Skill and Technology in Modern Warfare

By STEPHEN BIDDLE, WADE P. HINKLE, *and* MICHAEL P. FISCHERKELLER

What place does skill and technology play in determining the outcome of modern war? Is new technology—such as advanced command, control, communications, computers, intelligence, surveillance, and reconnaissance (C^4ISR)—significant enough to warrant scaling back training to acquire it? If something must be cut, is the Nation better served by older equipment and highly-trained troops, or better equipment but reduced skills and readiness for at least part of the force?

Such questions are increasingly critical as defense budgets decline and more people come to believe that unusual technological changes are imminent. Understanding how skill and technology interact is tough anytime, but it is unavoidable today to ensure sound decisions. Some might argue that underemphasizing modernization during a revolution in military affairs can enable a

Stephen Biddle teaches political science at the University of North Carolina; Wade P. Hinkle and Michael P. Fischerkeller are members of the research staff at the Institute for Defense Analyses.

Kuwaiti desert, February 1991.

DOD (Robert L. Reeve)

potential enemy that aggressively takes advantage of technology to leapfrog over a conservative military and present it with disaster in the field or irrelevance with the advent of new threats. But the other side of that coin is the argument that underemphasizing skill makes it impossible to exploit technology—or worse, mistakes made by information-overloaded, undertrained forces can expose even a radically modernized military to sudden heavy losses on a lethal 21st century battlefield.

Unfortunately, the available decisionmaking tools are not equal to such questions. Current models focus almost exclusively on the quality, number, and types of weapons. Warfare is treated as a physics problem in which superior weapons carry the day. The skills, operational concepts, and organizational structures of the combatants cannot be evaluated because they are not modeled. Moreover, the improved generation of models presently under development will still be driven by technology. They focus on information technologies in the form of C^4ISR as both enablers and multipliers of weapon technologies. But they will share the inabilities of their predecessors to portray the effects of skill. This is significant: analytical tools that ignore skill cannot be much help in identifying the right balance between skill and modernization in the U.S. defense program.

In fact, current models may not even be helpful in identifying the right systems to develop with the funds which are available to modernize. Evidence is mounting that the interaction between technology and user skills and methods profoundly influences combat outcomes. If this interaction is ignored, the Department of Defense risks profound errors in choosing systems. Most combat models assume perfect skills on the part of fighting forces and their commanders: gunners score hits with probabilities computed on test ranges and leaders never misinterpret orders. No matter how simple or complex the tactical situation, new weapons must be employed. No matter how the targets might actually behave under fire, most current models simply assume perfect skills on all sides and compute outcomes accordingly. Can one assume that systems which function well in a perfect world will work in the same fashion in the world of real people, both our own and that of an enemy? If skill and technology do interact, that assumption is wrong—and the results of using methods that ignore this interaction could lead us to choose the wrong weapons for the real world in which the Armed Forces will have to fight.

With the approach of another Quadrennial Defense Review, this is the time to determine how technology and skill affect the outcome of theater wars. This article is an effort to jumpstart that process and proceeds in three steps. First, it presents evidence that the interaction between skill and technology is central to warfare and that ignoring it risks serious miscalculation. Second, it presents a hypothesis to explain the nature of this interaction, which is consistent with emerging evidence and could be incorporated into formal combat models, although further testing is required to establish it as a basis for defense planning. Finally, the article suggests implications for policies and programs that would flow from the hypothesis if it holds up and that planners should start to take into account pending further testing.

this is the time to determine how technology and skill affect the outcome of theater wars

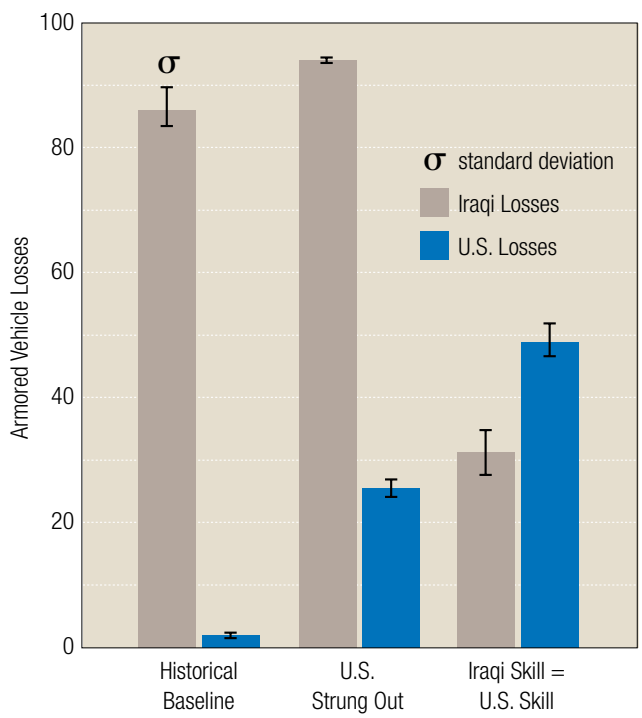
Why should one worry about leaving skill out of the military balance? After all, technology has been the main focus of the debate for a generation, and many analysts presume that technology ensured an unprecedented low rate of casualties in the Persian Gulf War. Indeed, this perception is fueled by the widespread belief that we are embarked on a revolution in military affairs.

Desert Storm

The conventional wisdom holds that the radically low losses sustained in the Persian Gulf War resulted from a new generation of surveillance, air defense suppression, and precision guided air-to-ground weapon technology that destroyed the Iraqi will to fight or their weapons. Yet now it is known that far too many enemy soldiers and weapons survived the air campaign and were in a position to resist the coalition ground attack for technology alone to account for the historically low attacker losses.

Some 4,100 Iraqi armored vehicles evaded destruction from the air, a figure equal to the entire Egyptian tank force in 1973. At least 1,200 of the vehicles were dug in astride the VII Corps axis of advance and could have fought back as ground forces struck beginning on February 26.[1] The forces opposing VII Corps alone deployed more active armored vehicles than the Israelis in the Six Day War, and more than twice as many as the Germans in Normandy. If the surviving Iraqis had simply inflicted as many casualties per capita as the Arab forces in 1967, the Coalition loss rate in 1991 would have been more than ten times higher.[2] In sum, the air campaign did not neutralize enough Iraqi armor to account for our radically low losses by itself.

Recreating the Battle of 73 Easting



What about high technology ground weapons? Did thermal sights, stabilized 120 mm guns firing depleted-uranium ammunition, or new compound armor account for low losses? Here again the facts do not support the conventional wisdom. For example, the Marine Corps fought its way through hundreds of enemy vehicles with M–60A1 tanks originally fielded in the 1960s. Yet the Marines suffered no greater losses than the better-equipped Army. In fact, in some of the heaviest combat (the Iraqi counterattack at the Burqan oil field), the Marines did not have M–60s and fought with wheeled, thin-skinned, light armored vehicles. The Army had deployed thousands of lightly-armored M–2 and M–3 Bradleys, while the British committed hundreds of similarly light Warrior troop carriers, all of which engaged in extensive close combat yet suffered few losses.[3] If superior guns, armor, and thermal sights were responsible for low losses, one would expect units fighting without them to suffer heavier casualties.

This conclusion will not surprise veterans of the National Training Center (NTC) where hundreds of battles have been waged between M–1A1 equipped Army units and a (simulated) T–72 equipped opposing force (OPFOR). If the superior technology of M–1A1s was responsible for the low losses in Desert Storm the same result should emerge at NTC—yet OPFOR almost always wins. OPFOR is admittedly an elite unit with complete mastery of the terrain on which it fights day in and day out. But if technology rather than skill or tactical acumen is the principal determinant of modern combat outcomes, the overmatch of M–1A1s should overwhelm the effects of an imbalance in skill levels.

Combined, these findings strongly suggest that technology alone cannot explain the losses in the Persian Gulf War. Instead, it is necessary to consider how technology and a skill differential interacted. To explore the issue further, the Institute for Defense Analyses has conducted a series of simulation experiments in which a representative engagement from VII Corps action against the Republican Guard—the battle of 73 Easting—was re-fought with systematic variations in the skills and equipment of both forces. The results suggest that without a major skill advantage (see accompanying figure), the outcome could have been radically different in spite of superior technology. When tight, efficient Coalition combat formations of the historical attack were replaced with a strung-out alternative typical of poorly trained units, for example, simulated friendly losses rose by a factor of ten even when equipment on both sides was kept constant. Worse, when the unskilled Iraqis of 1991 were replaced with troops who performed at the skill levels of American personnel, even the combination of superior technology and the 1991-level proficiency of the Armed Forces could not prevent friendly losses from increasing by a factor of more than 20.[4]

Taken together, what is now known about the Gulf War strongly suggests that technology, although important, does not explain the low loss rate of the U.S. military. To analyze that war without systematically accounting for the skills shown by both sides is to risk serious error.

La Haye du Puits

The question of skill is not limited to recent combat experience. Detailed case studies of less-proximate historical battles enabled us to isolate the effects of skill and technology for study by controlling for terrain, force ratio, weather, posture, and opponent.

In the first, the Battle of La Haye du Puits in July 1944, three U.S. divisions—the 90th and 79th Infantry Divisions and 82d Airborne Division—conducted a simultaneous assault on elements of the German LXXXIV Corps in Normandy.

Soldiers moving along hedgerows, Normandy.

Courtesy Military History Institute

The hedgerows, clear weather, opposing forces, and mission of deliberate assault on a prepared defense were common to each division. Enemy weapon holdings were effectively common to all three while the American holdings were similar for the 79th and 90th Divisions, although the former deployed about 10 percent fewer troops and 24 percent less artillery than the 90th Division. The 82d Airborne, by contrast, was significantly smaller and lighter than the other divisions, with about half the troop strength and less firepower (half the artillery of the 90th Division, three-fourths of its mortars and machine guns, and no tanks). Thus orthodox models based on the number and types of weapons would predict that the 90th Division should have performed best and the 82d Airborne worst.

the 82d Airborne maintained the fastest rate of advance and lowest casualties

The skills of the three American divisions, however, suggest quite the opposite. The 82d Airborne was an elite unit that trained intensively in the continental United States (CONUS) with consistently excellent exercise evaluations, followed by six months of unit-level training overseas and three months of combat experience before the battle. The 90th and 79th Divisions, by contrast, were standard infantry units with lower levels of training and experience. Neither had overseas unit training and neither had seen more than a few days of combat. The 90th Division had been idle for six months and the 79th Division for two (in addition, the former division was reorganized three times during CONUS training). Two commanding generals of the 90th Division had been relieved and the unit had consistently received poor exercise evaluations. On the basis of training and skills, one would predict that the 82d Airborne should have performed the best and the 90th the worst.

The outcome contradicts the orthodox technology-based prediction and corroborates one based on training and skills. Controlling for the objectives of the three divisions and the amount of time it took each to reach them, the 82d Airborne maintained the fastest rate of advance and lowest casualties per square kilometer of ground

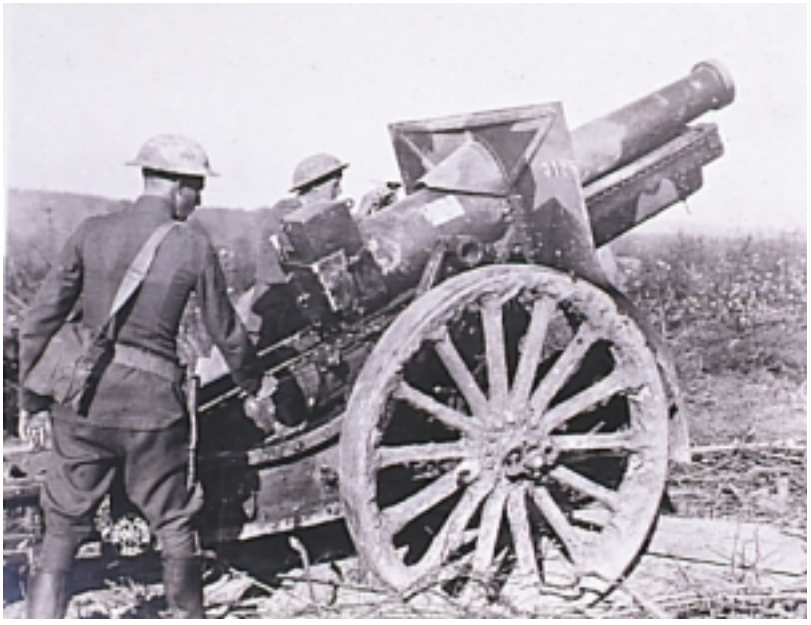
Table 1. Battle of La Haye du Puits

	Ground seized (km^2/hour)	Losses for ground taken (TBC*/km^2/hour)
82d Airborne Division	.28	564
79th Infantry Division	.22	841
90th Infantry Division	.17	1,035

* Total battle casualties per thousand troops engaged.

Source: Martin Blumenson, *United States Army in World War II, The European Theater of Operations: Breakout and Pursuit* (Washington: Office of the Chief of Military History, 1961), pp. 60–77.

taken. The 90th Division had the slowest rate of advance and the highest casualty rate (table 1).[5] To analyze this battle using standard models would thus introduce a significant bias into the results: relative advance rates would be off by 65 percent or more. Casualty rates would be off by at least 84 percent.



U.S. Army Military History Institute

Last gun fired, November 1918.

The Western Front

The La Haye du Puits case considers the effects of variation in skill and friendly technology when other things remain constant. What if friendly skill and technology are held constant and the effects of changes are isolated in enemy technology? To do this German units were compared during World War I in actions on the Western Front: the 73d Fusilier and 91st Infantry Regiments in the Third Battle of Ypres (July 1917), the 84th Infantry and 384th *Landwehr* Regiments in the Battle of Cambrai (November 1917), and elements of the 2d Army in the Second Battle of Amiens (August 1918) on the opening day of the respective battles.

By focusing on the three engagements, skill, terrain, weather, and defender technology are held constant. By mid-1917, each regiment was a veteran regular infantry unit with comparable experience, training, and leadership (though the 384th *Landwehr* had entered the war as a reserve unit, such distinctions had vanished by 1917 in the face of extended combat). Each was an element of a division rated mediocre by Allied intelligence and fought under a common military doctrine. Each was similarly equipped: supporting artillery tubes per yard of front—or total firepower per yard of front—varied by less than 9 percent between Ypres and Cambrai, for example. Each was opposed by veteran units: the British Guards Division in Third Ypres, the British 62d Division at Cambrai, and the Australian 5th Corps in Second Amiens had comparable experience, personnel turbulence, training, and rest. In each engagement, rain and fog precluded serious aerial support, while the battlefields amounted to trench-rutted, shell cratered moonscapes effectively devoid of vegetation or roads suitable for vehicles.

Allied technology, however, varied substantially. In particular, the large-scale use of tanks was introduced at Cambrai. Although the assault by the Guards Division at Ypres was conducted by walking infantry supported only by artillery firing indirectly, the 62d Division at Cambrai was supported by more than 70 Mark IV tanks and substantially more artillery fire. The Australian 5th Corps at Second Amiens nine months later was similarly equipped, with 135 tanks spearheading the initial assault.

Orthodox models based on the number and types of weapons would predict very different outcomes for these engagements: the Guards Division's less materially sophisticated offensive at Ypres should fare far worse while the comparable advantages of 62d Division and 5th Corps should enable them to fare far better and perform more like one another than like the earlier tank-free attack at Ypres.

The historical outcome does indeed show very different results across these three actions, but not in the way orthodox models would predict. German losses at Cambrai were far higher than at Ypres: the 84th Infantry and 384th *Landwehr* suffered almost 85 percent casualties on the first day at Cambrai, compared to 46 percent losses by the 73d Fusiliers and 91st Infantry on the first day at Ypres. Moreover, Allied attackers fell 1500 yards short of first-day objectives at Ypres; in the other two battles they were met or slightly

Table 2. Skill and Technology Demonstrated during World War I

	Third Ypres, July 1917 *(no tanks)*	Cambrai, November 1917 *(first tank use)*	Second Amiens, August 1918 *(anti-tank tactics)*
Capabilities			
Allied firepower*	3,550	3,350	5,100
Allied tanks (per yard of frontage)	0	.02	.02
Allied/German firepower ratio	2.8:1	3.2:1	9:1
Outcome			
German casualties (thousands)	460	848	657
Loss ratio (Allied/German)	1:1.4	1:5	1:3.8
Did Allies reach objective?	1,500 yards short	early afternoon	after midnight

* Potential lethal area in millions of square yards per day.
Sources: Various German and British official accounts and unit histories.

exceeded. This is much as one would expect. But whereas orthodox models would predict roughly comparable outcomes for Cambrai and Amiens, in fact the German loss rate fell from roughly 85 percent at Cambrai to about 66 percent at Amiens. Conversely, Allied losses increased dramatically, from a first-day loss rate of 15 percent of tanks at Cambrai to more than 45 percent of those committed at Amiens (table 2).

Much of the explanation for this outcome lies in German tactical adaptation and a significant retraining of their troops in new antitank methods following the debacle at Cambrai. Beginning in November 1917, the German units received some 39 weeks of specialized training in new antitank countermeasures. Artillery units were instructed to engage tanks in direct fire over open sights, while infantry tank panic that had affected defenders at Cambrai was addressed by training troops in methods for grenade attacks on tank engines or fuel tanks while vehicles climbed the rear walls of trenches and by training machine gunners to direct fire at tank vision apertures rather than trying to penetrate their armor. While the infantry training was mainly intended to restore troop morale, the new artillery methods proved deadly. With essentially the same equipment, tank kills increased by a factor of three in only a few months.

A model that encompassed both skill and technology would explain each of these cases, but the result of orthodox methods would be radically off in anticipating the transition from Cambrai to Second Amiens. If training and tactics in combat models cannot be accounted for, there is a risk of major errors in analysis.

Modeling Interaction

How can the interaction between skill and technology be better integrated in modelling and decisionmaking? We propose a four-step process. First, given what is known about interaction in combat, how is that interaction understood? Second, the resulting hypothesis can be formalized in a specific cause-and-effect relationship: if weapon technology becomes more lethal but skills fall, combat outcomes should be x; if skills increase but technology remains the same outcomes should be y. The relationship is best stated in mathematical terms because that adds precision to the description, makes it easier to prove if our hunch is wrong, and makes it easier to use the results in ongoing DOD modeling efforts if we eventually get it right. Third, this hypothesis can be tested as embodied in an equation against real combat experience to determine whether it has anything to do with the real world. If the test succeeds, that's it: we have a specific statement which explains how technology and skill interact for decisionmaking and which stands up against historical evidence. But if the test fails, we must go to a fourth step: the hypothesis is modified to reflect what has been learned and start again. By constantly moving between mathematical expressions of warfare and historical evidence of how it is actually conducted, two problems can gradually be overcome: one will not end up with a model that is mathematically elegant but cannot represent the real world; and one does not end up with a rich historical description that is neither precise nor prescriptive enough to guide decisionmaking.

Which hypothesis emerges? Technology can be viewed as a wedge: advancing technology gradually divides the military capabilities of skilled and unskilled armies, but it has much less effect on outcomes between equally skilled forces. This is because technological effects differ radically depending on countermeasures adopted by targets, and especially on how an enemy uses counters such as (in the case of ground combat) cover, concealment, dispersion, suppressive fire, combined arms, and independent maneuver by small units. Exposed, bunched-up, unsupported targets in the open have long been very vulnerable to modern weapons whatever the armor protection. Survival on the 20th century battlefield has long required the ability to reduce exposure to hostile firepower. Properly implemented, tactical countermeasures are quite effective. Well dug

hull-to-turret defilade vehicle fighting positions can negate many advantages of advanced sights and long range gunnery by keeping below grade until an enemy draws near. Suppressive fire can reduce hostile firing rates by a factor of 10 (or more) even when no target is directly killed. Attackers capable of using cover and concealment can often advance to within a few hundred meters of a typical defensive position without extended exposure to defensive direct fires even in the open North German Plain.

But while such countermeasures are potentially effective, they are getting harder to apply. To make the most of cover and concealment, for example, requires the thousands of commanders in a mass army to fashion unique plans for movement and disposition based on local conditions.

both dispersion and independent small-unit maneuver increase the number of independent decisionmakers

Troops cannot simply be laid out in standard textbook formations and marched toward objectives or deployed in formulaic cookie-cutter defensive layouts. Proper use of suppressive fire requires tight coordination between widely separated, moving units and multiple commanders. To protect assault units, suppression must be maintained until the last possible minute but then lifted in time to allow the assault to overrun the objective without casualties from friendly fire. Sightings of enemy weapons must be communicated to supporting units and suppressive fire redirected as intelligence develops. Because the pace of an assault varies unpredictably with terrain or unanticipated enemy action, maintaining continuous suppression requires a tangled combination of planning, adaptation, and efficient communications between harried commanders at many echelons. Both dispersion and independent small-unit maneuver increase the number of independent decisionmakers. They also demand greater initiative and tactical judgment from junior leaders, make it harder for leaders to see and communicate with their troops, and challenge morale and combat motivation by putting more distance between forces, reducing the power of group reinforcement to motivate individuals.

As the range and lethality of weaponry increased, so did the depth over which techniques must be exercised. When the range of weapons was limited to 2–5 kilometers and aviation was in its infancy, only front line units had to be covered, concealed, dispersed, and integrated. Units to the immediate rear could be massed in assembly areas and moved safely in the open. The arrival of longer-range weapons and airpower extended the zone of maximum complexity to front line units and their immediate supporting elements. Current systems can place entire theaters at risk.

Although this is a major development, it is one of degree, not kind. Cover, concealment, dispersion, suppressive fire, combined arms, and independent small unit maneuver will remain critical. What will change will be the difficulty of making them work over the required span of space and time. Traditional operational countermeasures work by exploiting the weaknesses of technology that are evolving slowly if at all. In particular, the ability to engage dispersed targets in cover is improving much less rapidly than the ability to destroy massed armor in the open. Yet it is precisely the ability to exploit cover, concealment, and dispersion that has characterized all effective tactical systems in this century. The net result is thus to progressively increase the premium on the ability to exploit the kinds of operations that skilled militaries have employed in warfare—even as technology raises skill levels to use such methods over ever-larger areas and ever-longer periods.

Militaries that can cope with such growing complexity, however, are likely to find that their vulnerability changes little even as the nominal lethality and reach of modern weapons continues to grow. Militaries that cannot cope with such complexity, on the other hand, are likely to see their vulnerability grow dramatically. Thus, the Gulf War did not represent some new phenomenon of technology that created a novel form of warfare, but an extension of a very longstanding trend: the increasing gap in the capability between skilled and unskilled organizations in the face of changing technology. The Iraqi inability to manage the extreme complexity of the modern battlefield led to critical mistakes that enabled technology to operate with proving ground effectiveness and to sweep Republican Guard units from the field with radically low losses to Coalition forces. The ability to cope with such complexity enabled us to exploit this potential without leaving ourselves vulnerable in the process. While there have always been mismatches between skilled attackers and unskilled defenders, what 1991-era technology accomplished enabled the more skilled to punish the mistakes of the unskilled with unprecedented severity. Changing technology thus magnifies the results of skill differentials over time. Absent a favorable skill overmatch, however, technology cannot be relied on to produce such results in the future.

The Institute for Defense Analyses is currently converting the logic of this hypothesis into mathematical language and testing the resulting

Allied encampment, Desert Storm.

DOD (Perry Heimer)

OD (Gary Littleton)

Firing round downrange, Fort Hood.

equations against new data on battles fought under conditions that aggressively challenge the hypothesis. (The cases presented above are drawn from that work.) An early result is sufficiently clear: start thinking about the implications on policy if the hypothesis holds up.

Modernization and Readiness

The skill-technology hypothesis implies that one must be wary of protecting modernization at the expense of readiness. This is not to say that modernization should be halted: weapons, like any other capital stock, wear out and must be replaced. The question is the pace of modernization, and analysis suggests that slowing weapons and C^4ISR modernization to protect training, exercise, schools, and quality-of-life accounts (that is, parts of the budget that help develop and retain skilled personnel) would be the better choice because accelerated modernization increases U.S. capabilities mostly where they are already strong (that is, against unskilled opponents) but offers little where they are not (against those with better skills). Current technology is already so effective against mistake-prone enemies that it is hard to see how faster acquisition of a new generation of weapons would be much more than gilding the lily. Against an enemy like OPFOR at NTC, on the other hand, even a new generation has limits. And, if the weaponry is acquired by allowing skills to atrophy, it is possible to end up worse off on both counts. Poor skills will create vulnerabilities in the form of mistakes that even an enemy with lesser technology can exploit, and it will also be impossible to conduct sophisticated tactics and operational routines needed to get the most out of new systems.

U.S. Army Military History Institute

Maron, France.

By contrast, a highly skilled military will exploit its capital investment to the fullest while hedging against faster than expected modernization by enemies. Without the mistakes to exploit, an enemy with advanced technology will see a smaller payoff in confronting the United States than the Persian Gulf War might lead them to expect. Denying an enemy such mistakes is demanding. In ground combat, for example, high skills are required to exploit cover, concealment, dispersion, suppressive fire, combined arms, and independent maneuver by small units to the fullest—but forces that can do this have bought themselves the best insurance available against an unexpectedly sophisticated opponent.

In the final analysis, technology and skill are poor substitutes for one another. It is hard to buy more of the former at the expense of the latter without ending up worse off.

The Active-Reserve Mix

The foregoing has major implications for the mix of active and Reserve components. Some Reserve forces can operate at very high skill levels. Reserve pilots, for example, can compete with the best aviators in the world. But other elements engage in less sustained skill-building and skill-maintaining activity than their active component equivalents. With ever more lethal technology in hostile hands, the risks of fielding partly trained units are growing rapidly. And the complexity of the tactics needed to survive in the modern battlespace suggests that training times required to reach full proficiency are growing. Taken together, this points to important limits in the ability to save resources by shifting combat missions from the active to the Reserve component.

This does not mean that the Reserve components cannot fill important roles. The skills required for modern combat are demanding, but they are not magical: even large Reserve units can be trained to perform the requisite tasks with proficiency. Military roles that resemble civilian jobs and depend largely on individual rather than group proficiency are especially suitable for Reservists. The Reserve force structure is much cheaper, so it makes sense to leverage it whenever possible. The central issue is how to ensure that Reserve component skills can be matched to their missions within anticipated mission timelines. Without proper skills, large Reserve units can be expected to suffer increasingly disproportionate losses, and the time needed to achieve full proficiency can be expected to grow as weapons become more sophisticated.

This suggests various changes to active/Reserve force management policies. The Reserve components will remain an important hedge against fighting prolonged wars or support extended deployments. But their ability to provide responsive combat power for short-notice, short-duration contingencies is likely to shrink in the next century absent new policies. Such policies might include lengthening annual active duty

training for some units, forming hybrid active-Reserve units composed of active duty staffs and Reserve combat elements (the Army is now experimenting with such an approach with the 24th and 7th Infantry Divisions), and a rotating program of bringing units in the Reserve components to higher states of readiness. Whether these approaches will enable the Nation to field adequately skilled, large Reserve units rapidly is still unclear, partly because there is very little empirically based research on the subject.

Force Restructuring

Many have argued for a major restructuring of the Armed Forces to transform them from direct-fire ground capabilities toward a reliance on deep fires, precision strike, and the exploitation of dominant battlefield awareness to avoid the necessity for close combat. The hypothesis outlined in this article, on the other hand, suggests that such restructuring could be very risky. Sometimes it may be highly effective: against an unskilled, mistake-prone enemy, such a mostly air- and deepstrike-oriented force would be the ideal solution. Against a skilled enemy better capable of limiting its exposure by tactical and technical countermeasures, however, such an imbalanced force would be gravely disadvantaged. By giving up direct-fire ground capability in exchange for more deep-strike systems, it would be much weaker than our current forces against an enemy able to escape destruction at extreme range and close with our forces. Such a restructuring would thus strengthen the U.S. military mostly where it is already so strong as to be nearly beyond challenge (that is, against error-prone enemies) by creating weaknesses elsewhere. Unless it is certain that the Nation will never again face a skilled enemy, this approach could be dangerous.

many have argued for a major restructuring of the Armed Forces to avoid close combat

Most force planning and joint campaign assessment methodologies focus on the numbers and technical characteristics of opposing weaponry. Many believe that such methods are ill suited to a revolution in military affairs based on information technologies and a more highly integrated joint systems of systems. Thus DOD embarked on a significant program to update models and correct these shortcomings. But even if these proposed changes do address C^4ISR and joint precision strike in detail, the models will still risk serious error if they ignore the relationship between technology and skill. In fact, if the new models are focused on depicting new technology while overlooking the ways skilled and unskilled enemies differ in their vulnerability to such systems, they could leave the Armed Forces worse off analytically. To capture the dynamics of actual warfare, new methods must account for the crucial interaction between new technology and variations in the ways different enemies will actually use their capabilities.

While the task is not impossible, it will require a sustained, systematic analytic effort. The stakes are high. Although a proper understanding of cause and effect in warfare has always been important, the rapid pace of change in technology and geopolitics makes it even more so today. From budgeting, to total force policy, to force design, to weapon acquisition, the long-term effects from a tremendous range of decisions rely upon a full understanding of how current tradeoffs will affect likely outcomes of future wars. The next Quadrennial Defense Review will begin soon. It is time to create the improved understanding necessary to cope with difficult choices. Making sound choices requires the best analytical methods, and an essential attribute of any new generation of models must be an appreciation of the way skill and technology interact to produce combat outcomes in the real world. **JFQ**

NOTES

[1] Stephen Biddle, "Victory Misunderstood: What the Gulf War Tells Us about the Future of Conflict," *International Security*, vol. 21, no. 2 (Fall 1996), pp. 139–79; Eliot A. Cohen and Thomas A. Keaney, *Gulf War Air Power Survey*, Volume II, Part 2: *Effects and Effectiveness* (Washington: Government Printing Office, 1993), pp. 170, 214, 218–19.

[2] Martin Blumenson, *Breakout and Pursuit* (Washington: Office of the Chief of Military History, 1961), pp. 30, 700; Anthony H. Cordesman and Abraham R. Wagner, *The Lessons of Modern War,* volume 1 (Boulder, Colo.: Westview Press, 1990), pp. 15, 18.

[3] Michael R. Gordon and Bernard E. Trainor, *The Generals' War: The Inside Story of the Conflict in the Gulf* (Boston: Little, Brown, 1995), pp. 363–68.

[4] The experiment is detailed in Biddle, "Victory Misunderstood," pp. 165–73.

[5] Blumenson, *Breakout and Pursuit,* pp. 60–77.