The Fog and Friction of Technology

by Dr. Jacob W. Kipp and Mr. Lester W. Grau, Foreign Military Studies Office

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Blessed be those happy ages, that were stranger to the dreadful fury of those devilish instruments of artillery, whose inventor, I am satisfied, is now in hell, receiving the reward of his cursed invention.

-*Don Quixote*, Cervantes

Merely because technology plays a very important part in war, it does not follow that it alone can dictate the conduct of a war or lead to victory.

-Martin van Creveld

The application of modern technology by by armed forces is supposed to reduce manpower requirements, provide transparency to the battlefield, and lessen risk and casualties to the force wielding the higher technology. In some past instances, technology actually has done just that- but usually at a price and to a comparatively limited advantage. Often its exact impact on military art has been badly misjudged. Magazine rifles, machine-guns, quick-firing artillery, smokeless powder and railway mobilization were supposed to give the offense a decisive advantage and lead to short, decisive wars. In fact, they promoted stalemate and attrition and deadlocked industrial war in Europe- World War I.[1]

Today, faced with a period of rapid technological growth, armed forces are trying to stay abreast of technology by incorporating that which is perti-nent and then applying it to the current revolution in military affairs.[2] The siren song of technology is that it will eliminate the fog and friction of war. The reality is that the military's application of technology has usually created its own fog and friction. Advances in technology expand the battlefield, transform the relationship between time and space and create new demands on command and control.[3] With the pace of scientific and technological inno-vation constantly accelerating, military institutions face a perpetual challenge of change, and the very nature of that challenge becomes more problematic as weapon systems become more complex.

Armed forces are conservative institutions, often slow to change. Sometimes the military's slow-paced change is justified since many technological advances are developed and realized over generations, not overnight. At other times, the military's reluctance to change is similar to that same reluctance found in any organization or traditional profession. Technology is tempting, but it is outside the formative experience of the senior members of the profession.[4] Often budgets are tight, and generals and politicians are sometimes reluctant to invest in new, unproven technology at the expense of the tried and true. Sometimes new technology is inconvenient because it gets in the way of how things are done. Often technology is developed for one use or theater but has greater impact in another.

Maximum combat effectiveness is not the only driving force behind new technology. Transportation technology is often the determining factor. The US Army's first major combat in World War II was in North Africa-a theater in which it had not planned to fight. In 1940, the US Army found itself mobilizing to confront the German armored and airborne forces that the *Wehrmacht* had used so effectively in the Battle of France. The ideal US Army force structure developed after World War I was the square division. The Army leadership had trained and maneuvered with the square division, but it was too big and cumbersome to ship overseas on existing naval transport. Therefore, General Lesley J. McNair reconstituted the division as a lighter triangular division so that it could be more readily deployed on naval transport. The US Army stormed ashore in North Africa using this new force structure.[5]

Technology transportation issues continued throughout World War II. The US M4 Sherman tank was no technological match for German armor, but this was not because the United States could not design and build a better tank. It was because the Sherman tank fit easily into Liberty ships, and a major change in design would have meant severely reduced production while factories retooled for the new model. McNair, as chief of ground forces, championed the concepts of streamlining and pooling to create a deployable force but also force-fed a new piece of technology-an undergunned tank destroyer built on the Sherman chassis-and a questionable doctrine for employing tank destroyer battalions.[6] The driving factor was that the Sherman chassis could be readily transported by sea.

Servant or Master?

Technology is supposed to serve the user's needs. Even so, technology usually requires a number of dedicated personnel to maintain it, repair it and often decipher it. These personnel are often highly paid technicians who are hired in lieu of combatants. Often, the newer the technology, the greater the number of dedicated personnel and the longer the repair, calibration and maintenance time required. Field positions are frequently selected to accommodate technology rather than for advantages of the terrain. Newer technology is almost inevitably more expensive than the technology it replaces, so technology upgrades usually mean that other necessary equipment is not purchased or sufficient technicians are not hired. Very often the new technology brings with it unique logistics requirements, which create new demands on combat support.

Technology is supposed to ease the commander's burden by providing information to aid his deci-sionmaking; this certainly is the promise of the new generation of automated control devices and electronic sensors. The result, however, is often too much data. No one person can cope with a constant data feed. Today, a platoon leader whose platoon is in contact must control his platoon's fires, maneuver it, preserve its fighting strength and accomplish his mission. These are historic platoon leader tasks. Thanks to older technology, the platoon leader can radio for artillery fire, close air support, medical evacuation and reinforcements. Thanks to newer technology, his commanders from company to theater level and above can offer sage wisdom and counsel directly to the platoon leader while his platoon is fighting for its life. Some can fly high above their positions to offer encouragement and give orders based on their lofty view.

Just in case the platoon leader feels he does not have enough input and direction, he will soon have a portable computer to tell him what his situation really is. The platoon leader serves the technology by constantly monitoring and responding to his radio and inputting data into his computer, causing a clear struggle between controlling his platoon and serving technology's demands. Both require his attention, but neither receives it fully. The demands technology places on the platoon leader are relatively light, but technological demands increase with each higher level of command. Technology has changed over the centuries, but man has not. He is still the same basic naked ape who quickly tires, exhibits stress and makes irrational judgments when forced to respond to more than five simultaneous stimuli. Commanders try to cope with technological demands by positioning more screen-watchers on their staffs and in support units, but the impact on the commander is still significant.

B-29 Superfortress bombers on their way to Japan.

The unasked question often is, "Does the value technology adds exceed the time penalties it imposes on the commander?" One answer is to remove the commander from the loop when conducting preci-sion fire by permitting artificial intelligence to make the combat decisions while the commander serves as an override. This solution overlooks the probability that a thinking opponent is trying to deceive the commander. The commander has traditionally relied on experience and intuition to shape his course of action. Artificial intelligence and decision templates have no such intuition, nor do they possess much capacity for initiative to exploit a developing opportunity. To aggregate combat power, the modern commander must think in terms of systems, but he remains the vital key to combat success. Technology promises much-the paperless office, the perfect intelligence picture, the rapid destruction of enemy forces, the collapse of civilian morale-but it rarely delivers.

A Norden bombsight in the nose of a B-29.

Technology is seldom a complete answer. New systems must interface with other systems, but they are not developed primarily for that interface. Weapon systems are developed as complete packages that can perform their intended missions independently. Once they are purchased, military professionals must determine how best to integrate the new system with existing systems to achieve the maximum effect. Often the best combined arms solution will not be able to employ the full parameters of the new system's capabilities. For example, the recent history of technology reveals personnel carriers that cannot stay up with new tanks, new artillery that outranges forward observers' ability to observe and body armor that protects a soldier but is too heavy to fight in. The operating parameters of technology may be developed for one locale or type of combat but employed in another. The top-secret World War II Norden bombsight was developed over the cloudless plains of Oklahoma and Texas but employed over the cloudy, complex terrain of Germany and in the 100-knot jetstreams over Japan. The FM tactical radio that can transmit and receive for a distance of 30 kilometers over open ground cannot communicate two blocks away in a city full of high-rise buildings.

Application, Not Technology

New technology seldom lives up to its sales hype, and it is seldom perfect. Rather, it is usually "sold on the come"-buy the prototype, and the next version will be optimal for the battlefield. Following World War I, Brigadier General Billy Mitchell, Deputy Chief of the Army Air Service, wanted to develop a heavy bomber. Having claimed that bombers could sink capital ships, Mitchell received the chance to prove it in July 1921 using Martin bombers against former German warships. While Army pilots were successful in their attacks, Mitchell had not abided by the rules of the test, which were to drop a 1,000-pound bomb from 10,000 feet. Instead, he directed pilots to drop a 2,000-pound bomb from 3,000 feet. Critics cried foul, but Mitchell justified his directive with the belief that future technology would provide a bombsight accurate enough to attack from high altitude and aircraft powerful enough to carry heavy payloads. For now, it was sufficient to demonstrate the potential of air power against ships. In the end, the Navy entrusted the antiship mission to dive-bombers and torpedo planes, but this example illustrates how technology changes from prototype to fielded system.[7]

Frequently, scientists and engineers design new technology with military input but with little initial soldier-proofing. Often the scientists, engineers and military recognize that the new technology has tremendous potential but only have a rough idea of how to employ that technology. Subsequently, technology is developed to accomplish specific tasks, although later use may show that it is better suited for others. Thus, the best German antitank gun of World War II was developed from an 88-millimeter antiaircraft gun. The military potential of the helicopter has not yet been fully appreciated and developed, although there is finally some ongoing debate to marry light armored vehicles with helicopter lift to develop the air-mechanized concept.[8] Wing-in-ground technology has been known since the late 1930s but has only been partially developed to recognize its tremendous long-distance, heavy-duty capability.[9] Fuel-air explosives have had a long period of development and are only now approaching maturity and probable wide application.[10]

A German 88-mm gun fires on British armor in North Africa, circa 1941. The stripes on the barrel indicate five kills to its credit.

It takes time and experience to determine the optimum application of new technology. During the early days of World War I, a machinegun firing straight ahead at the advancing foe was only marginally more efficient than a rifle squad firing straight ahead. It was only after machineguns were sited to provide both straight-ahead fire and interlocking fire that they dominated the close battlefield. The tank was the eventual answer to the machine-gun, but even it enjoyed only limited tactical success since it was used primarily as an infantry support vehicle. Only after tanks were improved and combined with close air support, self-propelled artillery, mounted infantry, effective communications and airborne assault did tanks dominate the battlefield. But the primary genius of mechanized warfare was not the technology; it was its application-developing new techniques, doctrine, force structure and flexible leadership to meld the combat potential of the technologies into a coherent, comprehensive force.[11] Military culture proved decisive in effectively applying the concept.[12]

The *Wehrmacht* decisively used the *Reichswehr's* concept of combined arms, mechanized warfare, which the popular press named *Blitzkrieg*, in only two theaters-Poland and then France and the Low Countries. In Poland, victory was achieved by a single, decisive operation that culminated in a matter of weeks by destroying the Polish armed forces. In France, the *Wehrmacht* conducted successive operations, breaking through to the channel and encircling Allied armies on the beaches of Dunkirk. German armor, however, was not committed to destroying those armies. Instead, the German High Command directed the panzer divisions to regroup and redeploy to break through the Somme defenses and capture Paris. However, when the *Wehrmacht* tried to adapt this concept and force structure to the war against the Soviet Union, it resulted in crisis. The *Wehrmacht* had to reduce the panzer division's combat strength to get enough units to meet the initial operational requirements for Operation *Barbarossa* and subsequently lacked sufficient combat power where needed.

Operational art is concerned with regrouping forces to conduct successive operations leading to strategic decision. In 1941, the *Wehrmacht* planned for a single, decisive set of encirclement battles along the western frontier of the Soviet Union to be followed by a general pursuit to the Ural Mountains. What the *Wehrmacht* faced, however, were the demands of successive operations in a long war of attrition.[13] The crisis in July 1941 over the campaign's strategic objectives-Moscow or Kiev-was a direct result of the looming prospect of a longer war. Later, when on the offensive, the Red Army conducted successive, mechanized deep operations composed of *fronts* or groups of *fronts* with the intent of destroying a portion of the enemy force-*Wehrmacht* or Allied-throughout the depths of its deployments, that is, corps, army/armies and army group/groups. The key for the Red Army was not only the potential of armored forces but also the criticality of logistics support for those forces involved in offensive operations. Logistics set limits on the depth of attack and time of culmination. Railroads were critical to Soviet logistics and force regrouping. Soviet mastery of railroad movement, combined with tank-led deep operations, were key to Soviet victory.[14]

Technology may perform flawlessly, but the infrastructure or application developed for that technology may be flawed. Radar operators at Opana Point, Hawaii, detected and reported the first wave of the approaching Japanese air armada aimed at Pearl Harbor at 0702 on 7 December 1941. They passed this sighting to their information center, which interpreted it as US B-17 bombers coming in for refueling on their way to the Philippines. Even if the sighting had been correctly interpreted, there was no central operations room controlling the airspace over Oahu, and there was no way to pass information readily between the US Army and US Navy. US code-breaking efforts had determined that a Japanese attack was inevitable somewhere soon, but the information was so classified that military commanders were only told to increase alert measures. In Hawaii, this resulted in aircraft being concentrated so they could be readily guarded against sabotage. The first wave of the Japanese attack hit these tightly packed aircraft at 0755.[15]

British soldiers "yomping" near Onion Ridge in the Falklands. Loss of the ground force helicopters to Argentine action at sea necessitated that British troops conduct all operations by foot along the 80-mile route from the invasion site.

There is often a difference between theory and application when introducing new technology into a unit. What is taught and trained often differs from what is actually done.[16] The "Fort Benning solution" is often ignored in favor of local standing operating procedures, and what works in one locale or climate does not work in another. Other armies have the same problem. British ground forces train on Salisbury Plain in southern England only to deploy around the world where they must adapt to change. The British army provided an excellent example of professionalism and adaptability during the Falklands campaign when they persevered despite serious setbacks at sea and technology that was not up to the demands of the theater.

Military Art and Technology Diverge

"The process of military change, or reform, is extremely complex. Although there is no magic formula for success, there are certain steps that it seems to follow. The first is to determine a generally accurate picture of the nature of future war. To paraphrase [Carl von] Clausewitz, such a determination is the most significant and comprehensive question the erstwhile reformer must address. Even if he gets everything else right, if he misappreciates the essential dynamics of the next major conflict, he may well find his army perfectly prepared for the wrong type of war."[17]

Technology does transform military art but very often in unexpected, unintended ways. The dominant paradigm of war inherited from the French Revolution and Napoleonic wars seemed to confirm the division of military art into two parts: strategy, the art of moving forces to contact, and tactics, the conduct of forces in contact. Victory belonged to the commander who could successfully concentrate forces at a single point with tactical successes culminating in strategic victory. But the 19th century was not kind to that vision or to those who sought victory in that manner. Technological change transformed the battlefield with its greater lethality and lower force densities. This change expanded the battlefield's length and breadth until traditional command and control was no longer effective.

Mass armies and railroads brought more forces into play and changed the dynamic of mobilization. The strategy of a single point gave way to the strategy of an extended line. Tactical victory lost its decisive edge. Until 1863, commanders in the eastern region of the American Civil War considered themselves disciples of Napoleon and used a drill manual based on Napoleonic tactics and the smoothbore musket. Bloody battles were won and lost, but there was no strategic decision. In 1864, Lieutenant General Ulysses S. Grant moved east and Major General William T. Sherman south, and the war took on a new character. Grant fought a sustained operation before Richmond, intending to break General Robert E. Lee's army by the weight of numbers and industrial power. Sherman and Major General Philip H. Sheridan took the war into Georgia and the Shenandoah Valley to destroy the economic underpinnings of Southern resistance. Military art was shaped by its practical experience with mass industrial war.

Industrial war, like the industrial revolution, was ultimately about control and control systems. Innovations in communications, like the telegraph, made it possible to turn the single wire paralleling the railroad track into a complex system of signals. War underwent a similar revolution with the telephone and radio. However, unlike the business management revolution, where effectiveness set the criteria of success, innovation in the military sphere had to face a thinking opponent seeking to exploit any vulnerability. In the United States, this led to Herbert O. Yardley's developing signal intelligence during World War I. In the 1920s, his legendary Black Chamber intercepted and decoded Japanese message traffic in conjunction with the Washington Naval Conference. In the early 1930s, after the chamber had been closed down, Yardley, out of a job, published his sensational *America's Black Chamber*. This caused 19 governments to change their diplomatic codes and involved Yardley in a number of heated exchanges with editors who considered his revelations treason.[18] Yardley defended himself by saying that what he had revealed no longer mattered; governments were adopting machine encrypting, and that would make timely decryption a near impossibility.

Indeed, many governments took that attitude and considered their machine ciphers beyond attack. However, combined national efforts by England, Poland, France and the United States ultimately broke several invulnerable ciphers. Axis commanders who used coded signals to control tactical and operational forces met with disaster. Admiral Karl Doenitz, an experienced submariner and innovator, headed the German submarine arm. He massed his submarines into wolf packs to attack Allied convoys, but when the Allies broke the German submariners' codes, the wolf packs suffered serious losses. But both sides broke codes. On several occasions, U-boat commanders read decoded Allied convoy traffic at the same time the Allies' *Ultra* was decoding the Axis' *Enigma* traffic to send to its antisubmarine forces.[19] No information system is invulnerable, and a thinking opponent can find his way around a technological system.

Today, many argue that a new mode of warfare, dominated by information, will consign mass industrial war to the dustbin of history. They see the Gulf War as the harbinger of this new revolution. It is precisely the new information technology that has made automated command and control and precision fires possible. Yet, most of the arguments in favor of the new technology and systems seem to be one-sided, positing an asymmetrical struggle between those who have information technology fighting those who do not. It is not too much to argue that such a view is the equivalent of taking the European experience of the colonial wars of the late 19th century and saying that these wars would be the "future war" that modern armies should prepare for.

Such views are absolute in their cast; they reject any notion that military art must be adapted to particular theaters or opponents because the superior force will have a permanent technological delta or margin of victory. This technological arrogance almost inevitably invites surprise. Less-developed opponents will be able to determine an opponent's operational or tactical templates and exploit them. Cookie-cutter solutions do not work universally in different theaters, on different terrain, or against different forces and cultures. In fact, these solutions often increase the fog and friction of technology. The side with the greater ability to adapt, exercise initiative, and enforce tactical and operational innovations discovered during combat will enjoy success. Today's information revolution and information warfare rest upon the work of programmers writing millions of lines of code. Errors are inevitable, and there are already hostile attempts to intervene from outside the system. Algorithms have no nationality or loyalty but can be mastered or exploited by thinking adversaries. Information war has its own fog and friction that must be overcome, not assumed away.

In his book *On War*, Clausewitz observed that "war is a chameleon."[20] Technology cannot alter war's chameleon nature. Indeed, technology is very likely to stimulate the very surprises that make war a chameleon. Retired General Mahmut A. Gareev, Soviet/Russian Army, asserts that the task of foreseeing future war is an absolute necessity for success, but it is also a labor of Sisyphus, driven by the very change technology stimulates.[21] The military professional perpetually rolls the forecasting stone up the mountain of today's uncertainties, and it inevitably rolls back down on him under the pressure of diplomatic, economic, political, social, technological and military change. Those engaged in military foresight are in a perpetual struggle with the challenge of change, assessing whether change in armed struggle is evolutionary or revolutionary and whether it will affect military art. The process is usually a critical investigation, implying that a determined potential opponent's clever mind is seeking to gain a military advantage in a future conflict. Forecasts, by their natures, are incomplete, contradictory and subject to constant revision.[22] Gareev warns: "History knows many sagacious predictions regarding separate aspects of future war, however, to foresee correctly the nature of a new armed conflict in its entirety has practically never been achieved."[23]

Technology and Templates

Systems are optimized to the terrain, climate, force structure and culture of the armed force that will deploy them. Systems optimized for the northern European plain will not work equally well in the Amazon Delta, Sahara Desert, Antarctic wastes, Argentine pampas or Himalayan Mountains. There are also regional differences on how war is conducted; the tactics and technology of the Fulda Gap will not serve equally well on the grassy plains of Namibia or in the jungles of the Philippines.

Afghan guerrillas examining the remains of an ambushed Soviet convoy, 1986.

The modern, mechanized Soviet army that entered Afghanistan in late December 1979 was designed and trained to fight a theater war against a modern enemy who would occupy defensive positions stretching across the northern European plain. The Soviet army planned to overcome this defensive belt by massing artillery to obliterate key sections of the belt and then drive through the resultant gaps to strike deep and pursue the shattered enemy. Tactics, force structure, weapon systems and equipment were designed to function solely within the context of this massive strategic operation. It was to be a lethal, high-tempo offensive that carefully choreographed firepower and maneuver. Tactics were kept simple so they could be reduced to a series of well-rehearsed drills that conscripts and reservists could perform. The tactics were also designed not to get in the way of the operation.

The Afghan guerrillas did not cooperate by defending positions under massed artillery fire while being overrun by mechanized forces in a lethal advancing line. There were no linear defenses or no front line, and the Afghan guerrilla turned the war into a light infantry contest. The Soviet army had no light infantry. Soviet equipment often performed poorly in the dusty, hot mountainous terrain, and modern technology often failed to provide an appreciable advantage to the Soviet force. Before the Soviet army withdrew in 1989, it had redesigned or modified weapon systems, adjusted force structure, revised tactics, retrained forces, revised operations, issued new equipment and attempted new approaches to nonlinear combat. Despite the changes, the Soviet army only fought the war to a draw.[24]

During the Cold War, the United States developed its technology, force structure, training, tactics and logistics support for a war against the Soviet Union on the same northern European plain. The Soviet Union was a well-studied, fairly predictable foe with known technology, force structure and doctrine. An unfortunate outcome of this predictability was that the US military developed multiple templates for dealing with the Soviet foe. US military students and planners often used these templates as a planning shortcut or as a substitute for thought.
But the Cold War was not without its hot spots-Korea, the Dominican Republic, Vietnam, Grenada, Panama and Kuwait. In all of these, the templates developed from planning against the Warsaw Pact did not work. Technology, force structure, training, tactics and logistics required adjustment, if not complete overhaul, to the templates for them to work. The Cold War was an anomaly. For most of US history, the likely enemy and theater have been much harder to determine. Today, there is a concerted effort to build technology-backed universal templates that will work everywhere. Observing the impact of trying to move the planning template for introducing US Army forces into Macedonia onto the nearby, but different, undeveloped terrain of Albania during the Kosovo crisis revealed the fallacy of this effort.

Marines of the 2d Light Infantry Battalion conduct operations in Arrijan, Pan-ama, during Operation *Just Cause*, 20 December 1989.

Technology-based templates and technology can be negated, as demonstrated in Vietnam, Korea, Afghanistan and Kosovo. These templates look for a war of annihilation where technology's strengths will rapidly overwhelm the side with the less-robust technology. The side with the less-robust technology can offset this disadvantage by changing the nature of the conflict from a war of annihilation to a war of attrition. This is done by conducting combat where the impact of technology is lessened or neutralized such as using large amounts of trained light infantry or conducting combat on complex terrain such as mountain, jungle, forest, city or swamp. The side with the less-robust technology may also accept asymmetry in casualties to prolong the conflict. The side with the low-technology force does not have to match the superior technology system for system. Rather, it can buy off-the-shelf systems that negate or seriously disrupt key components of the superior technology. Finally, it can match the high-technology force with an economic, media or social counter.[25]

Technology is a Tool, Not a Solution

Currently, the US Army owns the night with its night sights and goggles. It is a tremendous, but temporary, advantage. It also gives a false sense of security. The World War II German armed forces felt secure in believing they had invented an unbreakable cipher system for message traffic. *Enigma* was eventually broken using clues and indicators from a variety of sources, and the Allies defeated the German U-boat campaign by breaking the unbreakable cipher. Conversely, the advantage that technology provides by breaking opponents' ciphers is a two-edged sword. A commander who is used to reading enemy intentions in decoded traffic can be led astray if the enemy deliberately transmits false information. A commander may feel secure monitoring decoded enemy radio traffic while a messenger is passing the real traffic on a land line.

To fully exploit the advantages of technology, a force must correctly determine who its opponent will be, where it will fight the opponent and how it will conduct the fight. Forecasting the nature of future war is the first step in effectively adapting technology. Only then can optimum weapon systems, force structures, tactics and supporting technology be designed. Even if the forecasting is accurate, technology will not solve everything. Innovation, professionalism, determination, and the ability to rapidly reconfigure and adapt will still play a major role in future war. Tests and experiments with honest feedback are necessary to the process and help redirect ongoing forecasting through successes and failures.

There are no ultimate silver bullets. The US military must study and thoughtfully adapt technology; it cannot afford to lag far behind technological advances. However, new technology will create many challenges. Military technological change is best conducted gradually. Peacetime exercises can help resolve some problems and lead to improved doctrine for using new weapon systems in combat. Unfortunately, the best test of new technology and its application is during combat or crisis-the historic spur to technological development and change when nothing is done gradually.

Technology will be used across the spectrum of combat but will seldom prove equally effective across that spectrum. A determined foe can work around technology to disrupt or destroy it by attacking its critical system nodes. Technology can be a strong element of military might, but it is only an element, and the principles of military art still apply. A professional military culture and a clear vision of future war are at the very heart of military foresight and can reduce, but not eliminate, war's fog and friction.

1.Martin van Creveld, *Technology and War: From 2000 B.C. to the Present* (New York: The Free Press, 1989), 6.

2.I.S. Bliokh, *Budushchaya voyna v tekhnicheskom, ekonomicheskom i politicheskom otnosheniyakh*, six volumes (St. Petersburg, Russia: Tipografiya I.A. Efrona, 1898). On how Bliokh/Bloch's vision of future war developed, see Jacob W. Kipp, "Soldiers and Civilians Confronting Future War: Leo Tolstoy, Jan Bloch and Their Russian Military Critics," *Tooling for War: Military Transformation in the Industrial Age*, Stephen D. Chiabotti, ed. (Chicago, IL: Imprint Publications, 1996), 189-230.

3.On the revolution in military affairs and the Soviet/Russian response, see Jacob W. Kipp, "The Labor of Sisyphus: Forecasting the Revolution in Military Affairs During Russia's Time of Troubles," *Toward a Revolution in Military Affairs?* Thierry Gongora and Harold von Riekhoff, eds. (Westport, CT: Greenwood Press, 2000), 87-104.

4.V.V. Serebryannikov, *Voyny Rossii* (Moscow: Nauchnyy Mir, 1999), 206-207. Serebryannikov identifies the introduction of nine new weapon systems during the Korean War, 25 during the Vietnam War, 30 during the various wars among the Middle Eastern states and 100 during the Gulf War.

5.Bernard and Fawn M. Brodie, *From Crossbow to H-Bomb* (Bloomington, IN: Indiana University Press, 1973), 12.

6.Christopher R. Gabel, *Seek, Strike, and Destroy: U.S. Army Tank Destroyer Doctrine in World War II, Leavenworth Paper No. 12* (Fort Leavenworth, KS: Combat Studies Institute [CSI], US Army Command and General Staff College [CGSC], 1995), 14-16.

7.Ibid., 67.

8.To its good fortune, US naval aviation did acquire its own aircraft-not the case for the Royal Navy, then the world's most experienced carrier navy. The Royal Air Force's carrier aircraft procurement left England an obsolete air park when war came in 1939.

9.David L. Grange, Huba Wass De Czege, Richard D. Liebert, Charles Jarnot and Mike Sparks, *Air-Mech-Strike: 3-Dimensional Phalanx-Full Spectrum Maneuver Warfare to Dominate the 21st Century* (Paducah, IA: Turner Publishing Company, 2000).

10.Lester W. Grau and Jacob W. Kipp, "The Tyranny of Time and Distance: Bridging the Pacific," *Military Review* (July-August 2000), 70-81.

11.Lester W. Grau and Timothy Smith, "A `Crushing Victory': Fuel-Air Explosives and Grozny 2000," *Marine Corps Gazette* (August 2000), 30-33.

12.Eliot A. Cohen and John Gooch, *Military Misfortunes: The Anatomy of Failure in War* (New York: Random House, 1991), 13.

13.James S. Corum, *The Roots of Blitzkrieg: Hans von Seeckt and German Military Reform* (Lawrence, KS: University Press of Kansas, 1992); Williamson Murray, "Military Culture Does Matter," Foreign Policy Research Institute Wire, <fpri@aol.com>.

14.Jacob W. Kipp, "Blitzkrieg in Crisis: Barbarossa and the Battle of Smolensk," *Soviet and Post-Soviet Review* (vol. 19, no. 1-3, 1992), 91-136 (special number edited by David Holloway).

15.On the theory of deep operations, see Jacob W. Kipp, ed. and author of foreword, V.K. Triandafillov, *The Nature of the Operations of Contemporary Armies* (London: Frank Cass, 1994).

16.Cohen and Gooch, 51.

17.Paddy Griffith, *Battle Tactics of the Western Front: The British Army's Art of Attack 1916-1918* (New Haven: Yale University Press, 1994), 26.

18.Harold R. Winton and David R. Mets, eds., *The Challenge of Change: Military Institutions and New Realities, 1918-1941* (Lincoln, NE: University of Nebraska Press, 2000), vi-vii.

19.Herbert O. Yardley, *The American Black Chamber*, 1st Edition (Indianapolis, IN: Bobbs-Merrill, 1931).

20.Carl von Clausewitz, *On War*, Colonel J.J. Graham, trans., Bandersnatch Unpress edition, July 1999, <http://melissa.nfr.net/~nav/unpress/clausewitz,cv /onwar.html>.

21.Patrick Beesly, *Very Special Intelligence: The Story of the Admiralty's Operational Intelligence Centre, 1939-1945* (London: Hamilton, 1977); from the Axis side of the argument, see Jürgen Rohwer, *Axis Submarine Successes of World War Two: German, Italian and*

Japanese Submarine Successes,1939-1945, with special assistance from Thomas Weis et al. (London: Greenhill, 1999).

22.M.A. Gareev, *If War Comes Tomorrow: The Contours of Future Armed Conflicts* (London: Frank Cass, 1998).

23.Makhmut Akhmetevich Gareev, *Esli zavtra voyna? . . .(Shto izmenitsya v kharaktere vooruzhennoy bor'by v blizhayshie 20-25 let)* (Moscow: VlaDar, 1995), 5.

24.Ibid.

25.Lester W. Grau, *The Bear Went Over the Mountain: Soviet Combat Tactics in Afghanistan* (London: Frank Cass, 1998), 200-208.

26.Lester W. Grau, "Bashing the Laser Range Finder with a Rock," *Military Review* (May-June 1997), 42-48.

Photos:
Europaische Wehrkunde
Imperial War Museum
US Air Force
Soldier, UK Ministry of Defense
USMC