call for above-average pay; and, historically, pay at around the 70th percentile or above has been necessary to enable the military services to recruit and retain the quantity and quality of personnel they require. The fact that RMC is nearer the 50th percentile of civilian pay for those with some college means that military compensation—and a military career—is relatively less attractive.

## Will the FY00 Pay Legislation Improve Recruiting and Retention?

The FY00 pay legislation—which mandated basic pay increases and modest structural changes in the pay tables, increased authorizations for bonuses, and created a thrift savings program—was a major step forward. However, its effects will take time to materialize. The pay increases can be expected to improve recruit quality to the levels prevailing in the early 1990s by the time they are fully implemented in 2006. And as the FY00 pay actions are phased in over the next five years, they should improve overall retention in all services and offset declines experienced since the early 1990s. However, shortages may persist in critical occupation areas.

For more information, see

*An Assessment of Recent Proposals to Improve the Montgomery G.I. Bill*, Beth J. Asch, C. Christine Fair, M. Rebecca Kilburn, DB-301-OSD/FRP, 2000.

*Enlistment Decisions in the 1990s: Evidence from Individual-Level Data*, M. Rebecca Kilburn, Jacob A. Klerman, MR-944-OSD/A, 1999.

*The Pay, Promotion, and Retention of High-Quality Civil Service Workers in the Department of Defense*, Beth J. Asch, MR-1193, 2001.

*The Thrift Savings Plan: Will Reservists Participate?* Beth J. Asch, John T. Warner, DB-306-OSD, 2000.

## How Should the Military Address Structural Changes in the Civilian Labor Market?

Long-term changes in the civilian labor market and their implications for military capability argue for an additional pay action for military personnel. But what type of pay adjustment is needed? Usually, military pay increases are across-the-board raises, which give the same percentage increase to everyone in uniform. However, research suggests a number of advantages to targeting or graduating pay raises that give larger increases to those in higher grades. A graduated pay raise would

- ▲ target resources to where the educational and skill content of the enlisted force is the greatest and where relative pay growth has been lagging;
- ▲ cost less than across-the-board pay raises;
- ▲ build on the FY00 pay legislation, enhance the rewards to promotion to higher grades, and increase the incentives in the pay system to work hard and effectively;
- ▲ help the military use compensation as a force management tool.

A recent Defense Science Board report recommended several fundamental changes to the military compensation system, including a recommendation to restructure it to emphasize pay for performance. A graduated pay raise would be consistent with that recommendation.

# Assessing DoD Education and Professional Development Programs for Civilian Employees

With some 700,000 civilian employees, the Department of Defense is the single largest employer of civil service workers in the U.S. government. Over the years, many of these civilian employees have taken advantage of a myriad of education and professional development courses that the DoD provides. Today, the department offers more than 100 of these courses to civilian employees. Many of these are sponsored by the OSD, which directs some 20 institutions (such as the Naval Postgraduate School) and 36 programs (such as the Defense Acquisition Career Development Program). Many more are provided by other defense offices and agencies. And still more civilian education and professional development takes place within each military service.

To get a handle on these various efforts, the DoD in 1998 established the Office of the Chancellor for Education and Professional Development, chartering it to serve as the “principal advocate for the academic quality and cost-effectiveness of all DoD civilian education and professional development activities.” The Office of the Chancellor is responsible for ensuring that all such educational and professional development activities achieve appropriate standards of quality and productivity.

## Identifying Assessment Alternatives

Shortly after its creation, the Office of the Chancellor asked NDRI to help identify promising approaches DoD might use to assess its educational programs. NDRI approached this task by reviewing the relevant literature and analyzing the methods that corporations, state governments, and universities use to assess education and professional development programs. In addition, it interviewed assessment experts

and visited organizations that conduct such evaluations.

NDRI found that the Office of the Chancellor might structure such evaluations in several ways, which are outlined in the table on page 27. It can allow individual DoD institutions or programs to review the quality and productivity of their efforts, with no outside involvement (Approach 1). A related approach is for such a review process to be monitored by the Chancellor’s office or a third party (Approach 2). Alternatively, the office or third party can take on the entire review process itself (Approach 3). Or the office can focus not on the institutions or programs but on their outcomes and attempt to measure and certify student achievement (Approach 4). Each approach has strengths and weaknesses; each works well in a different setting.

## The Academic Audit Approach: An Intriguing Alternative

Given that the DoD system of education and professional development is highly complex and decentralized, and that the Chancellor’s office has little formal authority over the organizations providing courses, NDRI found that Approach 2— involving an intermediary—appears to be the most promising. An intermediary is an organization other than the customer or provider of the education, and could be the Chancellor’s office, other DoD entities, or non-DoD organizations. Such intermediaries would be responsible for evaluating the processes that individual departments and schools employ to assess the quality and productivity of their educational efforts. This practice would be similar to quality improvement efforts that have been used in the business world for the last 25 years and that were adopted by the International Organization for Standardization (ISO) in the 1980s to certify that manufacturing

## Strengths and Weaknesses of the Four Assessment Approaches

Approach	Strengths	Weaknesses
<b>Approach 1</b> Provider designs the assessment process and conducts the assessment	<ul style="list-style-type: none"> <li>▲ Accommodates differences among institutions because it is flexible</li> <li>▲ Provides a stimulus to self-improvement</li> </ul>	<ul style="list-style-type: none"> <li>▲ Is less suitable for accountability purposes</li> <li>▲ Is not useful for assessing system-level needs</li> </ul>
<b>Approach 2</b> Provider conducts the assessment, intermediary reviews provider’s assessment process	<ul style="list-style-type: none"> <li>▲ Can accommodate diversity of institutions because it is flexible</li> <li>▲ Promotes program improvement</li> </ul>	<ul style="list-style-type: none"> <li>▲ Is less suitable for accountability purposes</li> <li>▲ Can serve to promote quality but not to ensure it</li> </ul>
<b>Approach 3</b> Intermediary designs the assessment process and conducts the assessment	<ul style="list-style-type: none"> <li>▲ Provides an independent check on quality</li> <li>▲ Is well-suited for accountability</li> <li>▲ Can focus on system-level goals</li> </ul>	<ul style="list-style-type: none"> <li>▲ May be overly standardized to reflect differences among institutions</li> <li>▲ May be driven by goals that have little relation to the quality of education</li> <li>▲ May lead to institutional resistance</li> <li>▲ May have little effect on quality improvement</li> </ul>
<b>Approach 4</b> Provider or intermediary assesses student competencies	<ul style="list-style-type: none"> <li>▲ Focuses on measuring student learning</li> <li>▲ Relates student learning to workplace competencies</li> </ul>	<ul style="list-style-type: none"> <li>▲ Is a time-consuming and expensive process</li> <li>▲ Involves competencies that are less defined and more abstract and are therefore difficult to measure</li> <li>▲ May be more suitable for professional education and training than traditional academic institutions</li> </ul>

companies worldwide adhere to certain quality standards. This practice also would be similar to academic audits that increasingly are being used in other education settings. Such audits typically are conducted by intermediary organizations and focus on ensuring that providers of education have effective processes in place to measure their own quality and engage in ongoing self-improvement.

The study also urged that the DoD look beyond assessments of existing education and development efforts. Following the lead of many corporations and educational institutions, a clear link between education and professional develop-

ment on the one hand and the basic mission of the DoD on the other is needed. The Office of the Chancellor should advocate for the development of a central learning organization within the DoD that would be modeled after a corporate learning organization or state higher education coordinating board. Such a move would be challenging: It would require high-level DoD support and substantial collaboration among a range of stakeholders, including other organizations within the Defense Department responsible for workforce planning and personnel policies.

For more information, see

*Ensuring the Quality and Productivity of Education and Professional Development Activities: A Review of Approaches and Lessons for DoD*, Susan M. Gates, Catherine H. Augustine, Roger Benjamin, Tora K. Bikson, Eric Derghazarian, Tessa Kaganoff, Dina G. Levy, Joy S. Moini, Ron W. Zimmer, MR-1257-OSD, 2001.

Veterans of the Persian Gulf War have reported a variety of physical and psychological symptoms, some of which remain unexplained. In an effort to do everything possible to understand and explain the illnesses, inform veterans and the public, and recommend changes in DoD policies and procedures, the Secretary of Defense in 1996 designated the Special Assistant for Gulf War Illnesses and his office (OSAGWI) to oversee all DoD efforts related to illnesses of Gulf War veterans.

To complement its investigations of Gulf War illnesses, OSAGWI commissioned NDRI to examine the scientific literature on the health effects of a number of possible causes of illness. Combining what science had to say with what happened in the Gulf, it was hoped, would produce a more complete understanding of illnesses among veterans.

The opposite table highlights NDRI's reviews of the scientific literature for seven potential causes of Gulf War illnesses. Although this table cannot detail the fine points of NDRI's detailed literature reviews and analysis, it nonetheless outlines the principal findings of the reviews and points out the degree to which NDRI has been able to determine whether a particular substance is a potential cause of veterans' symptoms.

In addition, NDRI pursued three related studies of Gulf War Illness.

**Military Use of Drugs Not Yet Approved by the FDA for CW/BW Defense: Lessons from the Gulf War.** To protect U.S. troops from chemical and biological weapons, the DoD used drugs and vaccines that, not having been tested for use in these specific situations, were considered "investigational" by the federal Food and Drug Administration. NDRI examined the rule that authorized the Commissioner of Food and Drugs to waive informed consent with respect to these substances; how this authority was used for pyridostigmine bromide and botulinum toxoid during the Gulf War; and the controversy surrounding the rule, its application, and its implications.

**Pesticide Use During the Gulf War: A Survey of Gulf War Veterans.** To quantify the in-theater use of pesticides before and during the conflict, NDRI surveyed 2,005 Gulf War veterans. While the majority of personnel were exposed to some pesticides, NDRI found that pesticide use differed by Service, season, rank, and living arrangements. NDRI found no evidence of

### NDRI Gulf War Illness Studies

Literature Review	Analysis and Findings	Possible Cause of Gulf War Illness?
<b>Infectious diseases</b>	<ul style="list-style-type: none"> <li>▲ Incidence of infectious disease was very low among U.S. troops in the Gulf War as compared to other wars.</li> <li>▲ Known infectious diseases were properly diagnosed and treated.</li> </ul>	<ul style="list-style-type: none"> <li>▲ Commonly recognized infectious diseases have been ruled out but the possibility exists that some unknown infectious disease could have been a contributing cause to undiagnosed illnesses among Gulf War veterans.</li> <li>▲ A theory under continuing investigation concerns the role of mycoplasma, a difficult-to-detect bacteria theorized as a cause in one researcher's published work.</li> </ul>
<b>Pyridostigmine bromide (PB)</b>	<ul style="list-style-type: none"> <li>▲ PB was distributed to U.S. and allied troops as a pretreatment for possible Iraqi use of the nerve agent soman. PB is an acetylcholinesterase inhibitor.</li> <li>▲ NDRI examined the known effects of PB on the central and peripheral nervous systems and the validity of hypotheses of how PB might contribute to illness.</li> </ul>	<ul style="list-style-type: none"> <li>▲ Based on the scientific evidence to date, we could not rule out PB as a possible contributor to some symptoms in Gulf War veterans.</li> <li>▲ The report calls for additional research on the safety and effectiveness of PB on humans.</li> </ul>
<b>Stress</b>	<ul style="list-style-type: none"> <li>▲ The general scientific literature has shown that stress can produce myriad health effects.</li> <li>▲ These effects can manifest themselves as symptoms and conditions similar to those that the Gulf War veterans report.</li> </ul>	<ul style="list-style-type: none"> <li>▲ Although the scientific literature shows that stress can produce symptoms seen in Gulf War veterans, there are presently no empirical studies that demonstrate this is the case.</li> <li>▲ Although it is inappropriate to rely on stress as a default explanation for the myriad health problems reported by Gulf War veterans without evidence, it is equally inappropriate to assume that stress played no role.</li> </ul>
<b>Chemical warfare (CW) and biological warfare (BW) agents</b>	<ul style="list-style-type: none"> <li>▲ No evidence was found of exposures to militarily effective doses. These would have resulted in death or severe symptoms.</li> <li>▲ Low-level exposure could have produced mild symptoms that could have been overlooked.</li> <li>▲ Little research exists on the effects of low-dose exposures below that which causes symptoms.</li> </ul>	<ul style="list-style-type: none"> <li>▲ Nerve agents, which are acetylcholinesterase inhibitors, could have produced symptoms similar to those seen in Gulf War veterans.</li> <li>▲ Exposure to militarily effective doses was ruled out. Although there is no evidence that exposure occurred, based only on the scientific literature, the possibility that low-dose exposure to some CW agents could have contributed to symptoms seen in Gulf War veterans can not be ruled out. More research is called for.</li> </ul>
<b>Oil-well fires</b>	<ul style="list-style-type: none"> <li>▲ Concentrations of pollutants in Kuwait and Saudi Arabia were magnitudes lower than recommended U.S. occupational standards and comparable to ambient levels.</li> <li>▲ Particulate concentrations were high, but were largely sand granules of a size that can affect the respiratory systems of smokers, asthmatics, or other sensitive populations.</li> </ul>	<ul style="list-style-type: none"> <li>▲ Nothing in the scientific literature reviewed suggests that there are health effects associated with pollutant levels measured during the oil fires.</li> </ul>
<b>Depleted uranium (DU)</b>	<ul style="list-style-type: none"> <li>▲ Armor and anti-armor rounds made from DU saw widespread use during the Gulf War.</li> <li>▲ While very little literature directly addresses the health effects of DU exposure, a wide body of literature deals with the health effects of natural uranium and enriched uranium. DU is toxicologically identical to but less radioactive than natural uranium.</li> </ul>	<ul style="list-style-type: none"> <li>▲ NDRI found no negative health effects in the literature as a result of exposure to natural uranium at levels exceeding those likely in the Gulf War.</li> <li>▲ Gulf War veterans most exposed to DU—those with embedded fragments—have shown neither adverse toxicological effects attributable to DU nor any adverse health effects related to DU radiation.</li> </ul>
<b>Pesticides</b>	<ul style="list-style-type: none"> <li>▲ NDRI examined the scientific literature on 12 active ingredients of 35 pesticides used during the Gulf War.</li> <li>▲ NDRI focused on known exposures or doses and related health outcomes, paying particular attention to long-term, chronic effects of exposures to organophosphate and carbamate pesticides, which are acetylcholinesterase inhibitors.</li> </ul>	<ul style="list-style-type: none"> <li>▲ There was little evidence of long-term effects for four ingredients studied.</li> <li>▲ Organophosphates and carbamates have been shown to produce symptoms similar to those reported by some Gulf War veterans. Evidence suggests that these pesticides potentially could contribute to some of the Gulf War veterans' undiagnosed illnesses. However, no prospective studies have positively identified pesticides as causative agents.</li> </ul>

widespread misuse of pesticides, but it did identify some cases of possible misuse.

**Psychological and Psychosocial Consequences of Combat and Deployment with Special Emphasis on the Gulf War.** This research documents that the stress of combat or simple deployment can have immediate and long-term physical and psychological consequences. The study notes that while it would be an oversimplification to assert that stress caused Gulf War illnesses, it contributes to many psychological and somatic symptoms, e.g., rendering soldiers more vulnerable to environmental pathogens. Because stress is likely to affect and be affected by many factors synergistically, this review argues that the existence of a single independent cause for illness seen in Gulf War veterans is unlikely.



Possible health effects of exposure to munitions made from depleted uranium were the focus of one NDRI scientific literature review.

For more information, see

*Documentation for the Survey of Pesticide Use During the Gulf War: The Survey Instrument*, Dalia M. Spektor, Elaine Reardon, Sarah K. Cotton, MR-1226-OSD, 2000.

*Military Use of Drugs Not Yet Approved by the FDA for CW/BW Defense: Lessons from the Gulf War*, Richard A. Rettig, MR-1018/9-OSD, 1999.

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The DoD also confronts questions that cut across the interests of individual sponsors or specific services. These questions touch on some of the most critical and challenging U.S. defense issues, which by nature require an integrated policy approach.

Such integrated, crosscutting research needs are driven by several factors:

## Past and Ongoing Crosscutting Research

**Planning Future Forces** focused on new directions in defense planning and helped the DoD conceptualize its “Shape, Respond, Prepare” strategy.

**Manpower in Strategic Defense Planning** explored whether and to what degree the DoD’s new approach toward deployments—in which the Pentagon has relied repeatedly on certain units and individuals to handle numerous diverse missions since the Gulf War—has had an unintended consequence: lower retention rates.

**Developing New Concepts for Military Operations** looked at ways to help the DoD envision and put in place crucial technologies.

**Meeting Future Critical Skill Requirements** built on past work relating to databases, estimates of personnel quality, measures of perstempo, models of retention, and projections of alternative compensation policies to create a framework for in-depth studies of skill requirements in particular occupational areas, such as information warfare.

**Defense Information Revolution** work has focused on information superiority, which has enabled the United States and its allies to employ new operational concepts, and thereby gain a distinct advantage over future adversaries. However, such superiority depends on a mix of C<sup>4</sup>ISR capabilities linked across forces, weapons systems, and networks. NDRI has helped improve DoD policymakers’ capabilities to assess how C<sup>4</sup>ISR contributes to the success of military operations.

▲ Less overall slack in the U.S. defense system has emphasized the interconnected nature of many policy concerns and the need for integrated solutions.

▲ A continuing series of broad examinations of defense issues (e.g., Bottom-Up Review, Commission on Roles and Missions, National Defense Plans, and Quadrennial Defense Review) have highlighted policy areas that transcend specific strategy, technology, personnel, and bureaucratic jurisdictions.

▲ New peacekeeping and peace enforcement roles and missions have required joint, integrated approaches to military problems.

RAND has responded to these crosscutting research needs by pursuing a small number of integrated national security studies, which typically span several fiscal years and draw expertise from across the corporation’s range of disciplines. One such stream of research that RAND continued to follow in 2000 is outlined on the next two pages.

As the new administration begins, it is likely that the President and Secretary of Defense will want a short list of priority defense objectives. One objective is sure to be “getting on with” the process of transforming U.S. forces for the needs of emerging military challenges. New capabilities do not come about naturally, or overnight. Instead, they are the result of sustained and determined efforts—often undertaken against resistance long before an immediate need is widely recognized.

The President and Secretary of Defense will discover well-laid organizational accomplishments (e.g., creation of U.S. Joint Forces Command [USJFCOM]) and broad guidance documents. However, they will discover a shortage of coherent, hard-nosed, output-oriented management actions with near- to mid-term effects; and they will find many disconnects between ideas being briefed and changes actually taking place.

NDRI has been helping senior defense policymakers think through this issue. In 2000, NDRI organized a project providing expert suggestions to the Commander-in-Chief, USJFCOM, a key figure in transformation strategy. A major element of the project is a “Board of Visitors” composed of very senior individuals with distinguished military, executive-branch, industry, academic, and institutional backgrounds. The board is providing experience-based suggestions on ways the CINC can move transformation from theory to practice.

Since 1997, NDRI has also assisted the Department of Defense in its development of transformation strategy. Now that some of the major organizational efforts have already been initiated, a key issue is identifying concrete steps that defense policymakers could take to implement transformation. As seen in the accompanying table, NDRI suggests that different kinds

of managerial instruments are needed for near-to mid-term (Era A) and longer-term efforts (Era B). For the former, organizing activity around defining and meeting discrete “operational challenges” is sensible and mainstream organizations should be action agents. For the latter, however, a more wide-open approach is needed, with more experimentation and less “management.” Such activities need to be protected from status quo organizations.

These distinct eras suggest that defense policymakers should address transformation differently in the near-to-mid and far terms. In Era A, policymakers should take the following steps to sharpen the Defense Department’s transformation efforts:

- ▲ Insist on near- and mid-term progress in the “real force,” not just in backwater research and development activities.
- ▲ Put in place a core set of multiyear operational challenges, establish what elements of the DoD should address them, and ensure that those parties focus on *outputs* (military capability to accomplish missions).
- ▲ Insist that the Services refine U.S. and coalition building-block forces (e.g., structure the Army with substantially smaller but more capable brigades than today).
- ▲ Impose a “mission-system view” — cutting across platforms, services, and tasks—to conceive, evaluate, and implement programs.

- ▲ Require all Services to *field* and begin to perfect initial versions of new building-block forces in the mid term.
- ▲ Implement network-centric operations.
- ▲ Consider fast-track authority and funding so that USJFCOM can develop and acquire high-priority command and control software.

For the longer term, DoD needs to

- ▲ develop and implement a management strategy to ensure a robust set of activities in preparation for Era B. This may require partnerships involving USJFCOM, the Services, and premier research and development organizations, plus arrangements for funding sufficient to permit vigorous “day-to-day” experimentation (as distinct from occasional demonstrations). The Department of the Navy’s structures and processes in the development of carrier aviation during the 1920s and 1930s may be a good model for what is needed here.

### Differences Between Planning for Era A and Era B

Planning for Era A and the Start of Era B (2000–2010)	Planning for the Long Term in Era B (2011–2020+)
<p>Though surprises are likely,</p> <ul style="list-style-type: none"> <li>• outcomes and outputs can be “reasonably” visualized</li> <li>• operational challenges can be sharply posed and decomposed</li> <li>• responsibilities can be assigned and success assessed</li> <li>• valuable mid-term measures can set the stage for the longer term</li> <li>• mainstream organizations can and should make them work</li> </ul>	<p>The nature of long-term changes is such that</p> <ul style="list-style-type: none"> <li>• fresh, out-of-the-box thinking is essential</li> <li>• much “discovery” is needed</li> <li>• outcomes are at best dimly understood</li> <li>• highly structured management is counterproductive</li> <li>• major surprises and changes of technology and concept are likely</li> <li>• mainstream organizations are likely to actively oppose them</li> </ul>

Initial documentation for this ongoing research was produced under RAND sponsorship. For more information, see *Taking Charge. Discussion Papers: A Bipartisan Report to the President-Elect on Foreign Policy and National Security/Transition 2001*, Edited by Frank Carlucci, Robert Hunter, Zalmay Khalilzad, MR-1306/1-RC, 2001, pp. 275–293, “Transforming Military Forces,” by Paul K. Davis.

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