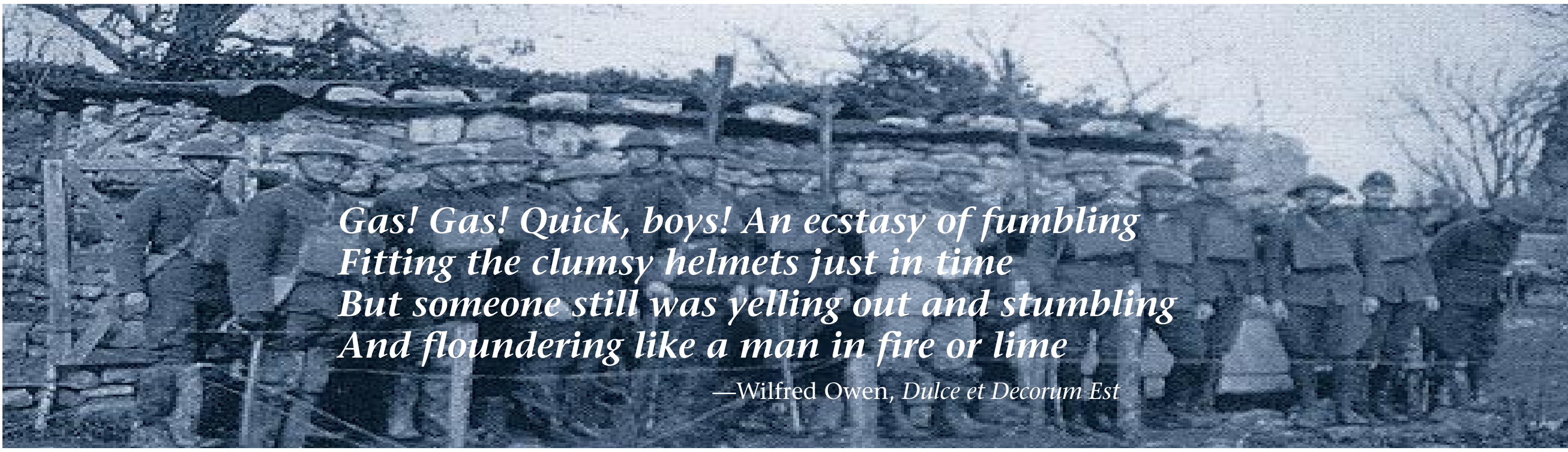

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An Ecstasy of Fumbling: Doctrine and Innovation

By KENNETH F. McKENZIE, JR.

The information explosion is beginning to influence that most conservative of institutions, the Armed Forces. Professional journals from *Parameters* to *Proceedings* are awash with articles on RMA and military technical revolution (MTR).[1] Depending on their technological or ideological bent, these articles either hail new developments as a shining path to the future or gloomily decry the shortcomings, both real and perceived, of emerging concepts and hardware. Thus it is difficult to tell if we are entering an era in which perfect knowledge—that is, information dominance—will be coupled to perfect strike capabilities or if we are about to field complex systems that will deluge users under mountains of trivial data attached to easily thwarted strike technologies. What we can be sure of is that we are on the verge of an explosion in ideas as well as systems that promises to change the way war is fought. In fact, RMA is nothing more than the military application of ideas from a global revolution in technology brought about by advanced computerization techniques.

Two Cultures

Technological innovation is unruly, spasmodic, and to a certain extent uncontrollable—the opposite of developing force structure and doctrine which tends to be highly predictable, cautious, and self-regulating. To effectively link doctrine and technology one must combine the dynamism of scientific inquiry and the caution of military culture (see figure 1). This is not a condemnation of the military mind. Soldiers are innately cautious because the stakes in their profession are high. The outcome of war is critical to national survival. Success or failure is measured in human lives.

Operational doctrine and organizations must be flexible enough to embrace new capabilities that arise from research and applications far removed from military requirements. Taking practical battlefield advantage of new ideas is the responsibility of doctrine. To do this, the military culture must be prepared to leap forward with technology and establish meaningful paradigms for practical soldiers from technological starting points that may appear unreachable at first. At the same time, the culture must be discerning enough to reject irrelevant or unnecessary capabilities. This is a tall order for cautious minds forced to deal with explosive opportunities, but the alternative is disaster. An inability to accommodate ideas or, more likely, a tendency to misapply concepts will be paid for in opportunities lost in combat.

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Figure 1. The Scientific and Military Worlds

Scientific Culture	Military Culture
Driven by discovery; non-hierarchical	Driven by knowledge; hierarchical
Embraces the unknown	Avoids the unknown
Externally directed	Internally directed
Long term orientation	Short term orientation
Outcomes are secondary	Outcomes are paramount

The interaction between emerging technologies (together with the weapons and capabilities that ensue) and doctrine—the way land, sea, and air forces fight—will be the fundamental dynamic in determining whether new ideas are digested and used properly. In short the question is whether we can translate technological concepts into battlefield advantage.[2] That is a crucial step, because technological advances, regardless of their inherent brilliance, must be harnessed to a coherent model to be employed for decisive advantage. New technologies must be integrated with tactical organization, techniques, and procedures. This is easy to understand but difficult to accomplish. It requires managed, directed interaction of scientific and industrial methods with a military culture that must deal with the realities of the battlefield. These two worlds may be far apart, but they can eventually be merged. Avoiding an "ecstasy of fumbling" over integration can provide the margin of victory over an opponent who is struggling with the same problems.

translating potential into functional purpose dictates the pace of organizational and doctrinal integration

Chicken or Egg?

Requirements may be driven from the bottom up based on combat imperatives, or from the top down based on a concept for employment. Ideally, requirements are identified, then directed technological advances provide capabilities to answer the need. This almost never happens—and in an era of exploding ideas, requirements are vastly outpaced by burgeoning technical capabilities. This means that many ideas emerge from a growing external base, offering exponential advances increasingly dislocated from a conservative internal approach to requirements. In some cases this means that the requirements system is being wrung inside out. We are examining the relevance and utility of advanced systems and technologies that we have not requested and that have not been validated by any concept-based demand, which is uncomfortable and inevitable. Increasingly, the origin of a capability will become less important. The only criterion will be its advantage in battle.

New ideas and technologies introduce potentialities, some self-generated, others externally created. Cumulatively, they shape the expectations for the new idea. What is this thing supposed to do? How can we measure its success? Some expectations, such as the Manhattan Project, are obvious, others less so. Translating potential into functional purpose, articulating an end state, can destroy a project before it reaches fruition, regardless of technical feasibility. Expectations can be set too high or low. Either extreme is counterproductive. The ability to determine a reasonable and attainable end state for new technology dictates the pace of organizational and doctrinal integration. This can be difficult, because relationships of this nature are neither linear nor static. Instead, the interactions are dynamic—expectations change as technologies mature. At the same time, existing doctrine and organizational patterns are not frozen. They, too, are responding to external stimuli.

The development of the XB–70 as a high-altitude supersonic penetrating bomber in the late 1950s is a case in point. Despite technical feasibility that was demonstrated, the improvement in Soviet air defenses forced a shift in Air Force strategic bombing doctrine, away from high altitude to a low-level approach. Doctrine changed as the technology arrived. Many other examples come to mind. Royal Navy battlecruisers during World War I were designed and built for a high-speed scouting role, yet they were eventually forced to lie in the line of battle, largely because they looked like battleships—which had disastrous results at Jutland. The process of melding technologies and doctrine is difficult because both are "moving targets."

When new technology only modifies an existing paradigm for the conduct of war, it can be readily subsumed and digested. It may also be misapplied. The disastrous fielding by the French of the *Mitrailleuse* in 1870 is an example (this early machine gun was employed as an indirect fire weapon and kept so secret that its users were unfamiliar with its capabilities). Conversely, some technologies establish entirely new paradigms—the tank, airplane, and radar, for example (though it should be remembered that the tank was initially misused as a pillbox, the airplane as a horse that flew, and radar as a pair of binoculars). The creation of revolutionary new paradigms like these is relatively rare. Most new technologies only modify existing methods, although even incremental modifications eventually may greatly change an operational paradigm.

Germany and Chemical Warfare

The German attempt to integrate the technology of gases in World War I is a telling case of the difficulties in harnessing technology to military purposes. No clear requirement generated the capabilities inherent in gas; instead chemical assets emerged almost without regard to requirements. Gas warfare began as a technological initiative of the German chemical industry. It is the story of the translation of an experimental concept into integrated doctrinal and organizational acceptance. The final adoption was ultimately expressed in approved tactics, techniques, and procedures, all part of a coherent doctrine for employment. The cost of achieving this integration was time—time lost that could never be recovered.

German experience with offensive chemical warfare is particularly relevant today because it clearly illustrates the difficulty of integrating developing technology and existing doctrine. In many ways, it parallels the broad yet second-order technology of information management as related to the battlefield. Unlike the tank or airplane, gas was not developed as an independent weapon. It did not alter the paradigm of ground combat in World War I. Instead its effects were distributively felt and essentially supportive. By 1918 these effects were evident across all aspects of German tactical doctrine, but as an enabling force rather than a centerpiece. This makes the study of these German attempts to integrate gas useful in examining new technologies today that must be linked to doctrine and organizational architecture not only directly, but more often indirectly.

French 340mm (13.9 inch) gun.

Strategic Framework

Like most wartime marriages of technology and tactics, German gas warfare was driven by military necessity. By late 1914 it was clear that the great maneuver battles on the Western Front at the beginning of World War I had not been decisive. Out of broken plans came the establishment of static positions which yielded slowly but inevitably to trench warfare. This reflected a strategic stalemate that characterized the conflict until 1918. Strategic mobility, made possible by railroads and theater logistics, enabled both sides to shift reserves to prevent local successes from becoming breakthroughs. At the same time, on the tactical level, fire dominated the battlefield. The limited offensive tactical mobility of foot-mobile infantry, horse-drawn artillery, and primitive battlefield logistics systems could not overcome the defensive supremacy of fire. It was virtually impossible to generate opportunities for operational maneuver beyond the depth of enemy trenches before the latter could redeploy sufficient forces to reestablish his defenses.

The Germans endeavored to break this static front on both the strategic and tactical levels. The strategic recourse included the ill-fated 1916 Verdun offensive, an attempt to bleed the French army to death that inexorably bled both armies white. After this, the correlation of forces drove the Germans to the strategic defensive. Thus, they developed a doctrine of elastic defense in depth, designed to minimize Allied artillery superiority. In 1917 victory over the Russians allowed them once again to shift their forces westward where they could attempt to achieve a decision before the weight of American arms could be brought to bear.

Ypres

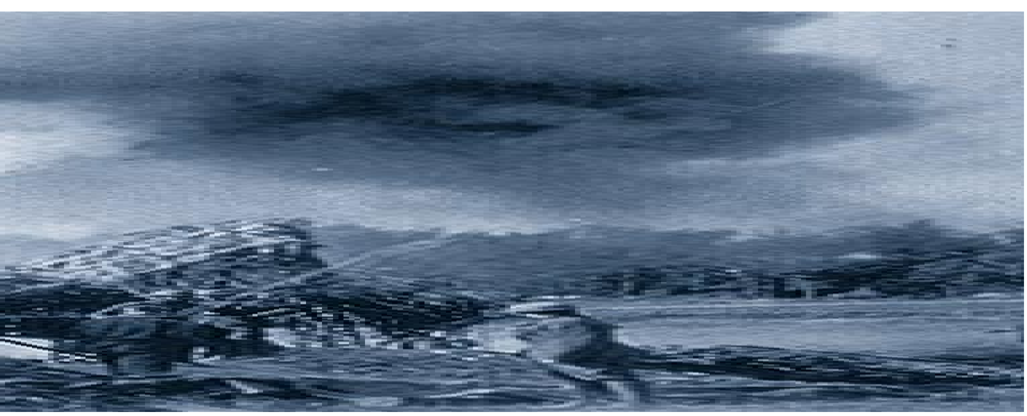
In the winter of 1914 the Germans experimented with gas in two small-scale attacks, but it did not affect enemy troops. In October 1914, at Neuve Chapelle in France, tear gas (dianiside chlorosulphate) was delivered by primitive artillery projectiles.[3] In January 1915, at Bomilov in Russia, artillery-delivered xylil bromide was used, but an attack designed to take advantage of the presumed effect of gas was a costly failure. Extreme cold weather dissipated the effects of the gas. Problems were encountered in matching gas projectiles with high explosive shells.[4] Despite these setbacks German scientists and soldiers remained interested in gas. Certainly the Allied newspaper articles claiming new and ominous French gases were a spur to German chemical enthusiasts.

Fritz Haber of the Kaiser Wilhelm Institute for Physical Chemistry in Berlin observed these failures and offered an alternative gas and delivery means. He proposed using chlorine, a lethally toxic gas to be delivered by cloud. Large quantities of commercial chlorine were readily available. Gas cylinders would be transported to the trenches and opened. Favorable winds would move the cloud over no man's land to Allied trenches. With enough cylinders, a lethal concentration could be achieved. Because the gas dispersed rapidly, an exploiting infantry attack would not be slowed. Expectations were relatively low. Scientists saw gas as simply a casualty producer. Concurrently, it might reduce the demand for high explosive projectiles. For German war planners, a shortage of helium

(HE) was a real possibility. No operational requirement had been set forth for gas.

General Erich von Falkenhayn, chief of staff and de facto supreme commander, took Haber up on his offer. He decided to employ gas on the Western Front as part of a limited attack at Ypres that did not heighten expectations for using gas. Ypres would test gas as an offensive weapon and cover redeployment to the eastern theater, where the main effort for 1915 was planned. The failure of earlier chemical experiments was duly noted. There was no attempt to consider exactly how gas might change the tactical balance of power.

Duke Albrecht's Fourth Army had emplaced over 5,700 large and small chlorine cylinders. Two infantry corps were prepared to follow the cloud this would generate, overrunning the Allied positions. But a complication arose. The prevailing winds were from west to east, which was bad both in the long and short term for German gas cloud operations. The Fourth Army waited over a month before the weather was adequate. To planners, the Western Front had become a supporting action. Falkenhayn's attention had swung east to Galicia. Thus, on April 10, 1915, Falkenhayn made it clear to General Ilse, chief of staff of Fourth Army, that it was "more important to launch the gas cloud as soon as possible than it was to obtain a deep penetration." As if to emphasize his point, Falkenhayn refused the Fourth Army request for an additional division to exploit possible success and also turned down requisitions for supplementary artillery ammunition.[5]



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Once started, late in the afternoon of April 22, 1915, things went better than even the most sanguine gas enthusiast could have hoped. The brunt of the attack was borne by Algerian troops who broke and ran. A gap of some four miles appeared in Allied lines. Thirty minutes after the gas discharge, German troops advanced four and a half miles until encountering a rag-tag cordon of Canadians. The assaulting infantry, tired and perhaps having lost their edge in the month-long wait for proper winds, could not break the line. There were no German reserves to throw in, so the momentary gap disappeared.

gas seemed to slow the advance of the attackers almost as much as the fire of the defenders

Subsequent gas attacks over the next 48 hours were unfruitful, although they caused over 5,900 Allied casualties, a ratio of over two Allied soldiers to each German.[6] In the context of most engagements, this was a heartening statistic for the Germans. Interestingly, the gas seemed to slow the advance and depress the ardor of the attackers, who feared its unknown effects almost as much as the fire of the defenders.[7] There were positive technical and tactical aspects of Ypres. The ratio of casualties was favorable, and a gap opened in the French lines. Unfortunately, there was no plan for taking advantage of the penetration, and while one can criticize the Germans for wasting an opportunity in an insignificant localized operation, this is hindsight. All the Germans expected of gas was that it would produce casualties. Gas had been effective against unprepared forces, but such surprise could be achieved only once. The success of Ypres was not exploited, so thus it was irrelevant and meaningless. The shock effect of the new technology was not matched by tactics for a fleeting opportunity. Even if the Fourth Army had been better prepared to continue the attack, given the limitations of artillery mobility and logistics, it is difficult to believe that it could have been translated into an operational success.

Chemical warfare was primitive and unable to produce the ideal gas for maneuver support, one of high toxicity but not persistent. Such developments (nerve agents) rested in the future. The gas used by the Germans, particularly when limited to cloud attacks, could produce casualties but were too blunt to shape the battlefield decisively. Their net effect was simply to add more friction to a situation that was already frightful enough. Gas was a two-edged sword that worked against attackers as well as defenders, and it was not lethal enough to be used as an independent bludgeon. Without maneuver, it could not produce enough attrition to alter the balance of power. The basic problem, which would haunt the Germans for three years, was the relation of gas to maneuver.

Failure to Integrate

Over the next two years, the Germans used various gases and delivery systems against the Russians and Italians and on the Western Front. Results were generally favorable but not decisive. One problem with gas attacks was the lack of reliable means for assessing results which plagued the Germans throughout the war. Professor Haber was placed in charge of the German chemical warfare effort. Eventually, he served as the link among science, industry, and the high command. It was not

Meuse-Argonne, 1918.

an altogether successful linkage. The military distrusted scientists to some degree, but a reasonable amount of cooperation was achieved by Haber. The Germans consciously decided to make their effort self-contained "on account of the special nature of the work, the need for secrecy, and the desirability of avoiding any delay with a weapon that was developing so rapidly."[8] The industrial production of gases and delivery systems was generally adequate. Over time, the problem became less one of scientific research and industrial manufacture than tactical application. The gases could be produced; but what were they supposed to do?

The introduction of phosgene, a more potent agent, was accompanied by improved artillery and projectiles as the principle delivery technique for German chemical weapons. Artillery added depth to gas, making it less reliant upon weather. Diphosgene (green cross) gave German gunners a potent, in-depth offensive chemical capability. By mid-1915 German offensive chemical thought began to embrace a concept which has become basic to chemical warfare: the division of offensive chemical weapons into persistent and nonpersistent agents. The recognition of this duality started the interpretation of chemical warfare technology and conventional artillery tactics. With this came a heightened set of expectations for chemical weapons. They could perhaps do more than create deadly friction and fear in friend and foe alike. This blunt, deadly weapon could be sharpened.

With this technical interpenetration, artillerymen began to apportion chemical targets in two categories. Targets attacked by infantry received nonpersistent agents, and those attacked by fire only, suppressed, or denied, received persistent agents. This split was, and remains today, a pillar of offensive chemical warfare doctrine.[9] For the Germans it began—but only began—to provide the structure for a coherent application of chemical weapons. Despite these technical advances, it was clear that offensive chemical warfare alone would not break the tactical stalemate in the West. The opportunity proffered at Ypres, combining German surprise and Allied unpreparedness, defied replication. In fact, if the machine gun was the essence of infantry, then gas remained the essence of attrition. It simply added to the coefficient of friction on a battlefield already overwhelmed with obstacles to maneuver and casualty-producing systems. Because it proved difficult to link gas to maneuver, by late 1915 chemical operations had become dislocated from offensive maneuver.

The goal of German chemical attacks had nothing to do with attempts at a breakthrough. Instead they sought simple attrition. The nadir of this offensive chemical employment was typified at Verdun in 1916 where massive amounts of diphosgene were fired on French artillery positions in barrage operations which were not linked to ground maneuver to take advantage of success.[10] Despite the development of a technical architecture for targeting, a broad doctrine and a vision for operational integration were lacking. From 1915 to autumn 1917, the German chemical warfare effort, regardless of how relatively advanced it was, would be without a framework for employment. This diffusion of purpose prevented gas from being used in an integrated combined arms effort.

Figure 2. German Chemical Warfare Development, 1914–18

Time	Illustrative Battles	Expectations	Effects	Doctrine
1914–15	Bomilov, Nueve Chapel, Ypres	none	mixed	none
1915–17	Verdun	low	indecisive, attritive	technical only, not linked to maneuver
1917	Riga, Caporetto	moderate	successful, attritive	informal technical and operational; linked to maneuver
1918	Michael	high	very successful	formal technical and operational; linked to maneuver


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Changing Expectations

A doctrinal development reflecting organizational and tactical changes brought gas to the fore as a tool to break the tactical deadlock: the introduction of infiltration tactics. These tactics put a premium on short, high-intensity hurricane artillery barrages that gas projectiles could enhance. In October 1917, artillery-delivered chlorine and phosgene were fired against Italian positions on the Isonzo River at Caporetto, coupled with an attack led by infantry trained in infiltration tactics. The Italians were unprepared for both the gas and *Stosstrupen* and were routed.[11] It was one of the most complete successes for gas in the war and served as a model for subsequent attacks in the West. This action, coupled with similar success at Riga in September 1917, were harbingers of an increasing role for gas in German offensive thinking.[12] Another was the German counterattack at Cambrai. In November 1917 a short artillery preparation preceded the infantry infiltration-style attack. A large percentage of the shells were chemical, which disoriented the British defenders as much as caused injury. The use of gas in such cases was aimed at suppression, not destruction, and greatly reduced the time required for the German artillery to achieve effect on target.

The Germans developed a vision for effective, coherent offensive chemical doctrine in early 1918, when informal procedures of the previous two years were superseded by a comprehensive work released by the high command on January 1, 1918 entitled *The Attack in Position Warfare*. This document set out the German approach to breaking the tactical stalemate of trench warfare. It reflected the lessons of Riga, Caporetto, and Cambrai. Gas was a key element, both because of its "disruptive characteristics" and because it gave artillery greater effectiveness over shorter times.[13] For rapid suppression, gas was far more economical. Excellent suppression, particularly against enemy artillery, could be obtained with far fewer gas than conventional HE shells.

the technological advantage afforded by industry was not matched in doctrine or organizational concepts

In infiltration tactics, speed of attack was critical, and artillery-delivered gas heightened the shock and force of indirect fire without requiring the long preparatory fires typical of both British and French tactics at this period. Toward that end, by the close of the war the basic load of German artillery units was 50 percent gas shells.[14] In certain operations the ratio of gas to conventional rounds fired was three to one. Driven by a slowly awakening doctrine, technological advances were being integrated into organizational practice and tactics. The expectations were shifting, with chemical warfare techniques being integrated into a larger tactical calculus.

An important development was technological, the widespread adoption of mustard gas, or yellow cross. Mustard was lethally toxic and persistent; it could kill up to 72 hours after exposure and acted against skin as well as lungs. In the German Michael offensive of 1918, mustard agent was fired as a barrier to deny the flanks of attacking formations and against targets that were not to be assaulted by infantry. Nonpersistent agents such as chlorine and diphosgene were fired against targets to be carried by the German infantry. It was a sophisticated approach: lachrymatory gases, or throat irritants, were mixed with other gases to force defending infantry to remove their masks, thus rendering them vulnerable to lethal agents. As the 1918 offensives ground themselves out and reached an end, the Germans discovered the utility of mustard agent as a defensive weapon. It proved a highly effective barrier weapon and ultimately was more successful in the defense than in the attack. Had the war remained mobile, mustard agent—available to both sides by 1918—might have served to slow the tempo of the fight yet again by denying vast areas to maneuver forces.[15]

The Lessons

The hinge of history turned at Ypres, but the Germans were unprepared. The technological advantage afforded by industry was not matched in doctrine or organizational concepts. Ironically, initial German conservatism toward gas was sparked by earlier small-scale failures.[16] It would not be until late 1917 that offensive chemical warfare again played a significant combat role. For the Germans, systematic success with offensive chemical warfare finally occurred when it was used in a totally integrated operational concept, when the strengths of gas warfare—suddenness, shock, and variable persistencies—were linked to a broad, thorough tactical scheme: infiltration tactics. This interpenetration of technology and doctrine yielded a coherent framework for employment. Gas was the junior partner in 1918, one of the key supporting tools for infiltration tactics; a means, not an end. In this case, the shifting paradigm of infantry and artillery combat for the Germans absorbed the capabilities provided by gas and gave them useful expression. Before the linkage of gas to infiltration tactics, chemical warfare was a clumsy, balky killer; after the linkage it became a lethal accomplice.

As shown in the accompanying figure, German offensive chemical warfare ultimately helped to break the tactical deadlock on the Western Front, but the long gap between first use in 1915 and coherent employment in 1918 blunted its contributions. Despite the best of intentions, the Germans were unable to rise above the lure of simple, direct attrition and to effectively link chemical warfare to maneuver until 1918. By then it was too late.

The German experience offers important lessons. The inability to fully exploit offensive chemical capabilities was linked to the dynamic nature of war. New weapons may have enormous shock value but also operate under a principle of rapidly diminishing returns. We must plan for their initial use with maximum effect. If capabilities are either misunderstood or unappreciated, they will be misused—or, as with gas, underused. The chance for decisive action can disappear because the opposition will compensate, often at a fraction of the original cost.

Weapons and technologies which are becoming available today, particularly those related to information management, represent only part of a larger global revolution in technology. On the operational level, we must exploit fleeting advantages that even immature, incomplete technologies offer. This involves recognizing that new ideas may well bring new vulnerabilities. Time is a key consideration in using new technology, for action deferred may be success denied. At the same time, the casual, unconsidered use of immature technology, while locally successful, may prevent a subsequent coordinated application of its ultimate strategic significance. But there is no formula for success. Each opportunity must be weighed against the potential cost. Our goal must be to reduce the period of fumbling, the time in which we try to mesh capabilities with a coherent plan for employment. Success will largely be a function of how quickly we mesh them operationally.

As we enter the next century, the Armed Forces must accommodate significant changes in alliance structures and political direction, and soldiers, sailors, marines, and airmen must consider how best to cope with new weapons and technologies. Not every decision about these weapons and technologies—and, importantly, how we think about them—will have an immediate tactical effect, but as the Germans learned in World War I, an "ecstasy of fumbling" about how to integrate a new idea can cost dearly in both the short and long runs. Thus we should think critically about how ideas have been integrated into military organizations in the past and should not hesitate to apply the lessons to current situations. JFQ

NOTES

[1] Andrew F. Krepinevich, in "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest*, no. 37 (Fall 1994), p. 30, defines MTR as "what occurs when the application of new technologies into a significant number of military systems combines with innovative operational concepts and organizational adaptation in a way that fundamentally alters the character and conduct of conflict."

[2] Michael T. Mazarr et al., *The Military Technical Revolution: A Structural Framework* (Washington: Center for Strategic and International Studies, 1993), p. 18.

[3] Charles E. Heller, *Chemical Warfare in World War I: The American Experience, 1917–1918* (Fort Leavenworth, Kans.: Combat Studies Institute, 1984), p. 6.

[4] Guy Hartcup, *The War of Invention: Scientific Development, 1914–1918* (London: Brassey's, 1988), pp. 95–96.

[5] J.L. McWilliams and R.J. Steel, *Gas! The Battle for Ypres, 1915* (St. Catherines, Ont.: Vanwell Publishing Co., 1985), p. 26. See also Basil Liddell Hart, *A History of the World War, 1914–1918* (Boston: Little, Brown and Co., 1935), p. 248.

[6] Heller, *Chemical Warfare*, p. 31.

[7] Liddell Hart, *History*, p. 248.

[8] Hartcup, *War of Invention*, p. 105.

[9] Edward M. Spiers, *Chemical Warfare* (Urbana: University of Illinois Press, 1986), p. 23; Edward M. Spiers, *Chemical Weaponry* (New York: St. Martin's Press, 1989), pp. 26–27.

[10] Ibid.; Bruce I. Gudmundsson, *Stormtroop Tactics: Innovation in the German Army* (New York: Praeger, 1989), pp. 67–68.

[11] Patrick T. Stackpole, "German Tactics in the Michael Offensive, March 1918" (MA thesis, School of Advanced Military Studies, Fort Leavenworth, Kans., 1993), pp. 35–41.

[12] Ibid., pp. 28–34.

[13] T.T. Lupfer, *The Dynamics of Doctrine: The Changes in German Tactical Doctrine during the First World War* (Fort Leavenworth, Kans.: U.S. Army Command and General Staff College, 1981), p. 41.

[14] Stackpole, *German Tactics*, pp. 49–53.

[15] Stockholm International Peace Research Institute, *The Problem of Chemical and Biological Warfare: Vol. 1, The Rise of CB Weapons* (Stockholm: SIPRI, 1971), p. 140; Heller, *Chemical Warfare*, pp. 24, 27.

[16] McWilliams and Steel, *Gas*, p. 214.