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Tomorrow's Army: The Challenge of Nonlinear Change

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The architects of the US Army's future face an experience which in many ways parallels that of a century ago. Today's force designers, like those at the last turn of the century, must wade through a sea of futuristic materials, some fantastic, some prescient, to make projections about future geopolitical environments and military-technological capabilities. Given the right political circumstances, the proliferation of off-the-shelf warfighting technologies may produce a destabilizing effect resembling the one generated by the arms race between the Central and Entente powers before the Great War.[1] The need to cross the deadly zone quickly and decisively forms, as it did a hundred years ago, the central tactical-technological issue for current military theory--each case involves an increase in battlefield lethality and the sudden emergence of additional warfighting dimensions.[2] Like the 19th-century's military-technological entrepreneurs, today's technology salesmen predict that future units will have at least three to five times the firepower of current ones, and thus can afford to be smaller in size and fewer in number. The Army and its sister services face budgetary, doctrinal, and proponency battles comparable to those that nearly stymied force modernization in several nations at the beginning of the 20th century. Moreover, like the Second Industrial Revolution at the turn of the last century, the rapidly unfolding Information Age has produced diverse primary, supporting, and enabling technologies requiring investment, testing, and evaluation.

Accordingly, future-oriented initiatives like the Force XXI and Army After Next projects, which probe likely changes in the character of warfare out to 2025, would gain much from an accurate understanding of why similar efforts a hundred years ago missed their mark. Conventional wisdom maintains that military thinking is inherently conservative and more concerned with refighting the last war than preparing for the next. In the case of 1914, for instance, the supposed failures of military thinking have become almost legendary. Late-19th-century military theorists, "*ignorant* and *suspicious* of all the great advances in firearms," stubbornly clung to "outmoded tactical conceptions" reflecting the "old aspirations and ideals of a defunct social class." Fortunately, amateur theorists, open-minded and full of practical sense, saved the military mind from itself--or so the story goes.[3]

History demonstrates that ignorance, suspicion, and stubbornness have played a role in every era and in every human endeavor: They are hardly unique to the military mind. Identifying these human characteristics as the most important reason for the "failure" of pre-1914 military thinking overlooks the part played by other, and in this case more significant, forces. Such caricatures of the past limit what we might learn from history. This article argues that the conventional view of military-technological change in the pre-World War I era overlooks the manner in which the dynamics of technological change--in terms of its rate, scope, and nonlinear nature--exacerbated the difficulties of integrating new technologies into European and American military structures. It also discusses the implications of those dynamics for Assumption-Based Planning, a tool with the potential to help the US Army conduct long-range planning in uncertain times.

Visions of Future War: The Professional

When we actually look at the historical evidence, the military professional's vision of future war at the last turn of the century proves to have been much more forward-looking than the conventional wisdom allows. Military theorists of the day clearly recognized that new technologies in the form of railroads, wireless telegraphy, telephone networks, smokeless powder, magazine-fed rifles, self-powered machine guns, quick-firing artillery, and aircraft had irreversibly altered the conduct of war.[4] The many after-action reports and official histories written about wars that occurred between 1870 and 1914, along with countless other professional books and journals, acknowledged that the range, accuracy, and rate of fire of contemporary weaponry had expanded the deadly zone to 1000 meters or more, and would very likely prohibit attacks over unbroken ground.[5] Numerous theorists predicted that land battles would resemble the sieges of old rather than the free-wheeling engagements of Napoleon's or Moltke's day. "Million-man" armies would take the field, severely taxing the coordinating capacities of commanders and their staffs, even with the aid of revolutionary communications technologies. Future battles would also occupy a new warfighting dimension, the air.[6] The increased lethality of the modern battlefield made it nearly impossible for an attacker to close with the defender and defeat him in battle.

Indeed, crossing the deadly zone became the tactical problem of the day, and military theorists in Britain, France, Germany, and the United States spared no effort in attempting to solve it.[7] If this problem remained unsolved, decisive victory would vanish from the military lexicon and warfare would become nothing more than an exercise in attrition. Such an outcome represented either a failure of arms or an absence of military genius, each equally unacceptable to the military professional. Proposed solutions to the crisis assumed many forms. Fundamentally, however, military theorists believed that achieving fire superiority at the decisive point would allow the attacker to overwhelm the defender and restore mobility to the battlefield.[8] The pre-WWI infantry drill regulations of Britain, France, Germany, and the United States reflected this belief by advocating attacks with small, open-order formations, advancing in short rushes under cover and concealment, followed by the concentration of all available direct and indirect firepower at the decisive point to weaken the enemy before the final assault.[9]

Although pre-1914 military thought certainly had its share of ignorance, suspicion, and stubbornness, it appreciated quite well the advantages that modern weapons technology afforded the defender. It foresaw the potential stalemate of trench warfare and the probable carnage of "no man's land" and attempted to avoid them. However, it made an apparently logical but ultimately erroneous assumption: that achieving fire superiority (i.e., employing superior firepower technology) would suffice to avoid a stalemate on the battlefield.[10] The emphasis that some military theorists placed on the morale element as a means to overcome material superiority must be viewed as a counterweight to the enthusiasm that the era often exhibited toward technological solutions.[11] As a result of its assumption that fire superiority would enable the attacker to cross the deadly zone, turn-of-the-century military theory did not fully develop alternative operational-level maneuver technologies capable of dealing with a defense in depth and of exploiting a breakthrough once achieved. Without recourse to either large-scale, live-fire maneuvers or the test of battle--the only proving grounds truly acknowledged by soldiers--military theory alone could not solve what by 1907 had become a general crisis in warfighting.[12] Military theory could approach the tactical problem of the day only on an abstract level.

Visions of Future War: The Amateur

Contrary to the myth that nonprofessionals saved the military mind from itself, amateur visions of future war, though originating "outside the box," often reflected errors in fact or logic which made them questionable or even dangerous. Celebrated amateur theorists such as Ivan Bloch (1836-1902), a Polish banker and writer, produced a vision of war that actually differed little from the one forecast by military professionals. Bloch claimed that the next war would become a stalemate of huge proportions with armies fully entrenched, unable to advance, the spade as indispensable to the soldier as the rifle, and victory forever beyond reach. However, Bloch departed from the vision of the military professionals in one key respect--his prediction that war itself would cease because states could no longer use it as a rational political instrument.[13] In the eyes of the period's military men, Bloch failed to understand that irrational forces, like basic enmity, nationalistic passion, or religious zeal, would continue to cause wars, regardless of rational influences to the contrary.

In another example, H. G. Wells (1866-1945), reputedly one of the most forward-thinking individuals of the *fin de siècle*, failed to recognize the revolutionary potential of the wireless. He also predicted that submarines would do little more than suffocate their crews and founder at sea. In 1902, barely a year before the Kitty Hawk flight, he declared that airplanes would not fly until about 1950; nor did he believe that they would affect transportation in any significant way.[14] In the meantime, other amateurs prognosticated about the nature of air power at the turn of the century and how it would render war on land obsolete.[15]

Reflecting still more the unbridled imagination of the nonprofessional, popular journals and magazines like *Punch*, *Strand*, and *Blackwood's* in Britain, *La Caricature* in France, and *Kladderadatsch* in Germany featured stories by famous authors like Sir Arthur Conan Doyle (1859-1930), A. A. Milne (1882-1956), and Jack London (1876-1916). Their tales described fantastic dynamite cruisers, electric rifles, compressed air carbines, mobile armored artillery bases, flying fortifications, underwater sleds, protective fogs, exotic chemicals and diseases, corrosive dewdrops, human mind-benders, and brain-disrupting psychic mediums.[16] Many of these ideas were simply too far ahead of their time to be of use to professionals worried about a general war breaking out in the next two or three years. Other ideas would simply never see their day. This is not to say, however, that amateurs had nothing worthwhile to offer to professionals. On the contrary, cooperation between the two occurred on a large scale, particularly in the field of aeronautics, and their ideas and visions of future war co-evolved.

The Dynamics of Technological Change

Although ignorance, suspicion, and stubbornness played a part in the development of both military *and* civilian visions of future war, their role pales in comparison to that played by the rate, scope, and nonlinear nature of change. The *rate* of technological change itself exceeded anything Western society had hitherto experienced. In 1908, only 142,000 motorized vehicles cruised the roads of Europe and North America. By 1913, this number had increased more than tenfold, to 1.5 million. Similarly, within five years of the Wright brothers' first flight at Kitty Hawk, Europe and the United States had established over 130 aeronautical records.[17] Likewise, the rate of military-technological change accelerated dramatically in the last quarter of the 19th century.[18] Western armies completed twice as many doctrinal revisions in this period than they had in the previous 75 years.[19] Admittedly, many of these revisions were minor, reflecting more a desire to refine rather than to reinvent. Nonetheless, by the turn of the century, military regulations were being reviewed for pertinence more often than ever before.

In response to such rapid change, Western society developed a new infrastructure for testing, evaluating, and integrating the flood of technological innovations that inundated it. Technological assessment required the creation of new organizations or the reorganization of existing ones--difficult processes in their own right. These new bureaus often had to conduct their tests and evaluations without the benefit of any experience or precedent. Once selected, a specific technology required staffing to determine its appropriate quantity, organization, distribution, and doctrine. These decisions, in turn, depended upon the pace and extent of other modernization efforts within the organization as a whole, such as the major expansion and revision of the US Army's force structure that occurred between 1899 and 1904. Consequently, the rate of technological innovation soon outpaced the still nascent process of integration. Put another way, the rate of technological change often got "inside" bureaucratic decision cycles and created nearly unbridgeable gaps between theory and practice.

Second, this era, this first great age of the future, witnessed an unprecedented *scope* of technological change that reached into every facet of modern life. Revolutionary inventions like the typewriter, the phonograph, the motion-picture camera, the telephone, the wireless, the transoceanic cable, the bicycle, the automobile, the airplane, the electric street car, and the subway irreversibly changed the way in which Western society pursued its business and leisure activities.[20] This Second Industrial Revolution gave rise to an infinite variety of new industries, reshaped existing ones, and left in its wake a series of vast urban centers and transportation networks. Between 1890 and 1913, for example, Germany's population increased by 36 percent (from 49.2 million to 66.9 million); between 1896 and 1913 its national income rose by 85 percent (from 23.5 billion marks to 43.5 billion), and its per capita income by 43 percent (from 450 marks to 645 marks).[21] By 1900, Britain, Germany, and the United States together accounted for 67 percent of the world's industrial output. Such vast economic changes also transformed European social structures, resulting in, among other things, a greater presence of commoners and members of the up-and-coming middle classes in the formerly aristocratic officer ranks of European armies.[22]

Culturally, the pervasiveness of technological change produced a profound tension between optimism and anxiety. On the one hand, progress brought an increase in knowledge and education, significant prosperity and wealth, modern conveniences, and welcome advances in the medical sciences. On the other hand, its relentless and irreverent march forward destroyed long-standing religious and cultural icons, challenged the political status quo, and supported a revolt against past beliefs and codes of conduct. The scope of technological change thus set in motion a complex series of unanticipated events, problems, and consequences, which turn-of-the-century civilians and soldiers had to confront as neophytes.[23]

Third, the technological innovations that flooded Western society at the turn of the century did not develop in an autonomous, linear, and predictable manner, but in a *nonlinear* way, that is, interdependently, unevenly, and contrary to expectation. The success of a complete system depended upon the timely advance and integration of its supporting and enabling technologies. For example, the US Army's selection of a standard machine gun between 1901 and 1904 depended upon the development of a new service rifle (M1903), the caliber of its ammunition at the Springfield Armory, and the testing of ancillary equipment related to the weapon's handling, transport, and storage.[24] Small changes in supporting technologies--often easily overlooked--sometimes proved as revolutionary as the advent of whole systems. A series of minor improvements in traverse-and-elevation mechanisms, metal-cased and cleaner-firing ammunition, and broader-vision field glasses for spotting the weapon's fall of shot combined to make the machine gun even more lethal at longer ranges than expected. Likewise, unanticipated discoveries in apparently minor and unrelated fields repeatedly--and sometimes decisively--deflected the expected trajectory of technological change. The advent of inexpensive steel plate combined fortuitously with the new "hardening processes" of the 1890s to upset the global status quo: It enabled Germany, Italy, Japan, and the United States to emerge as significant naval powers in less than 25 years.[25] Thus, the nonlinear nature of technological change consistently surprised conservative and visionary alike by producing complex and often disproportionate effects.[26]

Implications for Planning in Uncertain Times

The dynamics of technological change served not only to unhinge expectations of the future but to perplex the process of technological integration at the turn of the century. Today, similarly, advances in chemical and genetic engineering, propulsion technologies, composite materials, and information and simulation systems create challenges for soldiers and civilians about to enter the 21st century. As it did a hundred years ago, technological change will likely transpire incrementally and imperceptibly in some cases, abruptly and dramatically in others. New discoveries or experiments in any number of diverse scientific and technological fields may render obsolete initiatives already in development. To face such challenges, the US Army must reconsider the way it plans for the future.

One key component in that approach is the Assumption-Based Planning (ABP) tool, an instrument for long-range planning developed by the RAND Corporation which has gained currency in recent years.[27] ABP involves five steps:

- Identify the explicit and implicit assumptions expected to remain true over a reasonable time horizon.
- Identify assumption vulnerabilities.
- Define "signposts" that will indicate when one or more assumptions have become vulnerable.
- Define appropriate "shaping" actions that avoid assumption vulnerabilities.
- Define "hedging" actions that minimize the effects of an assumption failure.

Although it does not claim to be a panacea, ABP does offer a much improved alternative to trends-based forms of planning which posit only a single, "most likely" future.[28] Most important, ABP helps expose organizational assumptions that might prove invalid, and therefore dangerous, to a long-range plan in a given period of time. Its success depends on the ability of decisionmakers to link their implicit and explicit assumptions to events in the physical world.

Applying ABP effectively in a fluid technological environment like the one that confronted pre-1914 military thinkers, however, requires that users understand the tool's limitations. The first of these involves the sensitivity of human perceptions. ABP requires the identification of "genuine and unambiguous signposts."[29] Yet, in fluid environments, signposts are myriad, conflicting, and at times almost invisible. For example, in the United States alone, more than 3000 different makes of cars appeared around the turn of the century. These diverse models and prototypes were produced by some 1500 firms, most of which would fall into bankruptcy and disappear before the Great War, a reflection of the uncertainty of the times. Of the three general engine systems available to propel these vehicles, the gas-powered, internal combustion engine seemed the least promising because it required a very complex transmission, was expensive and noisy, and had the psychological disadvantage, as one contemporary manufacturer explained, of forcing people to "sit over an explosion."[30] The electric car, on the other hand, had none of these problems, but its battery prevented it from operating at high speeds and over long distances. Signs indicated, in fact, that the steam-powered vehicle would dominate the market, since it ran more cleanly and quietly and proved more powerful than the other two. Yet, due to a "historical accident" which remains something of a mystery, the steam-driven automobile suddenly declined in popularity and the gasoline engine became the industry standard.[31]

The appreciation of signposts often eluded even those who had spent their lives working on a particular project or invention. James Prescott Joule (1818-1889) was the inventor of one of the first electromagnetic engines. Nonetheless, he failed to recognize the vast potential of electricity as an energy source, even though it would eventually revolutionize all forms of industry.[32] Compounding the problem of perception, inventors or entrepreneurs often generated misinformation, inadvertently and otherwise, about the potential benefits of a new kind of technology. A notorious weapons dealer by the name of Basil Zaharoff several times wrecked the European trials of Maxim's machine gun through lies, bribery, and sabotage. Richard Gatling (1818-1903) naively marketed his famous gun as "a great economy" that would save the US Army men and money. Two gatlings--at a cost of $1,500 each--were presumably enough to replace an entire infantry regiment--costing in excess of $150,000 per year to maintain.[33] However, as events were to prove, the dynamics of combat generated demands for more of everything--machine guns, munitions, *and* soldiers.[34]

In fact, the Russo-Turkish War of 1877-78, the Boer War of 1899-1902, and the Russo-Japanese War of 1904-05 delivered no "genuine and unambiguous" signposts to indicate that the fundamental assumptions of military theorists had become vulnerable. As the many after-action and observer reports indicated, differences in terrain, equipment, training, doctrine, leadership, morale, and "racial characteristics" served to obscure the genuine lessons or signposts that these wars had to offer. Since the Japanese managed to execute numerous successful attacks when they coordinated them with sufficient heavy artillery and machine gun support, the three major assumptions that guided turn-of-the-century military thought did not appear vulnerable: the deadly zone has grown larger and more lethal (*explicit*); well-directed firepower may make it possible to cross the deadly zone (*explicit*); and armies must cross the deadly zone to achieve decisive victory (*implicit*).[35] These assumptions appeared to remain valid well into the first eight weeks of the Great War on the Western Front, and even longer on the Eastern Front.[36]

In addition to the very real problem of signpost detection and perception, ABP depends upon the accurate identification of explicit and implicit assumptions likely to prove vulnerable over a given period of time. However, the identification of assumptions is at best a solipsistic process. In other words, our ability to recognize the assumptions that guide our thinking is limited by our willingness to perform a rigorous self-critical analysis. Turn-of-the-century armies developed their tactics not only with an eye on the effects of improvements in weapon technologies, but also with an appreciation for what they called the "national character" of their soldiers. The French army accepted a casual state of indiscipline within its ranks to preserve "*souplesse*"--mental agility and initiative--and because it believed that Frenchmen did not respond well in a rigidly structured environment.[37] The German army, on the other hand, placed a higher premium on drill and discipline in order to promote responsiveness and endurance in personnel whom it deemed lacked a "natural talent" for them.[38] Hence, there is a danger that the identification of explicit and implicit assumptions may not proceed much beyond a similar type-casting of oneself and one's opponents.

Third, the shaping and hedging actions so integral to ABP methodology will likely compete for the same finite resources; one action might preempt the success of another. Shaping actions designed to assist infantry in crossing the deadly zone began almost as soon as the problem emerged in the mid-19th century. These shaping actions propelled improvements in firepower technologies, especially cannons, munitions, and powder, so that by 1897 the French army had developed a highly effective 75mm cannon with a recoil mechanism that allowed an unheard of rate of fire--20 to 30 rounds per minute. By 1905, all major European armies possessed some version of a quick-firing gun comparable to the French 75mm. By 1914, cannons had increased dramatically in number and caliber; howitzers of 105mm and 150mm were standard in the German army.[39] However, the resources required for the development of firepower technology left little opportunity for resourcing alternative maneuver technologies, an important but underdeveloped hedging action.

In a world of limited budgets, therefore, armies will have to prioritize resources for shaping and hedging actions, an activity that might complicate, if not compromise, long-range planning. This was clearly the case with turn-of-the-century armies, which had insufficient resources for modernization given the rate and scope of technological innovation they experienced. In fact, every army encountered frustrating budgetary battles within its respective parliamentary or congressional processes. In one case, Colonel Erich Ludendorff, head of the German General Staff's Mobilization Section in 1912, was summarily posted to a regimental command after demanding a budgetary increase that would have authorized an additional 300,000 recruits for the Imperial German Army over the course of two years.[40] Hence, the right vision of future war may not matter if the processes for achieving technological integration remain inflexible and unresponsive to those signposts that are in fact recognized. In addition to correctly identifying the measures necessary for military victory, therefore, force designers must possess the ability to clarify and justify military necessities to legislators. Soldierly inspiration may avail little without the corresponding ability to persuade.

Fourth, in an environment in which technological change may take place "inside" institutional decision or adjustment cycles, hedging actions--while appearing to remedy vulnerable assumptions--may only further reduce the overall pace of technological integration. ABP will not eliminate the risks that decisionmakers face as they attempt to determine the "right" pace of modernization for the Army. In the decades before World War I, the German General Staff and the German War Ministry battled extensively over the proper size of the army. The former wanted a larger army to meet operational requirements brought about by rapid changes in warfare and mobilization schedules. The latter preferred quality over quantity and insisted on maintaining a smaller force to preserve homogeneity and political reliability. The compromise that occurred with the German army bill of 1912-13 satisfied neither party.[41]

As pointed out in *Knowledge & Speed*, the US Army's 1997 report of the Army After Next project, changing too quickly will likely result in the acquisition of "immature or inappropriate capabilities" or even undermine the "doctrinal organization or cohesion" essential to an army.[42] Modernizing too slowly, on the other hand, runs the risk of fielding a force with outclassed and therefore restricted capabilities. Finding the right "slope" of change will likely require a blend of experience and intuition.

The point of airing these concerns is to emphasize that ABP is merely a tool. Indeed, it constitutes only one pillar in the effort to achieve timely and effective technological integration. Human resources and the integration process each play decisive roles in the activity of building the future. Weaknesses among any of these roles, especially in an environment in which change is rapid, pervasive, and nonlinear, may compromise the overall effort. The value of a tool like ABP depends upon how well it compensates for human limitations within a particular environment. For this reason, we must make our human resources as capable as possible by educating ourselves about the dynamics of technological change and by "hedging" the assumption that change will proceed at a reasonable pace, within discrete fields, and in a linear manner. In addition, we must make our integration processes as responsive as possible to rapid, broad, and nonlinear change. Finally, we must continue to refine ABP and any other planning tools we develop.

General Recommendations

Formal planning tools like Assumption-Based Planning offer no "silver bullets" to prevent the unhinging effects of rapid, pervasive, nonlinear change. Decisionmaking in fluid conditions will likely remain more art than science. However, the following recommendations may serve to both "shape" and "hedge" the Army's efforts to prepare for military operations in the 21st century:

- Continue to study the dynamics of technological change. Revise ABP as our understanding of the dynamics of technological change improves.
- Revamp DOD acquisition and procurement processes to accommodate such change. Ensure that such processes remain streamlined, flexible, and capable of establishing resource priorities between shaping and hedging actions.
- Maintain a "push-pull" approach for incorporating technological innovations into operational concepts. Operational concepts drive technology toward desired end-states, while technology offers new capabilities--actual and potential--that might enlarge, cancel, or otherwise alter operational concepts.
- Genuine intuition and experienced judgment may prove just as valuable as formal decisionmaking tools, perhaps even more so. Commit more resources to understanding the vital role that these factors play in decisionmaking.
- Emphasize thorough research and rigorous analysis throughout the various stages of officer education. Develop an officer corps capable of preparing and presenting credible and convincing arguments for force modernization to appropriate lawmakers.

Foster a military culture that is open to change and supports the development of broad visions of the future. Officer experience and education must remain equal to the challenges of maintaining competence in a broad variety of fields while achieving mastery in select specialties.

As Army XXI and Army After Next set the Army's course for the next 30 years, they do so with the understanding that technological change occurs in a complex and dynamic manner. Appreciating its pitfalls and opportunities requires the right blend of formalism and intuitive insight.

NOTES

1. David G. Herrmann, *The Arming of Europe* (Princeton, N.J.: Princeton Univ. Press, 1996); Keith Wilson, ed., *Decisions for War, 1914* (New York: St. Martin's Press, 1995).

2. See *Knowledge & Speed*, the annual report of the Army After Next project (Ft. Monroe, Va.: US Army Training and Doctrine Command, July 1997); and US Army, *Concept for Future Joint Operations: Expanding Joint Vision 2010* (Ft. Monroe, Va.: Joint Warfighting Center, May 1997).

3. For works representing the conventional wisdom, see Alfred Vagts, *A History of Militarism* (New York: The Free Press, 1967); John Ellis, *The Social History of the Machine Gun* (New York: Pantheon, 1976); Edward L. Katzenbach, Jr., "The Mechanization of War, 1880-1919," in Melvin Kranzberg and Carroll W. Pursell, Jr., eds., *Technology in Western Civilization: Technology in the Twentieth Century*, Vol. II (New York: Oxford Univ. Press, 1967); Jack Snyder, *The Ideology of the Offensive: Military Decision Making and the Disasters of 1914* (Ithaca, N.Y.: Cornell Univ. Press, 1984); Stephen Van Evera, "The Cult of the Offensive and the Origins of the First World War," in Steven E. Miller, ed., *Military Strategy and the Origins of the First World War* (Princeton, N.J.: Princeton Univ. Press, 1985); Dieter Storz, *Kriegsbild und Rüstung vor 1914: europäische Landstreitkrafte vor dem Ersten Weltkrieg* (Herford, Berlin, Bonn: Mittler, 1992); and I. F. Clarke, *Voices Prophesying War, 1763-1984* (London: Oxford Univ. Press, 1966).

4. Compare Prince Kraft zu Hohenlohe-Ingelfingen, *Letters on Infantry*, trans. N. L. Walford (London: Edward Stanford, 1892); see also R. v. Caemmerer, *Die Entwicklung der strategischen Wissenschaft im 19. Jahrhundert* (Berlin: Wilhelm Baensch, 1904); G. F. R. Henderson, *The Science of War: A Collection of Essays and Lectures 1892-1903*, ed. N. Malcolm (London: Longman's, Green, & Co., 1905); Friedrich v. Bernhardi, *Vom heutigen Kriege* (Berlin: E. S. Mittler, 1912); C. v. der Goltz, *Kreig-und Heerführung* (Berlin: R. v. Decker's Verlag, 1901); *Kriegführung. Kurze Lehre ihrer wichtigsten Grundsätze und Formen* (Berlin: R. v. Decker's Verlag, 1895); and *Volk in Waffen. Ein Buch über Heerwesen und Kriegführung unserer Zeit* (Berlin: R. v. Decker's Verlag, 1899); [Sigismund] v. Schlichting, *Taktische und strategische Grundsätze der Gegenwart*, 3 vols. (Berlin: E. S. Mittler, 1898-99); Schlieffen, *Cannae*; Frhr. v. Freytag-Loringhoven, *Krieg und Politik in der Neuzeit* (Berlin: E. S. Mittler, 1911).

5. By 1900, the deadly zone already exceeded 800 meters, and the danger zone, the area in which formed bodies of troops could not survive, was nearly three times greater than that. For a representative sample of works addressing the deadly zone, see Sisson C. Pratt, *A Prècis of Modern Tactics* (2d ed.; London: Her Majesty's Stationary Office, 1896), p. 25; Francis V. Greene, "The Important Improvements in the Art of War During the Past Twenty Years and Their Probable Effect on Future Military Operations," *Journal of the Military Service Institute of the United States*, 4 (1883), p. 24; August von Janson, "Die Entwickelung unsere Infanterie-Taktik seit unseren letzten Kriegen," *Beihefte zum Militär-Wochenblatt* (No. 1, 1895), pp. 105-28. General Warnet, *Le combat et les feux d'infanterie: de l'offensive--de la dèfensive* (Paris: L. Baudoin, 1892). See also Perry D. Jamieson, *Crossing the Deadly Ground: United States Army Tactics, 1865-1899* (Tuscaloosa: Alabama Univ. Press, 1994).

6. See especially, Bernhardi, *Vom heutigen Krieg*; Schlieffen, "Der Krieg der Gegenwart," *Deutsche Revue* (1909), pp. 13-23; and John H. Morrow, Jr., "Expectation and Reality: The Great War in the Air," *Air Power Journal*, 10 (Winter 1996), 27-34; *The Great War in the Air: Military Aviation from 1909 to 1921* (Washington: Smithsonian Press, 1993); Robert Wohl, *A Passion for Wings: Aviation and the Western Imagination, 1908-1918* (New Haven, Conn.: Yale Univ. Press, 1994); Lee Kennett, *The First Air War, 1914-1918* (New York: Free Press, 1991).

7. Of course, other problems confronted turn-of-the-century military thinkers: the loss of officers with combat experience due to the prolonged period of peace; slow promotion; low pay; army size and mission; and an increase in international tensions, especially after 1905. Martin Kitchen, *The German Officer Corps, 1890-1914* (Oxford: Clarendon Press, 1968); Richard D. Challener, *The French Theory of the Nation in Arms 1866-1939* (New York: Columbia Univ. Press, 1955), pp. 46-90; Douglas Porch, *The March to the Marne: The French Army 1871-1914* (New York: Cambridge Univ. Press, 1981); David B. Ralston, *The Army of the Republic: The Place of the Military in the Political Evolution of France, 1871-1914* (Cambridge, Mass.: M.I.T. Press, 1967); Jay Luvaas, *The Education of an Army* (Chicago: Univ. of Chicago Press, 1964); and Tim Travers, *The Killing Ground: The British Army, the Western Front and the Emergence of Modern Warfare 1900-1918* (London: Allen and Unwin, 1987).

8. Antulio J. Echevarria II, "A Crisis in Warfighting: German Tactical Discussions in the Late Nineteenth Century," *Militärgeschichtliche Mitteilungen*, 55 (No. 1, 1996), 51-68; Tim Travers, "The Offensive and the problem of innovation in British military thought, 1870-1915," *Journal of Contemporary History*, 13 (No. 3, 1978), 531-53; Tim Travers, "Technology, Tactics, and Morale: Jean de Bloch, the Boer War, and British Military Theory," *Journal of Modern History*, 51 (June 1979), 264-86.

9. *Infantry Drill* (London: 1905); *Règlement de manoeuvre d'infanterie* (Paris: 1912, 1914); *Exerzier-Reglement für die Infanterie* (Berlin: 1906); and *Infantry Drill Regulations. U.S. Army* (Washington: 1911).

10. The most important firepower technologies were of course machine guns and quick-firing artillery. Their doctrines were well developed before the Great War. Machine gun manuals included various maneuvers and techniques of fire, along with a section of questions for instructional and testing purposes. Friedrich von Merkatz, *Unterrichtsbuch für die Maschinengewehrkompagnien: Gerat 08* (Berlin: R. Eisenschmidt, 1909); Krieger, *Das Gefecht der Maschinengewehrkompagnien* (Oldenburg: Gerhard Stalling, 1913); and *Die Maschinengewehrkompagnie, ihre Ausbildung, Führung im Gefecht und ihre Verwaltung* (Berlin: E. S. Mittler, 1914); Gobillot, *Emploi de la mitrailleuse dans le combat offensif* (Paris: Berger-Levrault, 1909); and US War Department, *Drill Regulations for Machine-Gun Platoons, Infantry, 1909* (Washington: 1909). See also A. Fleck, *Maschinengewehre: Ihre Technik und Taktik* (Berlin: E. S. Mittler, 1909); F. V. Longstaff, *The Book of the Machine Gun* (London: Hugh Rees, 1917); G. S. Hutchison, *Machine Guns: Their History and Tactical Employment* (London: Macmillan, 1938); C. H. B. Pridham, *Superiority of Fire: A Short History of Rifles and Machine-guns* (London: Percy Lund, Humpfries, 1945); David A. Armstrong, *Bullets and Bureaucrats: The Machine Gun and the United States Army, 1861-1916* (Westport, Conn.: Greenwood, 1982).

11. Michael Howard, "Men Against Fire," in *The Makers of Modern Strategy*, ed. Peter Paret (Princeton, N.J.: Princeton Univ. Press, 1986).

12. Every European army conducted "large-scale" annual maneuvers, but these involved only a few corps at most and had no live-fire component. Every army also sent observers to each major turn-of-the-century conflict. However, military planners realized that the conditions under which the Russo-Turkish War 1877-78, the Boer War 1899-1902, and the Russo-Japanese War 1904-05, took place would not come close to those expected in a general European war.

13. Bloch's treatise was well documented and exhaustively researched. The original Russian version exceeded several volumes. However, Bloch too often took his statistics and quotations out of context to make them support his own argument. The abridged English version is Jean de Bloch [Ivan Bliokh], *The Future of War in Its Technical, Economic, and Political Relations*, trans. R. C. Lory (Boston: Ginn, 1902), xiii-xvi; compare with Schlieffen, "Krieg der Gegenwart."

14. H. G. Wells, *Anticipations* (London: Putnam, 1902), pp. 212ff.

15. F. Britten Austin, "Planes!" *In Action: Studies in War* (London: Nelson, 1913); Morrow, *The Great War in the Air* and "Expectation and Reality"; Wohl, *Passion for Wings*; and Kennett, *The First Air War*.

16. Albert Robida, "La Guerre au Vingtième Siècle" (*La Caricature*, 1887), and George Griffith, "The Raid of *Le Vengeur*" (*Blackwood's*, 1901) in I. F. Clarke, *The Tale of the Next Great War, 1871-1914: Fictions of Future Warfare and Battles Still to Come* (Syracuse, NY: Syracuse Univ. Press, 1995). See also in the same volume Conan Doyle's

short story, "Danger! Being the Log of Captain John Sirius" (*Strand*, 1914), which showed how a small nation using submarines in a blockade-like fashion might defeat a larger one, equipped with a surface navy. A. A. Milne's "The Secret of the Army Aeroplane" (*Punch*, May 1908) satirized Britain's scaremongers who claimed that her technological advances lay open to foreign spies and infiltrators. Jack London's "Unparalleled Invasion: Excerpt from Walt. Nervin's `Certain Essays in History'" (*McClure's Magazine*, 1910) told how China--the "yellow menace"--attempted to conquer the world by inundating it with waves of people. The world eventually defeated China by exterminating its population through biological warfare on an unparalleled scale.

17. Richard Overy, "Heralds of Modernity: Cars and Planes from Invention to Necessity," in Mikulás Teich and Roy Porter, eds., *Fin de siècle and its Legacy* (Cambridge, Mass.: Cambridge Univ. Press, 1990), pp. 58-65; and B. R. Mitchell, *European Historical Statistics 1750-1970* (London: Macmillan, 1975), pp. 350-51.

18. Martin van Creveld, *Technology and War: From 2000 B.C. to the Present* (New York: Free Press, 1989); Bernard and Fawn Brodie, *From Cross-Bow to H-Bomb: The Evolution of the Weapons and Tactics of Warfare* (rev. ed.; Bloomington: Indiana Univ. Press, 1973); and Donald Cardwell, *The Norton History of Technology* (New York: W. W. Norton, 1995).

19. The Prusso-German army revised its *Infantry Drill Regulations* in 1888 and 1906; its *Cavalry Drill Regulations* followed suit in 1895 and 1909; its *Artillery Drill Regulations* were updated in 1907 and 1910; and its *Field Service Regulations* were revised in 1887, 1900, and 1908. During the same period, the French revised their *Infantry Drill Regulations* in 1884, 1894, 1901, 1904, and 1914; the British updated theirs in 1914; and the US Army brought its up to date five times in the 1890s. The French *Artillery Drill Regulations* were updated in 1901 and 1910, and the US Army revised its twice in the 1890s. The French updated their *Cavalry Drill Regulations* in 1911 and 1912; the British revised theirs in 1907; and the US Army brought its up to date twice in the 1890s and twice more before WWI.

20. See, for example, Alfred D. Chandler, Jr., "*Fin de siècle*: Industrial Transformation"; Overy, "Heralds of Modernity: Cars and Planes from Invention to Necessity"; and Patrick Brantlinger, "Mass Media and Culture in *fin-de-siècle* Europe"; all in Teich and Porter, *Fin de siècle and its Legacy*. Also see I. F. Clarke, *The Tale of the Next Great War, 1871-1914: Fictions of Future Warfare and Battles Still to Come* (Syracuse, NY: Syracuse Univ. Press, 1995), p. 15.

21. Hajo Holborn, *A History of Modern Germany, 1840-1945* (Princeton, N.J.: Princeton Univ. Press, 1982), pp. 367-91. Kopel S. Pinson, *Modern Germany: Its History and Civilization* (2d ed.; New York: Waveland, 1989), pp. 224-26. Paul Kennedy, *The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500-2000* (New York: Random House, 1987), pp. 243-45.

22. By 1914, commoners in the Prusso-German army accounted for 36 percent of division commanders, 20 percent of corps commanders, and 52 percent of Deputy Chiefs of Staff of the Great General Staff. Ulrich Trumpener, "*Junkers* and Others: The Rise of Commoners in the Prussian Army, 1871-1914," *Canadian Journal of History*, 14 (1979), 29-47; and Daniel Hughes, *The King's Finest* (New York: Atheneum, 1987). Similarly, the British officer corps of 1875 contained 50 percent commoners, but by 1912, this figure had risen to 59 percent. Commoners accounted for only 36 percent of officers above the rank of major-general. P. G. Razell, "Social Origins of Army Officers," *British Journal of Sociology*, 14 (No. 3, 1963), 253. Most estimates for the French army reveal that by 1899 commoners comprised 89 percent of the lower officer ranks and 70 percent in and above the grade of major general. However, one can make only the broadest estimates for the French army. The French Revolution made aristocratic origins unpopular and thus many officers attempted to disguise their roots by removing the *de* from their name. Later in the 19th century, when aristocratic origins returned to vogue, many middle-class officers added the *de* to their name, though they had not a single drop of noble blood. Douglas Porch, *March to the Marne*.

23. Umbro Apollonio, ed., *Futurist Manifestos* (New York: Viking, 1973); Asa Briggs, "Past, Present and Future in the Headlines," in Asa Briggs and Daniel Snowman, eds., *Fins de Siècle: How Centuries End 1400-2000* (New Haven, Conn.: Yale Univ. Press, 1996), pp. 157-96; Chandler, "*Fin de siècle*: Industrial Transformation"; Brantlinger, "Mass Media and Culture in *fin-de-siècle* Europe."

24. Armstrong, *Bullets and Bureaucrats*, pp. 128-29.

25. Bernard and Fawn Brodie, *From Cross-Bow to H-Bomb*.

26. One author has described these as revenge effects. Edward Tenner, *Why Things Bite Back: Technology and the Revenge of Unintended Consequences* (New York: Knopf, 1996).

27. James Dewar et al., *Assumption-Based Planning: A Planning Tool for Very Uncertain Times* (Santa Monica, Calif.: RAND, 1993). Some branches of the US Army have adopted a variant called Decision-Based Planning which uses ABP principles.

28. Appendix B of *Assumption-Based Planning* discusses the differences between ABP and other forms of long-term planning.

29. Dewar et al., *Assumption-Based Planning*, pp. 25-26.

30. John B. Rae, "The Internal-Combustion Engine on Wheels," and Lynwood Bryant, " The Internal-Combustion Engine," in Kranzberg and Pursell, *Technology in Western Civilization*, p. 123.

31. One explanation suggests that gasoline achieved "lock-in" due to the disappearance of public horse troughs--the steam car's primary source of water--after an outbreak of hoof-and-mouth disease. M. Mitchell Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York: Simon & Schuster, 1992), pp. 40-41. W. Brian Aurthur, "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *The Economic Journal*, 99 (March 1989), 116-31.

32. Cardwell, *The Norton History of Technology*, p. 352.

33. Cited from P. Wahl and D. R. Toppel, *The Gatling Gun* (London: Herbert Jenkins, 1966), p. 12.

34. Between 1904 and 1914, for example, Vickers supplied the British army with roughly 11 machine guns *per year*. This rate increased to 12 *per week* in the first months of the war. The total number delivered in 1915 would triple in 1916, and would triple again in 1917. By the end of 1918, the British army had received nearly 250,000 machine guns of all types. Ellis, *The Social History of the Machine Gun*, pp. 34-36.

35. Ian Hamilton, *A Staff Officer's Scrap-Book During the Russo-Japanese War* (London: 1912); [Repington], *The War in the Far East 1904-1905: The Military Correspondent of the Times* (London: 1905); Ellis Ashmead-Bartlett, *Port Arthur: The Siege and Capitulation* (2d ed.: London: 1906); R. M. Connaughton, *The War of the Rising Sun and Tumbling Bear: A Military History of the Russo-Japanese War 1904-5* (New York: Routledge, 1988); Denis and Peggy Warner, *The Tide at Sunrise: A History of the Russo-Japanese War, 1904-1905* (New York: Charterhouse, 1974).

36. For an account of events on the Eastern Front, see Dennis E. Showalter, *Tannenberg: Clash of Empires* (Hamden, Conn.: Archon, 1991).

37. France's Ministry of War, *Décret du 3 Décembre 1904 portant règlement sur les manoeuvres de l'infanterie* (Paris: 1904); cf. Herrmann, *The Arming of Europe*, pp. 81-84.

38. Cited in Herrmann, *The Arming of Europe*, pp. 88-89.

39. Storz, *Kriegsbild*, pp. 184-85.

40. The German Reichstag finally approved an increase of 136,000 officers and men. Gordon Craig, *Germany 1866-1945* (Oxford, Eng.: Oxford Univ. Press, 1978), pp. 295-96; and Marilyn Shevin Coetzee, *The German Army League: Popular Nationalism in Wilhelmine Germany* (Oxford, Eng.: Oxford Univ. Press, 1990), pp. 38-39.

41. Craig, *Germany*, p. 294.

42. *Knowledge & Speed*, p. 5.

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