The Promise and Surprising Peril of Military Innovation

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Prevailing wisdom suggests that innovation dramatically enhances the effectiveness of a state's armed forces. My central claim, however, is that self-defeating innovation can and does occur when a service's growing security commitments outstrip shrinking military resources. In this environment, the service is incentivized to gamble on a new capability to meet overly ambitious commitments, while also cannibalizing traditional capabilities to do so because of tight resource constraints. But the service discovers that its resulting force structure and doctrine have over-specialized in a new capability that cannot alone accomplish assigned missions, that the loss of traditional capabilities leaves the service vulnerable, and that combat units must recover older methods of war. This paper tests the plausibility of this theory by comparing British and German army innovations in armored warfare before World War II (1919–1939) and their performance in the Desert War (1941–1942).

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Prevailing wisdom suggests that innovation consistently improves military power. Militaries that oppose change court defeat, but those that innovate secure victory. Innovation is considered a sign of organizational health because the ever-changing character of war constantly threatens to render existing capabilities obsolete. Innovators are intelligent and enlightened reformers struggling against a hidebound hierarchy populated by close-minded and reactionary conservatives. Misfortune comes to those who allow the march of historical change to overtake them. The notion that innovation and better military performance come hand-in-hand is therefore intuitive. It is also wrong.

In popular imagination, for example, the German blitzkrieg was a revolutionary innovation that restored the possibility of decisive victory in World War II, which had eluded European armies since the Franco-Prussian War. What is less known is that the British also innovated in armored warfare, and yet performed poorly on the battlefield. While the German army mechanized the combined arms tactics developed at the end of World War I, the British deployed armored brigades comprised almost entirely of tanks and expected them to fight with virtually no help from supporting arms.

What is puzzling about this example is not the presence or absence of innovation—both armies innovated new forms of armored warfare—but instead why do some innovations enhance military effectiveness, while other innovations do not? Too often, analysts focus only on beneficial change, but overlook harmful innovation in military organizations. This article's purpose is to restore to innovation the atmosphere of risk that is native to it and explain why the perils of innovation deserve as much attention as its promises. To do so, I develop a theoretical framework that relates patterns of peacetime innovation to its effects on wartime effectiveness.

My central claim is that innovation is more likely to weaken a military service's effectiveness when growing security commitments outstrip shrinking resources. This commitment-resource gap creates an atmosphere of professional crisis that animates a flawed innovation process that cannibalizes traditional capabilities before beliefs about the effectiveness of a new one is justified. When wartime comes, not only has the service lost proficiency in those older capabilities, but the new capability is also ineffective, thereby creating vulnerabilities that invite exploitation by the enemy.

Studying harmful innovation is crucial for both scholarship and contemporary policy challenges. Scholars study military innovation primarily because of its promise to improve

effectiveness. But whether, when, and how peacetime innovation increases military power is usually a relationship assumed rather than studied. As such, theories of military innovation focus on identifying conditions under which major change occurs without interrogating cases of harmful innovation.[1] Explaining the adoption of new ways of war, however, says little about whether the change is beneficial or harmful.

For defense policy, this article sounds a cautionary note about over-reliance on military innovation as a means of bridging wide commitment-resource gaps. The United States is in an era of military modernization in which military officers and civilian leaders must make important decisions about future platforms and systems that will shape U.S. military power for a long time to come. At the same time, the military is still in an era of constrained resources. The confluence of these trends creates pressure to make big bets on new capabilities and take risks in shedding traditional ones. My theory and findings suggest, however, that it is precisely this type of environment that encourages miscalculation.

This article proceeds in nine sections. First, I review the existing literature on military innovation, emphasizing the curious absence of studies that systematically study the downside risks of innovation. Second, I conceptualize military innovation in a way that encompasses various approaches to the phenomenon while also serving as a framework for understanding its relationship to military power. The third section provides a theory of harmful military innovation. In the fourth section, I introduce the puzzling case of British armor innovation and discuss the research design. Sections five, six, and seven test the theory, tracing British and German armor innovation in the interwar period and performance in the Desert War in World War II. I then evaluate alternative explanations in section eight, before concluding with implications for military innovation studies and defense policy.

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[1] On the role of civil-military relations, see Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca, N.Y.: Cornell University Press, 1984); Deborah Avant, *Political Institutions and Military Change: Lessons from Peripheral Wars* (Ithaca, N.Y.: Cornell University Press, 1994). On the role of inter-service politics, see Owen Coté, Jr., "The Politics of Innovative Military Doctrine: The U.S. Navy and Fleet Ballistic Missiles," Ph.D. dissertation, Massachusetts Institute of Technology, 1996. On the role of intra-service politics, see Stephen Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, N.Y.: Cornell University Press, 1991); Benjamin Jensen, *Forging the Sword: Doctrinal Change in the U.S. Army* (Stanford, Calif.: Stanford University Press, 2016). On the role of culture, see Elizabeth Kier, *Imagining War: French and British Military Doctrine between the Wars* (Princeton, N.J.: Princeton University Press, 1997); Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the US, and Israel* (Stanford, Calif.: Stanford University Press, 2010); Austin Long, *The Soul of Armies: Counterinsurgency Doctrine and Military Culture in the US and UK* (Ithaca, N.Y.: Cornell University Press, 2016).

Innovation and the Promise of Military Power

In popular discourse, the word "innovation" connotes desirable progress. The same is true in research on international relations and military innovation. Theories of international relations assume that it enhances a state's power in the international system. Innovation changes "the unit cost of military power" such that a given supply of resources is converted more efficiently into wartime effectiveness. Robert Gilpin argued that military innovation gives a "particular society a monopoly of superior armament or technique and dramatically decreases the cost of extending the area of domination,"[2] John Mearsheimer similarly observes that great powers "prize innovation" because it offers "new ways to gain advantage over opponents."[3] Assuming then that innovation bestows a competitive edge over rival armed forces, "contending states imitate the military innovations contrived by the country of greatest capability and ingenuity."[4]

Theories of military innovation reflect this optimistic view. In his influential review of the literature, Adam Grissom identified a "tacit definition of military innovation that is, approximately, 'a change in operational praxis that produces a significant increase in military effectiveness' as measured by battlefield results." He found that "only reforms that produce greater military effectiveness are studied as innovations, and few would consider studying counterproductive policies as innovations."[5] Some later adopted Grissom's descriptive definition as prescriptive, making effectiveness a defining feature of military innovation.[6]

The equation of peacetime innovation with greater military effectiveness, however, is puzzling because scholars do recognize that the two are not synonyms.[7] In 1984, Barry Posen categorized military doctrine as either innovative or stagnant, but recognized that "neither … should be valued a priori." He suggested that instead of stagnation, "*stability* might be a better

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[2] Robert Gilpin, *War and Change in World Politics* (New York: Cambridge University Press, 1981), p. 60.
[3] John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York: W. W. Norton & Company, 2001), p. 166.
[4] Kenneth Waltz, *Theory of International Politics* (New York, NY: McGraw-Hill Higher Education, 1979), p. 127.
[5] Adam Grissom, "The Future of Military Innovation Studies," *Journal of Strategic Studies*, Vol. 29, No. 5 (2006), p. 907.
[6] For example, see Nina Kollars, "Military Innovation's Dialectic: Gun Trucks and Rapid Acquisition," *Security Studies*, Vol. 23, No. 4 (2014), p. 790; Adam M. Jungdahl and Julia M. Macdonald, "Innovation Inhibitors in War: Overcoming Obstacles in the Pursuit of Military Effectiveness," *Journal of Strategic Studies*, Vol. 38, No. 4 (2015), p. 469.
[7] For a definition of military innovation that deliberately *excludes* effectiveness, see Michael Horowitz, *The Diffusion of Military Power: Causes and Consequences of International Politics* (Princeton, N.J.: Princeton University Press, 2010), p. 23.

choice of terms, as it is less loaded."[8] Militaries that "innovate in peacetime do so with considerable uncertainty and ambiguity about the nature and context of the next major conflict," so the historians Allan Millett and Williamson Murray caution "that wrong choices and irrelevant investments will occur and will be hard to correct."[9] Others warn that "it is entirely possible that a military innovation may make a military less effective," and that "[n]ot all innovations should be welcomed."[10]

Nonetheless, virtually all theories of military innovation are built and tested on cases of performance-enhancing innovations. Posen's influential study of the Battle of France and the Battle of Britain found that it was military services that innovated before the war that achieved political-military integration.[11] In *Winning the Next War*, another agenda-setting book, Stephen Rosen ignored "innovations that were put into practice but were clearly mistaken" because "despite an extensive and intensive search, no clear-cut cases of bad innovation in the United States military were found." Although the U.S. military made mistakes, "they all appear to have been the result of failures to innovate, rather than inappropriate innovations."[12] Despite a proliferation of case studies, military innovation research continues to focus almost exclusively on major changes that led to better combat performance.

I am aware of only two published studies in political science that explicitly theorize about the negative consequences of military innovation.[13] Chris Demchak and Jon Lindsay emphasize how the complexity of military technology can hamper combat performance. As technology and associated operations become more complex, military organizations need to know more information about their intricacies to operate effectively, but at the same time can struggle to

[8] Posen, *The Sources of Military Doctrine*, p. 29. Emphasis in original.
[9] Williamson Murray and Allan R. Millett, "Military Effectiveness Twenty Years Later," in Allan R. Millett and Williamson Murray, eds., *Military Effectiveness*, Vol. 2: *The Interwar Period* (New York: Cambridge University Press, 1988), p. xiii.
[10] Theo Farrell, Sten Rynning, and Terry Terriff, *Transforming Military Power since the Cold War: Britain, France, and the United States, 1991–2012* (New York: Cambridge University Press, 2013), p. 8; Harvey M. Sapolsky, "On the Theory of Military Innovation," *Breakthroughs*, Vol. 9, No. 1 (2000), p. 35.
[11] Posen, *The Sources of Military Doctrine*, pp. 25, 102–104.
[12] Rosen, *Winning the Next War*, p. 53. See also Adamsky, *The Culture of Military Innovation*, p. 2.
[13] In an unpublished manuscript, Paul MacDonald argues that innovation can divert investments away from critical technologies, or the competitive edge of a new weapon can be turned against first movers as it diffuses across the international system. Paul K. MacDonald, "Revenge of the Luddites: The Logic of Self-Defeating Military Innovation," unpublished manuscript. Cited with permission. On the diffusion logic, see Emily O. Goldman and Richard B. Andres, "Systemic Effects of Military Innovation and Diffusion," *Security Studies*, Vol. 8, No. 4 (1999), pp. 79–125.

manage the flow of information.[14] These scholars offer an important corrective to the pro-innovation consensus.

Based on an assumption that major military change improves performance, the literature overwhelmingly focuses on merely explaining the presence or absence of peacetime innovation. It therefore offers surprisingly thin expectations about whether, when, and how innovation affects military power.[15] This strips the concept of military innovation of its most interesting and dangerous attribute—innovation is a gamble that costly changes are worth making.

What is Military Innovation?

Military innovation is defined here as the process of creating a new capability—a new institutionalized technique of organized violence intended to convert a service's resources into mission success.[16] Capabilities are embodied in the service's organization and equipment (i.e., force structure) and a relatively ordered and consistent way of using these components in combat (i.e., doctrine).[17] They instantiate preferred logics of using military force in response to particular historical modes of war.[18] An air wing designed for strategic bombing, for instance, will be organized, equipped, and trained to operate in a way distinct from close air support. Innovation thus involves changes to force structure and doctrine.[19]

I scope the concept to peacetime major innovations at the service level. Most studies distinguish between peacetime innovation and wartime adaptation because the performance

[14] Chris C. Demchak, *Military Organizations, Complex Machines* (Ithaca, N.Y.: Cornell University Press, 1991); Jon R. Lindsay, *Information Technology and Military Power* (Ithaca, N.Y.: Cornell University Press, 2020), pp. 240–242.
[15] This is less true for wartime innovation because militaries have the benefit of performance feedback from combat experiences. But even in wartime, learning is difficult. See Rosen, *Winning the Next War*, p. 22; Kristen Harkness and Michael Hunzeker, "Military Maladaptation and the Politics of Counterinsurgency," *Journal of Strategic Studies*, Vol. 38, No. 6 (2015), pp. 777–800.
[16] For similar definitions in military innovation studies, see Kimberly Marten Zisk, *Engaging the Enemy: Organization Theory and Soviet Military Innovation, 1955-1991* (Princeton, N.J.: Princeton University Press, 1993), p. 4; Harvey M. Sapolsky, Brendan R. Green, and Benjamin H. Friedman, "The Missing Transformation," in Harvey M. Sapolsky, Brendan R. Green, and Benjamin H. Friedman, eds., *US Military Innovation Since the Cold War: Creation without Destruction* (New York: Routledge, 2009), p. 6; Horowitz, *The Diffusion of Military Power*, pp. 22–23.
[17] Trevor N. Dupuy, *The Evolution of Weapons and Warfare* (Boston, Mass.: Da Capo Press, 1984), p. 9.
[18] J.F.C. Fuller, *The Conduct of War 1789-1961* (New Brunswick, N.J.: Rutgers University Press, 1961), p. 254.
[19] Posen, *The Sources of Military Doctrine*, 13; Adamsky, *The Culture of Military Innovation*, p. 1; Emily O. Goldman and Leslie C. Eliason, "Introduction: Theoretical and Comparative Perspectives on Innovation and Diffusion," in Emily O. Goldman and Leslie C. Eliason, eds., *The Diffusion of Military Technology and Ideas*, (Stanford, Calif.: Stanford University Press, 2003), pp. 7–8.

feedback from combat creates a learning environment that is unavailable in peace.[20] I additionally scope the analysis to "major" military innovations, which Michael Horowitz defines as "a major change in the conduct of warfare" that involves "shifts in the core competencies of military organizations, or shifts in the tasks that the average soldiers perform."[21]

The ostensible purpose of innovation is to enhance military effectiveness. The economist Joseph Schumpeter defined innovation as a new production function that changes the rate of converting a fixed quantity of factors into products.[22] In similar fashion, military innovation is intended to improve the efficiency of converting allocated resources—money and personnel—into mission success. Ideally, armed forces field capabilities that maximize their chances of accomplishing assigned missions at a minimal cost in resources.[23] By creating a new capability, military innovation promises to increase these chances.

But the promise of resource efficiency and mission effectiveness comes with risks. The first risk is that creating a new capability is a step into the unknown where the military lacks the benefit of experience, hindsight knowledge, and relevant skills—newness is a liability.[24] The second risk is the destruction of old capabilities in the process of creating new ones.[25] As military organizations innovate, they are "down-grading or abandoning of older concepts of operation and possibly of a formerly dominant weapon."[26] In other words, "a military service destroys or thoroughly redirect an important part of itself."[27] But destroying traditional capabilities is risky because they often have a proven track record as battle-tested methods of generating military power. Maintenance of existing "infrastructure"—which is unglamorous and related to old

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[20] For example, see Rosen, *Winning the Next War*, pp. 5–8; Theo Farrell, "Improving in War: Military Adaptation and the British in Helmand Province, Afghanistan, 2006-2009," *Journal of Strategic Studies*, Vol. 33, No. 4 (2010), pp. 568–569; David Barno and Nora Bensahel, *Adaptation under Fire: How Militaries Change in Wartime* (New York: Oxford University Press, 2020), pp. 12–17.

[21] Horowitz, *The Diffusion of Military Power*, p. 22–23. On major versus minor innovation, see Theo Farrell and Terry Terriff, "The Sources of Military Change," in Theo Farrell and Terry Terriff, eds., *The Sources of Military Change* (Boulder, Colo.: Lynne Rienner, 2002), p. 5.

[22] Joseph Schumpeter, *Business Cycles* (New York: McGraw-Hill, 1939), pp. 87–88.

[23] Klaus Knorr, *The Power of Nations: The Political Economy of International Relations* (New York: Basic Books, 1975), p. 65.

[24] Joseph Schumpeter, *Capitalism, Socialism and Democracy* (New York: Harper Perennial, 1942; repr., 2008), p. 132; John Freeman, Glenn R. Carroll, and Michael T. Hannan, "The Liability of Newness: Age Dependence in Organizational Death Rates," *American Sociological Review*, Vol. 48, No. 5 (1983), pp. 692–710; Michael L. Tushman and Philip Anderson, "Technological Discontinuities and Organizational Environments," *Administrative Science Quarterly*, Vol. 35, No. 4 (1986), pp. 604–633.

[25] The notion of "creative destruction" comes from Schumpeter, *Capitalism, Socialism, and Democracy*, p. 83.

[26] Rosen, *Winning the Next War*, p. 7.

[27] Coté, "The Politics of Innovative Military Doctrine," pp. 8–9.

investments—is a central activity for the survival and continued success of effective organizations.[28]

For innovation to improve military effectiveness, it must create more combat power than it destroys. A service ideally calibrates its balance of capabilities such that the marginal benefit of a new capability equals the marginal cost to traditional ones. The challenge is that the optimal balance between creation and destruction is unknown. If the organization invests too heavily in the new capability, the costs to long-established capabilities can weaken the service's overall combat performance. Destructive changes are not adequately compensated by the creative developments allegedly taking their place. But if it invests too little, it foregoes potential gains in military effectiveness. Innovation is therefore an exercise in risk management, a balancing act between the promises of a new capability and the perils of losing older ones.

A Theory of Harmful Innovation

My central claim is that harmful innovation is more likely to occur when military services, faced with growing security commitments that outstrip shrinking resources, make desperate gambles on new capabilities to meet overly ambitious goals, all while cannibalizing its older capabilities. The service treats innovation as a silver bullet and endorses the destruction of traditional capabilities before they can justify their beliefs about the effectiveness of the new one. The service later discovers that the new capability alone cannot accomplish assigned missions, that the enemy can exploit vulnerabilities produced by the loss of traditional capabilities, and that it must resort to traditional capabilities as a backstop to shore up its fighting power.

COMMITMENT-RESOURCE GAPS AND THE WICKED MISMATCH

Matching commitments and resources is a perennial concern of statecraft. The American journalist Walter Lippmann popularized the idea that "foreign policy consists in bringing into balance, with a comfortable surplus of power in reserve, the nation's commitments and the nation's power."[29] The strategic ideal is to achieve an economically solvent alignment between commitments and

[28] Andrew L. Russell and Lee Vinsel, "After Innovation, Turn to Maintenance," *Technology and Culture* 59, no. 1 (2018), pp. 1–25.
[29] Walter Lippmann, *U.S. Foreign Policy: Shield of the Republic* (Boston, Mass.: Little, Brown, 1943), p. 9.

resources.[30] But when available means are deficient to cover desired political ends, there is what scholars of foreign policy have called overstretch or overcommitment.[31] My theory emphasizes the ways in which the confluence of expanding commitments and shrinking resources—what I call a "wicked mismatch"—shapes innovation processes in harmful ways.

Security commitments refer to the mission burdens assigned to a military service. Some commitments are written down in treaties or domestic legislation, while others are declared in speeches announcing a vital interest or policy doctrine. The service uses these commitments to set appropriate benchmarks for the size, shape, and types of its forces, which need to be resourced by the state through the allocation of money and personnel.[32] Money is needed to maintain or expand force structures, training regimens, military bases, administration, and operations. A service also worries about whether it has enough personnel with the requisite skill and training to accomplish assigned missions. The service invests these resources into capabilities.

A commitment-resource gap opens when a service's mission burdens grow, its allocation of money and personnel shrink, or both. The state might acquire new territories and bases to defend, make or expand security guarantees to allies and partners, or face growing threats that render missions more difficult to accomplish, such as relative growth in a potential adversary's military strength. A gap can also open when the state reduces the service's allocated money or personnel. It might redirect money to other investments or public or civilian consumption.[33] A rival service may threaten its relevance and compete for its share of the budget. The quantity and quality of personnel can also vary given the relevant population's age distribution or the system of military recruitment.[34] If the state reduces resources or expands commitments, all else being equal, it can weaken or exceed the service's capabilities and, by implication, its military effectiveness.

Military innovation is attractive because it is a politically cheap way to bridge a commitment-resource gap, compared to the alternatives. One alternative is retrenchment in the form of territorial withdrawal, diplomatic accommodation, appeasement, arms control, or

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[30] Ibid., pp. 7–8.
[31] Harold Sprout and Margaret Sprout, "'Retreat from World Power': Processes and Consequences of Readjustment," *World Politics*, Vol. 15, No. 4 (1963), p. 659.
[32] I focus here on two prominent military-relevant resources, see Mearsheimer, *The Tragedy of Great Power Politics*, p. 55. But there are many others. For example, see Knorr, *The Power of Nations*, pp. 45–78.
[33] Harold Sprout and Margaret Sprout, "The Dilemma of Rising Demands and Insufficient Resources," *World Politics*, Vol. 20, No. 4 (1968), pp. 686–89; Klaus Knorr, *War Potential of Nations* (Princeton, N.J.: Princeton University Press, 1956), pp. 23, 231–39.
[34] Knorr, *War Potential of Nations*, pp. 167–169; Eliot A. Cohen, *Citizens and Soldiers: The Dilemmas of Military Service* (Ithaca, N.Y.: Cornell University Press, 1985), pp. 117–151.

increasing reliance on allies.[35] Doing so, however, may weaken the state's security posture, embolden rivals, and afford political opponents the opportunity to criticize incumbent leaders for destroying the country's international reputation or credibility, betraying allies, or being "soft" toward a security threat. Another alternative is a military buildup—to extract and/or allocate a larger portion of national resources to the service.[36] But constituents might prefer more spending on butter and less on guns; or policymakers might believe that a buildup will destabilize the economy.

In contrast to these alternatives, innovation promises to restore the service's effectiveness by increasing efficiency without the political costs of reducing commitments or expanding resources.[37] If political leaders reject retrenchment or a military buildup, the affected service is incentivized to innovate. Whether it does so is outside the scope of this theory, but the type of commitment-resource gap has important implications for whether innovation, if it occurs, is likely to deliver. I propose two types of gaps: an undermatch that permits healthier innovation, and a wicked mismatch that exerts harmful pressures on an innovation process.

An undermatch—when resources are shrinking *or* commitments are expanding—is a condition of optimal stress for innovation because the gap between current achievement and aspiration is not so wide as to completely dwarf the effectiveness of existing capabilities.[38] Most theories of military innovation begin with an undermatch. Some scholars emphasize changes in the external security environment that increase the mission burden, whether it be the imminence of war,[39] changes in an opponent's military strategy or the technological landscape,[40] or the addition of new missions.[41] Others focus on the role of reduced resources, such as shortened service for conscripts or civilians manipulating budget levels to incentivize innovation.[42] If

[35] Daniel Treisman, "Rational Appeasement," *International Organization*, Vol. 58, No. 2 (2004), pp. 345–373; Joseph M. Parent and Paul K. McDonald, "Graceful Decline? The Surprising Success of Great Power Retrenchment," *International Security*, Vol. 35, No. 4 (2011), p. 12.
[36] Waltz, *Theory of International Politics*, p. 118; Mearsheimer, *The Tragedy of Great Power Politics*, p. 157; Joseph M. Parent and Sebastian Rosato, "Balancing in Neorealism," *International Security*, Vol. 40, No. 2 (2015), pp. 51–86.
[37] Gilpin, *War and Change in World Politics*, pp. 188–189.
[38] James G. March and Herbert A. Simon, *Organizations* (New York: Wiley, 1958; second ed., Blackwell Publishers, 1993), p. 184.
[39] Posen, *The Sources of Military Doctrine*, pp. 59, 74–75.
[40] Rosen, *Winning the Next War*, p. 76; Zisk, *Engaging the Enemy*, pp. 3–4.
[41] Sapolsky, Friedman, and Green, "The Missing Transformation," pp. 8–9; Rebecca D. Patterson, *The Challenge of Nation-Building: Implementing Effective Innovation in the U.S. Army from World War II to the Iraq War* (Lanham, Md.: Rowman & Littlefield, 2014), p. 3.
[42] Kier, *Imagining War*, pp. 56–88; Coté, "The Politics of Innovative Military Doctrine," pp. 339–342.

innovation occurs amid a commitment-driven or resource-driven gap, it tends to be more incremental and less radical because the gap is not wide enough to incentivize large gambles on new, relatively untested capabilities. The innovation process is protracted as the new capability undergoes iterative testing through war-games, experiments, exercises, and possibly civilian scrutiny. In the process, the service tries to balance a drive for continuous structural reforms and the need for stability and confidence in existing doctrinal concepts.[43]

In contrast, I expect harmful innovation to occur when a service's commitments are increasing *and* its resources are decreasing, a situation I call a "wicked mismatch."[44] Whereas an undermatch leaves open the relevancy of some traditional capabilities, in a wicked mismatch, these capabilities are not only rendered ineffective by the ambition of future missions but also threatened by the pressures of severe resource scarcity.[45] The service is therefore in a professional crisis: officers doubt their service can perform assigned missions successfully, worry about their continuing relevance to national security, and fear that the security of the state is at risk. Innovation becomes a desperate, high-payoff, low-probability gamble to resolve the wicked mismatch.[46]

FLAWED INNOVATION PROCESS

The atmosphere of professional crisis generated by a wicked mismatch can produce flaws in the innovation process, with three particularly dangerous characteristics: radical proposals, wishful thinking, and rushed development.

First, a wicked mismatch elicits radical proposals for a new capability that can dramatically increase effectiveness and improve efficiency all while substituting for traditional capabilities. In professional military organizations, officers are expected to be constantly searching for new solutions to their service's problems.[47] Innovative proposals in themselves are thus not so surprising. What makes these proposals different is their radicalism and their ready audience. Radicalism refers to the degree of creative destruction. The new capability promises to do much

[43] Posen, *The Sources of Military Doctrine*, pp. 30–31.
[44] The term is drawn from what policy researchers call a "wicked problem." See C. West Churchman, "Wicked Problems," *Management Science*, Vol. 14, No. 4 (1967), pp. 141–146.
[45] On new performance targets rendering existing routines ineffective, see Arthur L. Stinchcomb, *Stratification and Organization* (Cambridge: Cambridge University Press, 1986).
[46] For analogous dynamics of desperation in wartime, see Alexander B. Downes, *Targeting Civilians in War* (Ithaca, N.Y.: Cornell University Press, 2008), pp. 29–35; Hein Goemans, *War and Punishment: The Fate of Leaders and the First World War* (Princeton, N.J.: Princeton University Press, 2000), pp. 14–15, 39–40.
[47] Jensen, *Forging the Sword*, pp. 16–17.

more with much less if the new capability cannibalizes traditional ones. Such proposals should fare poorly in hierarchical and conservative military bureaucracies, but the crisis produced by a wicked mismatch opens an opportunity structure for radical proposals to gain an audience. Desperation converts professional skepticism into a predilection for sweeping reforms and disruptive change to organization and doctrine.

Therefore, second, a wicked mismatch incentivizes wishful thinking that overemphasizes the rewards of innovation. An innovating service might prefer to keep a healthy portion of its investments spread across existing capabilities, while also exploring new ones. But a wicked mismatch deprives it of this luxury. Moreover, there is an overriding organizational imperative to find an intellectual justification for the service's continued relevance.[48] Desperation motivates generous interpretations of the limited data about the new capability's effectiveness. Officers might interpret experimental data using a one-size-fits-all approach to problem solving. If a capability allows the army to win major wars, for instance, this means it will be effective at fighting small wars as well.

Third, the professional crisis rushes the innovation process, reducing the quality of vetting. Acceleration increases the risk of implementing inferior procedures—what organization theorists call a "competency trap."[49] This is particularly dangerous when undertaking major changes in the conduct of modern warfare, which is a highly complex and difficult activity. The larger the magnitude of change, the more complications will arise, the more countervailing problems will emerge that must be addressed, all of which takes time and careful consideration. Radical change is not inherently harmful, but it incurs a higher degree of risk that requires time and resources to properly assess and manage.

In standard accounts, a military innovation process unfolds as a protracted even decades-long struggle between conservatives and innovators.[50] Naval aviators championing the aircraft carrier, for example, faced opposition from battleship admirals. The conservatives—a better term is maintainers—are often criticized for wanting to maintain outmoded ways of war. But the intellectual and bureaucratic tug-of-war serves a virtuous purpose because "debate and resistance

[48] Philip Selznick, *Leadership in Administration* (Evanston, Ill.: Row, Peterseon and Company, 1957), p. 14.
[49] Barbara Levitt and James G. March, "Organizational Learning," *Annual Review of Sociology*, Vol. 14 (1988), pp. 322–323; Daniel A. Levinthal and James G. March, "The Myopia of Learning," *Strategic Management Journal*, Vol. 14, No. S2 (1993), pp. 101–106.
[50] Horowitz, *The Diffusion of Military Power*, pp. 23–29.

are required to separate the truly good from the merely new among innovations."[51] Maintainers can serve as a healthy check on magical thinking untethered from reality.

But in desperation, a service can rationalize away even highly plausible criticisms and ignore contemporary evidence that the promises of the new capability may be exaggerated.[52] Innovators can parry critiques using a variety of counterarguments because peacetime experiments are necessarily artificial in nature. Enemy countermeasures, for instance, will be limited. The new capability will cover the vulnerabilities opened by the loss of traditional methods. Or, prototype units are not a true representation of what the new capability can accomplish. They may even find reassurance in the belief that unforeseen obstacles will be dealt with by future creativity.

In sum, a wicked mismatch elicits radical proposals for a new capability that promises to make the service more effective at its assigned missions while doing so with much fewer resources than traditional capabilities. At the same time, the wicked mismatch incentivizes wishful thinking among military officers to believe the promises of the new radical capability and move toward implementation without seriously grappling with plausible criticisms.

MILITARY EFFECTIVENESS

The theory expects an innovation process conducted under the pressures of a wicked mismatch to produce ineffective combat forces. Military effectiveness is the ability of a service to accomplish its assigned missions at acceptable cost.[53] It is ultimately about producing favorable outcomes, with the desired objectives varying between mission contexts.[54] Also, mission success will come at a cost in terms of the soldiers and materiel, and possibly territory.[55] What is considered acceptable cost is determined by political stakes and commanders' intent. An army might choose, for example, to cede meaningless tracts of land to score a defensive victory, but to lose politically significant territory would render the mission a failure.

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[51] Sapolsky, Green, and Friedman, "The Missing Transformation," pp. 6–7.
[52] This has been called the "superman syndrome." See Anthony Downs, *Inside Bureaucracy* (Boston, Mass.: Little & Brown, 1967), pp. 216–219.
[53] This definition is based on Dan Reiter, "Confronting Trade-Offs in the Pursuit of Military Effectiveness," in Dan Reiter, ed., *The Sword's Other Edge: Trade-Offs in the Pursuit of Military Effectiveness* (New York: Cambridge University Press, 2017), p. 4.
[54] Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, N.J.: Princeton University Press, 2004), pp. 5–6.
[55] On the importance of cost for power analysis, see David A. Baldwin, *Power and International Relations: A Conceptual Approach* (Princeton, N.J.: Princeton University Press, 2016), pp. 86–90.

Innovation harms military effectiveness insofar as it prevents fielded combat forces from achieving mission objectives, or from doing so at acceptable levels of cost in lives and equipment. The drivers of ineffectiveness are two-fold. First, combat forces associated with the new capability find that their organization and doctrine fail to deliver the promised decisive effects in combat. This could be because underlying technology is premature or the enemy deploys predictable countermeasures, among other possible obstacles to effectiveness. The point is not the specific problems, but rather that the service willfully ignored or wished away these concerns in their desperate search for silver bullet solutions. Second, traditional capabilities have atrophied, and the service cannot rely on these either. The innovation process ignored foreseeable vulnerabilities that would emerge if the service did not maintain its traditional methods—the very capabilities developed to prevent these vulnerabilities. The service over-specialized in a new capability to its own detriment.

A final indicator of harmful innovation is that, over time, disappointing results in combat prompts the service to unlearn or abandon the new capability and restore traditional ways of war. Reverting to older methods is an attempt to shore up combat power after the promises of military innovation—to increase the likelihood and extent of mission success and decrease the related costs—are unmet. The innovation is revealed to have been too radical, and the service must reverse creative destruction.

The Puzzle of British Performance in the Desert War, 1941–1942

I test the theory by comparing two military organization—the British and German interwar armies—that innovated with armor technology but did so under different types of commitment-resource gaps and thus innovated differently, with significant repercussions for battlefield performance in World War II. One of the most enduring images of World War II remains the so-called "blitzkrieg" that swiftly defeated France. The British Expeditionary Force, in contrast, hastily withdrew out of Dunkirk and, in the following years, the Eighth Army performed poorly against Axis forces in North Africa. According to standard treatments in political science and

strategic studies, the German army was effective because it innovated "blitzkrieg," whereas its British counterpart failed to innovate and performed poorly.[56] Both interpretations need correction.

The "blitzkrieg" is a misleading myth that the Germans innovated a revolutionary fully-mechanized approach to mobile warfare.[57] Rather than a "mechanized juggernaut," however, the Wehrmacht was a semi-modern, "semi-motorized" army reliant primarily on feet, horses, and railroads for movement.[58] The difference from World War I was that the radio and the internal combustion engine accelerated the tempo of combat operations for a select group of assault divisions. Otherwise, the German army applied traditional German principles of operation-level movement, concentration of mass at a single point of main effort, encirclement, deep penetration, and decentralized mission command.[59]

The blitzkrieg myth complements another misleading narrative that British armor innovation failed because conservative army leaders suppressed a small group of prophetic tank enthusiasts, which resulted in weak army performance on the armor-dominated battlefields of World War II. This narrative, advanced by the prolific military thinker Basil H. Liddell Hart, remained dominant until the 1980s, when historians noticed that Britain's interwar army favored reform and mechanization, contrary to orthodox accounts. Inspired by futuristic visions of mechanical warfare, the British army actually relied too heavily on armor organized in tank-heavy combat formations as the decisive arm on the battlefield.[60]

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[56] Posen, *The Sources of Military Doctrine*, p. 182; Kier, *Imagining War*, pp. 120–121. For other similar interpretations, see Williamson Murray, "Armored Warfare: The British, French, and German Experience," in Williamson Murray and Allan R. Millet, eds., *Military Innovation in the Interwar Period* (New York: Cambridge University Press, 1996), pp. 21–29; John Stone, "The British Army and the Tank," in Theo Farrell and Terry Terriff, eds., *The Sources of Military Change: Culture, Politics, Technology* (Boulder, Colo.: Lynne Rienner, 2002), pp. 193–194.

[57] Karl-Heinz Frieser, *The Blitzkrieg Legend: The 1940 Campaign in the West*, trans. John T. Greenwood (Annapolis, Md.: Naval Institute Press, 2005).

[58] Richard L. DiNardo, *Mechanized Juggernaut or Military Anachronism?: Horses and the German Army of World War II* (Westport, Conn.: Greenwood Press, 1991), p. 6; Martin van Creveld, *Supplying War* (Cambridge: Cambridge University Press, 1997), p. 142.

[59] Martin van Creveld, *Fighting Power* (Westport, Conn.: Greenwood, 1974), pp. 35–37; Martin Samuels, "Doctrine for Orders and Decentralization in the British and German Armies, 1885–1935," *War in History*, Vol. 22, No. 4 (2015), pp. 463–464; Frieser, *The Blitzkrieg Legend*, pp. 329–339.

[60] For the Liddell Hart thesis, see B.H. Liddell Hart, *The Tanks: The History of the Royal Tank Regiment and Its Predecessors Heavy Branch Machine-Gun Corps, Tank Corps and Royal Tank Corps, 1914–1945*, Vol. 1: *1914–1939* (New York: Frederick A. Praeger, 1959). For revisionist accounts, see Robert H. Larson, *The British Army and the Theory of Armored Warfare, 1918–1940* (Newark, N.J.: University of Delaware Press, 1984); Harold R. Winton, *To Change an Army: General Sir John Burnett-Stuart and British Armored Doctrine, 1927–1938* (Lawrence, Kans.: University Press of Kansas, 1988); John J. Mearsheimer, *Liddell Hart and the Weight of History* (Ithaca, N.Y.: Cornell University Press, 1988); J. P. Harris, *Men, Ideas and Tanks: British Military Thought and Armoured Forces, 1903–1939* (New York: Manchester University Press, 1995).

British armored warfare is therefore a "hard case" because the case outcome is surprising from the perspective of previously established theory yet matches the expectations of a new argument.[61] The narrative of British ineffective traditionalism and German effective radicalism has remained attractive because it conforms to the dubious assumption that innovation consistently improves military effectiveness. But any praise of German adoption of "blitzkrieg" ideas, and condemnation of British conservatism, must assume that the ideas would have worked if tried—but the Germans never did try it, and the British army in many respects did.[62]

To test the theory, I examine British and German armor innovation in two stages. First, the two armies innovated within the context of different commitment-resource gaps—the Germans in an undermatch and the British in a wicked mismatch. By examining objective indicators (i.e., foreign policy decisions, service budgets, troop levels) and subjective perceptions (i.e., the way service leaders describe strategic challenges), I identify whether each respective army faced an undermatch or wicked mismatch. Additionally, I trace the interwar debates among innovators and maintainers to observe whether the theorized characteristics of flawed innovation were present: radical proposals, wishful thinking, and a rushed process that dismisses critics. I draw British evidence from a variety of sources, including official government documents, internal army memoranda, contemporary army publications, the personal papers of key actors, published memoirs, and official histories.

To be clear, the British case study is a direct test of the argument, but the German comparison is not. The theory proposes that a wicked mismatch imposes harmful pressures on an innovation process, but an undermatch is merely permissive of beneficial innovation.[63] The German case therefore serves as a demonstration that the absence of a wicked mismatch permits a healthier innovation process and holds constant some factors that could potentially account for the divergent outcomes in innovation effectiveness. But the theory is agnostic about whether innovation amid an undermatch is more or less likely to be beneficial or harmful.

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[61] Aaron Rapport, "Hard Thinking About Hard and Easy Cases in Security Studies," *Security Studies*, Vol. 24, No. 3 (2015), p. 457. See also Alexander George, *Case Studies and Theory Development in the Social Sciences* (Cambridge, Mass.: MIT Press, 2005), p. 9; George Bennett and Colin Elman, "Case Study Methods in the International Relations Subfield," *Comparative Political Studies*, Vol. 40, No. 2 (2007), pp. 173–174.

[62] Timothy Harrison Place, *Military Training in the British Army, 1940–1944: From Dunkirk to D-Day* (London: Frank Cass, 2000), p. 96; James Corum, *The Roots of Blitzkrieg: Hans Von Seeckt and German Military Reform* (Lawrence, Kans.: University Press of Kansas, 1992), pp. 141–143.

[63] Gary Goertz, *Multimethod Research, Causal Mechanisms, and Case Studies: An Integrated Approach* (Princeton, N.J., Princeton University Press, 2017), pp. 70–71, 98–100.

After tracing the British and German innovation processes, the second stage analyzes their battlefield performance in the Desert War from February 1941 to November 1942. I selected this conflict because if prewar armor innovation is left out of the analysis, the British should have been the favored belligerent. At the outset of almost every battle, British forces had a quantitative superiority in infantry, tanks, and artillery. Also, British equipment was at least qualitatively equivalent to German tanks and artillery.[64] To be sure, the Germans had superior anti-tank guns, but British superiority in field artillery could have been used to negate this advantage.[65] Finally, some theories of military effectiveness emphasize regime type, arguing that democracies produce better armies because their meritocratic systems promote higher-quality commanders and liberal values cultivate tactical initiative.[66] But Britain was the relatively democratic belligerent, not Germany.

There are also historically-contingent reasons why the British army was favored. The British army was present and had trained and prepared to fight in the desert, and by none other than Percy Hobart, the army's leading armor innovator at the time.[67] In fact, desert warfare embodied everything British armor innovators dreamed of: a featureless landscape allowing fluid offensives carried out by fast tanks.[68] In contrast, the Germans armor organization and doctrine were developed with the narrower topographies of Europe in mind.[69]

I selected the time period of February 1941—when German armored forces began to arrive in Libya—to November 1942 because the periods before and after offer more ambiguous tests of the role of armor innovation in British ineffectiveness. In the Battle of France (May–June 1940),

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[64] On the favorable numerical and qualitative balance between British against German materiel in North Africa, see J.A.I. Agar-Hamilton, *Crisis in the Desert, May–July, 1942* (Cape Town: Oxford University Press, 1952), pp. 10–13; J.A.I. Agar-Hamilton and L.C.F. Turner, *The Sidi Rezeg Battles, 1941* (Cape Town: Oxford University Press, 1957), pp. 36–50, 53–56; Michael Carver, *Tobruk* (Philadelphia, Pa.: Dufour Editions, 1964), pp. 256–257. For less favorable views, see I.S.O. Playfair, *The Mediterranean and Middle East*, Vol. 3: *British Fortunes Reach Their Lowest Ebb* (London: HMSO, 1960), pp. 434–438.

[65] Agar-Hamilton, *Crisis in the Desert*, pp. 11–12; Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, pp. 45–46; Niall Barr, *Pendulum of War: The Three Battles of El Alamein* (London: Pimplico, 2005), p. 52.

[66] Dan Reiter and Allan C. Stam, *Democracies at War* (Princeton, N.J.: Princeton University Press, 2002). For an important critique, see Alexander B. Downes, "How Smart and Tough Are Democracies?," *International Security*, Vol. 33, No. 4 (2009), pp. 9–51.

[67] Anthony Clayton, *The British Empire as a Superpower, 1919–39* (Athens, Ga.: University of Georgia Press, 1986), p. 366; Barrie Pitt, *The Crucible of War: Western Desert 1941* (London: Jonathan Cape, 1980), p. 14.

[68] Hobart to Director of Staff Duties, "A.F.V. requirements in the revised Field Force," November 25, 1937, LH 15/11/7, Liddell Hart Center for Military Archives (LHCMA). On the desert environment and interwar armor theory, see Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, pp. 33–35; Carver, *Tobruk*, pp. 26, 267.

[69] Ronald Lewin, *The Life and Death of the Afrika Korps* (New York: Quadrangle, 1977), pp. 11–13; Barr, *Pendulum of War*, p. 65.

British armor played a limited and delayed role for which it was inadequately equipped.[70] Then, during Operation Compass (December 1940–February 1941), Britain's small Western Desert Force routed the large Italian Tenth Army in North Africa, but its 7th Armored Division only took part in a few minor skirmishes, while low morale and significantly inferior tanks could readily explain Italian defeat. Furthermore, the analysis does not extend beyond November 1942 because U.S. forces began landing in North Africa on November 8, which complicates the analysis by introducing additional factors related to coalition warfare that shaped British planning and performance.

Carrying the wartime analysis forward from British defeats in the desert to victories in the latter half of 1942 helps put in perspective the relative significance of command and leadership and Germany's general military prowess. Erwin Rommel's leadership of Axis forces alone cannot explain variation in British performance since he was primarily in command for much of the period under study.[71] And even though German forces had inherent advantages—a long legacy of combat effectiveness and ideologically-motivated cohesion—these too were constant throughout the Desert War, so again cannot itself explain variation in British army effectiveness.[72]

The British-German case comparison is a well-suited test of the theory. British armor innovation is a hard case by virtue of being a familiar case for dominant theories of military innovation. British army performance in the Desert War is also surprising from the perspective of common intuitions about the sources of military effectiveness. What is puzzling about the British-German comparison is not variation in the presence or absence of innovation—the standard puzzle of military innovation studies—but instead how did innovation affect military effectiveness.

British Innovation in Armored Warfare, 1919–1939

Britain's interwar army operated amid a wicked mismatch between expanding security commitments and shrinking military resources. The resulting atmosphere of crisis animated a flawed innovation process characterized by radical proposals, wishful thinking, and rushed

[70] Robert H. Larson, *The British Army and the Theory of Armored Warfare*, p. 223; Harris, *Men, Ideas and Tanks*, p. 306.
[71] For a critical assessment of Rommel's leadership, see Ralf George Reuth, *Rommel: The End of a Legend*, trans. Debra Marmor and Herbert Danner (London: Haus Publishing, 2019). For a defense, see David Fraser, *Knight's Cross: A Life of Field Marshal Erwin Rommel* (London: Harper Collins, 1993), pp. 237–240, 324.
[72] On German force cohesion, see Jasen Castillo, *Endurance and War: The National Sources of Military Cohesion* (Stanford: Stanford University Press, 2014).

development that dismissed plausible criticisms. Armor innovators argued that all-tank formations conducting armored maneuver could improve effectiveness in assigned missions and economize the army's limited budget and personnel by substituting armor for the traditional capabilities of the infantry, artillery, and horsed cavalry. In experiments, innovators liberally interpreted results as supporting evidence of a revolutionary way of future warfare, even though experimental forces failed to achieve exercise objectives and the lack of money limited the ability to conduct exercises that produced reliable data. Furthermore, critics pointed out that armored assaults without the support traditionally provided by other arms were susceptible to anti-tank countermeasures, and that contemporary tanks remained mechanically unreliable. Yet the army codified and implemented armored maneuver in organization and doctrine.

COMMITMENT-RESOURCE GAP: WICKED MISMATCH

The British army faced the challenge of bridging a wicked mismatch between expanding commitments and shrinking resources—a gap that persisted for most of the interwar period.[73] The army had imperial, internal, and continental obligations. The army had to police and defend an empire at its territorial zenith after it grew from a fifth of the world's landmass before World War I to a quarter of the globe.[74] At home, the army had to contain an Irish insurgency movement and quell what were perceived to be coordinated labor strikes that posed a political challenge to the government.[75] Finally, the army had continuing obligations in Europe, most significant of which was upholding the Locarno Treaty to guarantee the common borders between Belgium, France, and Germany.[76]

To meet these wide-ranging security commitments, the service had fewer soldiers and less money than before World War I, with both manpower and budget levels held as low as possible for almost two decades. Within a year of signing the Armistice, the army dropped from 3.5 million

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[73] Michael Howard, *The Continental Commitment* (London: Maurice Temple Smith, 1972; repr., 1989), p. 79, 116; Brian Bond, *British Military Policy between the Two World Wars* (Oxford: Clarendon Press, 1980), p. 94; John Ferris, "Treasury Control, the Ten Year Rule and British Service Policies, 1919-1924," *Historical Journal*, Vol. 30, No. 4 (1987), p. 874; Harold R. Winton, "Tanks, Votes, and Budgets: The Politics of Mechanization and Armored Warfare in Britain, 1919-1939," in Harold R. Winton and David R. Mets, eds., *Challenge of Change: Military Institutions and New Realities, 1918-1941* (Lincoln, Nebr.: University of Nebraska Press, 2000), p. 91.
[74] Howard, *The Continental Commitment*, pp. 28–29; Keith Jeffrey, "Sir Henry Wilson and the Defence of the British Empire, 1918–22," *Journal of Imperial and Commonwealth History*, Vol. 5, No. 3 (1977), p. 271.
[75] Jeffrey, "Sir Henry Wilson and the Defence of the British Empire," pp. 276–278.
[76] Douglas E. Delaney, *The Imperial Army Project: Britain and the Land Forces of the Dominions and India, 1920–1945* (Oxford: Oxford University Press, 2018), p. 165.

men to 800,000, and then down to 350,000 the following year.[77] Imperial manpower was also taken off the table. India and the Dominions, which made significant contributions to the war effort, were no longer willing to assist in imperial emergencies. They took responsibility for local defense, but Britain was responsible for imperial defense as a whole.[78]

The army's personnel shortage was exacerbated by its budget crisis. In August 1919, the cabinet decided that the defense departments should base their budget requests on the assumption that "the British Empire will not be engaged in any great war during the next ten years, and no Expeditionary Force is required for this purpose."[79] Beginning in 1928, this "Ten Year Rule" was renewed daily. To produce surpluses and pay off wartime debts, the Treasury secured spending cuts equal to the figure of 1913–1914 defense estimates which, due to inflation, was 20 percent below the real value of the prewar budget.[80]

Among the three armed services, the army was consistently in the weakest position. Between the 1922–1923 and 1925–1926 defense estimates, almost all real cuts came from the army, whose net estimates fell by 25 percent.[81] During the global depression, the army's annual expenditures reached its nadir in 1932.[82] Even after the cabinet revoked the Ten Year Rule in 1932, army spending remained low because the government allocated most of the rearmament funds to the Royal Air Force and Royal Navy.[83] Britain rearmed at a reluctant pace, particularly when it came to building a field army, due to many interlocking beliefs: Britons would "Never Again" fight a bloody conflict of attrition in Europe, another war spelled the end of empire if not civilization, rearmament would lead to an egalitarian socialist state, and financial stability could function as the fourth arm of defense.[84]

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[77] Bond, *British Military Policy*, p. 11.
[78] Howard, *The Continental Commitment*, p. 92; Clayton, *The British Empire as a Superpower*, pp. 5–9, 27–28; Delaney, *The Imperial Army Project*, pp. 166–167, 170–180; George C. Peden, *Arms, Economics and British Strategy* (New York: Cambridge University Press, 2007), pp. 148–150.
[79] Quoted in Bond, *British Military Policy*, 24–25.
[80] Ferris, "Treasury Control," pp. 863–871; Peter Dennis, *Decision by Default: Peacetime Conscription and British Defence, 1919–1939* (London: Routledge and Kegan Paul, 1972), p. 13.
[81] Ferris, "Treasury Control," p. 880. See also John Ferris, *Men, Money, and Diplomacy: The Evolution of British Strategic Policy, 1919–1926* (Ithaca, N.Y.: Cornell University Press, 1989), pp. 158–178.
[82] Dennis, *Decision by Default*, p. 50.
[83] Howard, *The Continental Commitment*, p. 116.
[84] Ibid., pp. 74, 107; Daniel Todman, *Britain's War*, Vol. 1: *Into Battle, 1937–1941* (New York: Oxford University Press, 2016), pp. 69–82; Alan Allport, *Britain at Bay: The Epic Story of the Second World War, 1938–1941* (New York: Alfred A. Knopf, 2020), pp. 44–47; Peden, *Arms, Economics and British Strategy*, p. 132.

The Chief of the Imperial General Staff (CIGS) and the general staff actively drew attention to the wicked mismatch and pressed civilian leaders to either reduce the army's commitments or increase its resources. CIGS Field Marshal Sir Henry Wilson (1918–1922) wrote to the secretary of state for war: "I cannot too strongly press on the Government the danger, the extreme danger, of His Majesty's army being spread all over the world, strong nowhere, weak everywhere, and with no reserve to save a dangerous situation or to avert coming danger."[85] Wilson and the general staff recommended ways to reduce commitments in India, Persia, Danzig, the Black Sea, and elsewhere.[86] Wilson's successor, Field Marshal Lord Cavan (1922–1926), recorded that "the whole of my four years as C.I.G.S. was a period of [army] retrenchment ... a struggle for existence."[87]

CIGS Field Marshal Sir George Milne (1926–1933) described how the army was operating at full capacity, with fewer infantry battalions than before World War I, while trying to match its Locarno obligations and respond to unrest in China, the Swaraj movement in India, policing Palestine and Iraq, and an anti-British Egypt.[88] Later, the Defense Requirements Sub-Committee, established to prepare recommendations for a rearmament program, argued that public criticism of the army's deficiencies "overlook essential elements in the problem, such as the immense range of our Imperial responsibilities and limitations of finance."[89]

The army's size and expenditure experienced unrelenting downward pressure for virtually the entire interwar period, despite a heavy mission burden and growing international threats to its security commitments. It turned to radical innovation to resolve the wicked mismatch.

BRITISH INNOVATION OF ARMORED MANEUVER

The army found an innovative solution in the form of armored maneuver. The idea was that a mobile force, consisting almost entirely of tanks, could maneuver on the future battlefield with impunity and land a decisive blow against the enemy's rear areas. This new capability allegedly solved the army's wicked mismatch by improving combat effectiveness in great wars, small wars,

[85] Wilson to Secretary of State, June 9, 1920, WO 33/1004, BNA. On the same point, see General Staff, "Military Liabilities of the Empire," July 27, 1920, CAB 4/7, British National Archives (BNA); Major General Sir Frederick Sykes, "Reduction of Armaments, Economy, and Imperial Defence," *Army Quarterly*, Vol. 12, No. 1 (1926), p. 17.
[86] "General Staff Memorandum," enclosed in Wilson to Secretary of State, January 20, 1922, WO 33/1004, BNA.
[87] Quoted in Jeffrey, "Sir Henry Wilson and the Defence of the British Empire ," p. 289.
[88] Milne to Worthington-Evans, November 2, 1927, WO 32/2823, BNA.
[89] "Report," February 28, 1934, Committee of Imperial Defence, Defence Requirements Sub-Committee, CAB 24/247/64, BNA, paragraph 16.

and internal security, while requiring fewer men and less money than the army's current force structure. But experimentation with prototype forces yielded worrying results; and critics raised plausible concerns about enemy countermeasures and mechanical unreliability. Nonetheless, armor innovators remained wedded to a futuristic vision of armored warfare.

RADICAL PROPOSALS. In the 1920s, Colonel J. F. C. Fuller and Captain Basil H. Liddell Hart were the key spokesmen for armored maneuver, though other figures in the Royal Tank Corps—namely, George Lindsay, Charles Broad, and Percy Hobart—were the actual implementers. They shared an overarching vision of armored warfare as mobile all-tank operations with little need for supporting infantry and conventionally-towed artillery.[90] Tanks were the optimal combination of protection, mobility, and offensive power.[91] As such, armored maneuver promised to be a panacea for the army's wide-ranging security commitments *and* a substitute for the traditional capabilities associated with the combined arms offensives of the Western Front. Armor radicalism demanded a high degree of creative destruction.

Armored maneuver allegedly increased the army's effectiveness in all its assigned missions, whether it be great wars, small wars, or internal security.[92] In the next great war in Europe, armored maneuver would prevent another Western Front and rescue "mobility from the toils of trench warfare."[93] Instead, battles would begin with an armored clash for "tank supremacy" in which infantry, artillery, and horsed cavalry would play "the part of interested spectators" and "do next to nothing."[94] Fast tanks would exploit into the enemy's rear, paralyze the enemy's communication and command centers, and plunge the opposing army into psychological disarray. The traditional arms came into play only after the battle was decided: as armored forces move forward "by a series

[90] Winton, *To Change an Army*, pp. 17–22.
[91] J.F.C. Fuller, "The Development of Sea Warfare on Land and Its Influence on Future Naval Operations," *RUSI Journal*, Vol. 65, No. 458 (1920): 289–90.
[92] J.F.C. Fuller, "Gold Medal (Military) Prize Essay for 1919: The Application of Recent Developments in Mechanics and Other Scientific Knowledge to Preparation and Training for Future War on Land," *RUSI Journal*, Vol. 65, No. 458 (1920), pp. 255–256; J.F.C. Fuller, "Problems of Mechanical Warfare," *Army Quarterly*, Vol. 3, no. 2 (1922), pp. 284–301; Hobart to Director of Staff Duties, March 22, 1935, LH 15/11/2, LHCMA, p. 7.
[93] B.H. Liddell Hart, *Paris, or the Future of War* (New York: E. P. Dutton, 1925), p. 73.
[94] Fuller, "Problems of Mechanical Warfare," p. 287. See also J.F.C. Fuller, "Progress in the Mechanicalisation of Modern Armies," *RUSI Journal*, Vol. 70, No. 477 (1925), p. 79; B.H. Liddell Hart, "Army Manæuvres, 1925," *RUSI Journal*, Vol. 70, No. 480 (1925), p. 653; Michael Carver, *The Apostles of Mobility: The Theory and Practice of Armored Warfare* (London: Weidenfeld and Nicolson, 1979), p. 22.

of bounds," the traditional arms would occupy conquered territory and garrison "a chain of fortified depots" established behind the advancing tank forces.[95]

In small wars, the main challenge was that military garrisons were usually located far away from disturbances and rebels had growing access to small arms. But tanks could allegedly travel far distances without relying on supply lines, do so quickly across various terrains, and counter small arms fire.[96] Mechanization functionally reduced the size of empire.[97] Finally, for policing and internal security, tanks dispensing non-lethal chemical gases offered a discriminate and non-escalatory way to disperse riots.[98]

Armored maneuver could also allegedly do these things at a cheaper cost than the traditional capabilities developed in World War I. In the final year on the Western Front, the British army was integrating infantry, artillery, and armor capabilities, with the aid of aerial spotting and surprise, to penetrate German defensive positions held in depth and do so with acceptable losses.[99] Heavy counter-battery artillery fire was followed by a tank-supported infantry advance under cover of a creeping artillery barrage that included high-explosive and smoke shells to suppress enemy resistance.[100] This became the standard way of war enshrined in British doctrine after 1919.[101]

In contrast, innovators touted armored maneuver as an efficient substitute for the difficult and demanding tasks associated with implementing combined arms principles.[102] Fuller and Liddell Hart proposed a "new model army" in which mechanical vehicles performed all primary

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[95] B.H. Liddell Hart, "The Development of the 'New Model' Army: Suggestions on a Progressive but Gradual Mechanicalisation," *Army Quarterly*, Vol. 9, No. 1 (1924), p. 45. See also Shelford Bidwell and Dominick Graham, *Fire-Power: British Army Weapons and Theories of War, 1904-1945* (London: George Allen & Unwin, 1982), p. 171.
[96] Fuller, "The Development of Sea Warfare on Land," pp. 283, 288; Fuller, "Problems of Mechanical Warfare," pp. 292–294; Gifford Le Quesne Martel, "A Tank Army," March 1917, Fuller 1/1/9, LHCMA; Hobart to Director of Staff Duties, "Memorandum on the Organization of Tank and Mobile Troops," March 22, 1935, LH 15/11/2, LHCMA, p. 42.
[97] Fuller, "Problems of Mechanical Warfare," pp. 292–294.
[98] Ibid., pp. 295–296. In contrast, policing from the air was criticized as indiscriminate.
[99] David French, *Raising Churchill's Army: The British Army and the War against Germany, 1919–1945* (Oxford: Oxford University Press, 2000), pp. 17–19.
[100] Robin Prior and Trevor Wilson, *Command on the Western Front: The Military Career of Sir Henry Rawlinson 1914–18* (Oxford: Blackwell, 1992), pp. 292–295, 311–315. This is not to overstate the uniformity of British tactics, see Aimée Fox, *Learning to Fight: Military Innovation and Change in the British Army, 1914–1918* (Cambridge: Cambridge University Press, 2018), pp. 51–77.
[101] French, *Raising Churchill's Army*, pp. 17–19, 27–33.
[102] On these difficulties, see Paddy Griffith, *Battle Tactics of the Western Front: The British Army's Art of Attack, 1916-18* (New Haven, Conn.: Yale University Press, 1998), pp. 70–125, 98–200; Biddle, *Military Power*, pp. 29–48; Michael Hunzeker, *Dying to Learn: Wartime Lessons from the Western Front* (New York: Cornell University Press, 2021), pp. 47–55.

land combat functions. The tank would "swallow the infantryman, the field artilleryman, the engineer and signaller, while mechanical cavalry will supersede the horseman."[103] Moreover, light tanks, fast cruiser tanks, and heavy tanks could allegedly cooperate better than the current arrangement of inter-arm cooperation.[104] Conversely, hitching tanks to slower elements such as infantry "is tantamount to yoking a tractor to a draught-horse" and having them "operate together under fire is equally absurd."[105]

With stagnant army budget estimates for the foreseeable future, mechanization plans had to assume that "any fresh outlay is balanced by a corresponding cut in some branch."[106] By reducing troop requirements and mechanizing the remainder, a remodeled army could "produce, within the limits of the money available, a military organization of the highest efficiency and with powers of efficient development along the economic line."[107] In a great war, a new model division was equivalent in fighting value to four or more current divisions, and to "almost any number of present-day divisions" if fighting a small war.[108]

WISHFUL THINKING. The British army experimented with armored maneuver over the course of two training seasons in 1927 and 1928, which featured the world's first fully mechanized combat brigade—the Experimental Mechanized Force, later renamed the Experimental Armored Force. When CIGS Milne agreed to establish the Experimental Mechanized Force in February 1926, he declared it the first phase of army reorganization.[109] Instead of a prototype all-arms mechanized division, Colonel George Lindsay, Inspector of the Royal Tank Corps, actively lobbied for armor-centric formations to economize manpower and money. Moreover, a small mechanical force "could pin to its ground indefinitely a division of all arms as presently constituted."[110] The CIGS sided with Lindsay ("Colonel Lindsay's ideas are very sound")[111] and

[103] Liddell Hart, "The Development of the 'New Model' Army," p. 44.
[104] Ibid., pp. 45–46.
[105] J.F.C. Fuller, *Lectures on F.S.R. III* (London: Sifton Praed, 1932), p. 12.
[106] Ibid., p. 39.
[107] Fuller, "Gold Medal (Military) Prize Essay," p. 255.
[108] Ibid., p. 263.
[109] David French, "Doctrine and Organization in the British Army, 1919-1932," *Historical Journal*, Vol. 44, No. 2 (2001), pp. 511–512.
[110] Lindsay, "Suggestions," May 15, 1926, LH 15/12/4, LHCMA. See also Lindsay, "The Organization and Employment of a Mechanical Force," April 25, 1924, LH 15/12/2, LHCMA.
[111] CIGS to Director of Staff Duties, Minute 2, June 1, 1926, WO 32/2820, BNA. See also Milne, "Comments on BM 796," May 15, 1926, LH 15/12/4, LHCMA.

offered command to Fuller (though he declined), all signaling the army's support of armored radicalism.[112]

The following experiments should have tempered excessive faith in the promises of armored maneuver, but failed to do so. First, the experimental force failed to achieve assigned mission objectives. The 1927 and 1928 training seasons culminated in large exercises that pit the experimental force against a more traditional opponent. In 1927, the Experimental Mechanized Force, opposed by an infantry division and a horsed cavalry brigade, failed to take a high-ground location. The infantry division stole an overnight march and reached the objective first. In 1928, the same infantry division, augmented by a tank company, an armored car company, cavalry regiment, and artillery brigade, successfully stalemated a combined force of the 2nd Cavalry Brigade and the Experimental Armored Force.

Second, given tight resource constraints, the mechanized formations lacked adequate and appropriate equipment, limiting the reliability of experimental data. Milne recognized that the army wanted "to make certain experiments and we have not had the money to do what we really intended."[113] The prototype units often lacked suitable, reliable, and streamlined vehicles to conduct the desired exercises, and struggled to field them in adequate numbers. Through the early 1930s, the cost of a single experimental medium tank could exceed the annual budget available for experimenting with tanks.[114]

Finally, exercises were designed to press on the vulnerabilities of armor. Major General Sir John Burnett-Stuart served as the director of the maneuvers. He openly admitted that the armored force's 1928 "exercises have been deliberately planned to bring out its limitations rather than to make a display of its powers."[115]

Nonetheless, the experiments somehow confirmed the radical trajectory of British armor innovation. Liddell Hart declared that the 1927 training season demonstrated how a mechanized force could strike freely without fear of enemy attack.[116] And the 1928 exercises revealed nothing that reasoning—"the cheapest form of experiment"—had not already made self-evident: "that the

[112] On the debate over force composition, see Harris, *Men, Ideas and Tanks*, pp. 211–214. On Fuller's refusal of command in the so-called Tidworth Affair, see J.P. Harris, "British Armour 1918–40: Doctrine and Development," in J.P. Harris and F.H. Toase, eds., *Armoured Warfare*, (London: B. T. Batsford, 1990), pp. 36–37.
[113] Address by CIGS to Experimental Mechanized Force, September 1927, LH 11/1927/5–16, LHCMA.
[114] Liddell Hart, *The Tanks*, pp. 248–249; J.P. Harris, "British Armour and Rearmament in the 1930s," *Journal of Strategic Studies*, Vol. 11, No. 2 (1988), p. 223.
[115] "Experimental Armoured Force Report 1928," Minute 1C, WO 32/2828, BNA.
[116] Liddell Hart, *The Tanks*, p. 249.

present composition of the force is fundamentally unsuitable" and the "obvious truth that armoured and unarmoured vehicles do not coalesce." The solution, Liddell Hart reiterated, was an all-tank force with streamlined vehicles. A "true armoured force" should consist mainly of "light tanks, such as the new Carden-Lloyd, with a proportion of 'gun-tanks' such as the new 16-ton Vickers [medium tank] for its extra fire support, and perhaps a sprinkling of six-wheeled armoured cars as its long-range 'feelers.'"[117]

More significantly, the CIGS endorsed the core ideas of armored maneuver. In September 1927, Milne praised the Experimental Mechanized Force "because I am perfectly certain that we are working on absolutely the right lines." At the outbreak of war, a mobile force designed to operate across hundreds of miles, could deliver "a swinging blow to come around the flank" and "carry out big operations and big turning movements." Normally, this force would remain entirely armored because infantry became a liability in combat.[118] Milne proposed to the Army Council a future armored brigade with essentially the same blueprint as Liddell Hart's "true armoured force."[119] When Milne's successor, Field Marshal Sir Archibald Montgomery-Massingberd, permanently established the 1st Tank Brigade in 1933, it adhered to an all-tank conception with close support tanks, mixed light-medium tank companies, and machine-gun carriers serving as light tanks in a reconnaissance role.[120]

The 1934 trials represented the last attempt to temper armor radicalism. Colonel Percy Hobart, now Inspector of the Royal Tank Corps and commander of the Tank Brigade, preferred an independent tank brigade concept, with tanks carrying out deep penetrations with only the smallest attachments to avoid problems with logistics and coordinating different arms.[121] But Lindsay pushed for a mobile division concept in which the Tank Brigade was incorporated into an all-arms mechanized division.[122] The two agreed to temporarily form a Mobile Force comprised of the 1st

[117] B.H. Liddell Hart, "Armoured Forces in 1928," *RUSI Journal*, Vol. 73, No. 492 (1928), p. 722, 723.
[118] Address by CIGS to Experimental Mechanized Force, September 1927, LH 11/1927/5–16, LHCMA. On the influence of armor innovators on this speech, see Carver, *The Apostles of Mobility*, p. 47.
[119] Milne to Worthington-Evans, November 12, 1928, WO 32/2825, BNA.
[120] Larson, *The British Army and the Theory of Armored Warfare*, p. 156; Harris, "British Armour," p. 40.
[121] Bond, *British Military Policy*, p. 165.
[122] Lindsay to Hobart, November 17, 1933, 17 Nov. 1933, LH 15/12/8, LHCMA. The difference between their concepts, however, can be easily exaggerated because both organizations lacked substantial organic support from arms other than the Royal Tank Corps. See Winton, *To Change an Army*, p. 178.

Tank Brigade, 7th Infantry Brigade, a mechanized field artillery brigade, and other supporting arms—an armored division in all but name.[123] Lindsay was in command.

The Mobile Force had three days to penetrate enemy lines and destroy supply and command centers, opposed by the unmechanized 1st Infantry Division. The enemy prepared significant defensive arrangements and successfully used motorized units to get behind the Mobile Force and block its retreat with mines and anti-tank guns. The Mobile Force was defeated. The Royal Tank Corps blamed the poor performance on Lindsay's command of the Mobile Force, not the principles of armored maneuver; and as a result, Hobart's independent tank brigade concept eclipsed Lindsay's mobile division.[124]

RUSHED DEVELOPMENT. Criticism of armored maneuver centered on enemy countermeasures and the unreliability of tank mobility, but implementation began before these were rigorously studied.[125] Post-exercise assessments repeatedly emphasized the need for greater supporting fire in any tank attack on enemy defenses because of anti-tank countermeasures. The commander of the Experimental Mechanized Force argued that mechanized formations were vulnerable to enemy anti-tank weapons and artillery.[126] Similarly, a general staff memorandum on army training criticized the failure to secure proper fire support to suppress enemy anti-tank fire before assaulting a position, violating the "correct principles" established during World War I. It warned that mechanized forces must not be allowed to "upset all our preconceived notions of war."[127] Tank mobility was also a perennial issue. Burnett-Stuart cautioned that tanks could not traverse all terrain and its mobility was still in the developmental stage.[128] The early experimental force lost many of its medium tanks from breakdowns even on short trips.[129]

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[123] Harold R. Winton, "The Evolution of British Mechanised and Armoured Doctrine 1919-1938," *RUSI Journal*, Vol. 130, No. 1 (1985), p. 63.
[124] Winton, "Tanks, Votes, and Budgets," p. 94; Larson, *The British Army and the Theory of Armored Warfare*, p. 167. On the reasons for this defeat, see Harris, *Men, Ideas and Tanks*, pp. 250–252.
[125] Both criticisms were given public voice by the military writer Victor Germains. See Victor Germains, *The "Mechanization" of War* (London: Sifton Praed, 1927); Victor Germains, "'Armoured Warfare': A Plea for Common Sense," *Army Quarterly*, Vol. 16, No. 2 (1928), pp. 361–374. The *Army Quarterly* dismissed his critiques as "theoretical rather than practical." See "Editorial," *Army Quarterly*, Vol. 16 (April 1928), pp. 178–179.
[126] R.J. Collins, "Experimental Mechanized Force," *Journal of the Royal Artillery* Vol. 55 (1928), p. 33.
[127] Army Training Memorandum, "Collective Training Period," 1927, Liddell Hart 15/3/115, LHCMA.
[128] J.T. Burnett-Stuart, "Armoured Force Training Report—1928," WO 32/2828, BNA; "Experimental Armoured Force Report 1928," Minute 5A, WO 32/2828, BNA.
[129] David French, "The Mechanization of the British Cavalry between the World Wars," *War in History*, Vol. 10, No. 3 (2003), p. 306.

These criticisms were highly plausible. In World War I, British tanks were indeed vulnerable to German countermeasures in the form of field guns, anti-tank rifles, armor-piercing machine gun ammunition, and minefields. In the interwar period, British tanks could not survive a direct hit by the shell of even a small caliber, high velocity gun (technology that was already available).[130] Moreover, much like tanks in World War I, interwar models had trouble traversing difficult terrain and often broke down.[131] When the War Office dispatched an armored Mobile Force to Egypt during the Abyssinian crisis, it had the newest light tanks, yet struggled with so many broken tracks that it was nicknamed the "Mobile Farce."[132]

Nonetheless, armor innovators continued to appeal to tank mobility as a form of protection rather than concede the need for the traditional capabilities of infantry cooperation and indirect artillery fire support. As the most prolific advocate of armored maneuver, Liddell Hart's argumentation strategy is representative. First, he criticized the umpires for overestimating the effectiveness of anti-tank weapons. The representative white and green flags used to fortify defenses in the exercises were "cheap to provide and easy to wave" but "an effective weapon, complete with tractor and ammunition trailer, is an expensive item," such that no "infantry division could be provided enough to form the immense circular screen that would be necessary for its protection."[133]

Second, Liddell Hart asserted that European armies in the next great war would be smaller than the last one, leaving open flanks.[134] Even if anti-tank weapons *were* lethal, an armored force could use its incredible mobility to flank obstructions, which in turn precluded the need for infantry cooperation to establish bridgeheads and clear localities.[135] A few years later, when crystal sets (a rudimentary form of radio) made possible the tactical control of a mobile force, Liddell Hart hailed the dawn of new "anti-anti-tank gun" tactics with which a "few scattered guns can easily be overrun by a tank force in its onward surge."[136]

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[130] Bidwell and Graham, *Fire-Power*, p. 179; French, "The Mechanization of the British Cavalry," pp. 307, 311.
[131] French, *Raising Churchill's Army*, p. 28; David J. Childs, *A Peripheral Weapon? The Production and Employment of British Tanks in the First World War* (Westport, Conn.: Greenwood Press, 1999), pp. 141–170.
[132] French, "The Mechanization of the British Cavalry," pp. 306–309.
[133] Liddell Hart, "Contrasts of 1931: Mobility or Stagnation," *Army Quarterly*, Vol. 23, No. 2 (1932), p. 248.
[134] Liddell Hart, "Armoured Forces in 1928," p. 725. This was a common belief among armor innovators. See J.F.C. Fuller, *Armoured Warfare* (London: Eyre and Spottiswoode, 1943), p. 11.; Hobart to Lindsay, November 10, 1933, Liddell Hart 1/376/5, LHCMA.
[135] Liddell Hart, "Armoured Forces in 1928," pp. 723, 727–728. He was only willing to consider a company of "land-marines" for "stalking and silent penetration."
[136] Liddell Hart, "Contrasts of 1931," pp. 244, 248–249.

Concerns about anti-tank weapons and unreliable mobility arose from the army's own practical experience with tanks and anti-tank countermeasures in World War I. In contrast, armored maneuver was based primarily on deductive logic and theoretical leaps into an uncertain future. But for Liddell Hart, the antidote to doubt was greater faith in the principle that "he who applies a novel device by a novel method has oftenest attained revolutionary results in history."[137]

Armor innovators were largely successful in their mechanization agenda. The historian David French observes that "by the end of the 1920s the British had virtually abandoned the attempt to create permanent, all-arms formations incorporating a balance of tanks, infantry, and supporting arms."[138] The CIGS tasked Colonel Charles Broad, a known supporter of armored maneuver, to compile primers on armored warfare. These envisioned tank brigades achieving decisive victory with numerically inferior forces comprised of light tanks for reconnaissance and medium tanks for striking but excluding other arms.[139]

As the army designed its armored division, it was designed for armored maneuver carried out by their main striking element—all-tank armored brigades. The Director of Staff Duties observed that CIGS Montgomery-Massingberd believed, and "it can safely be said that the general consensus of Army opinion was in agreement," that the armored brigade was a commander's "most powerful offensive agent."[140] Tanks and infantry would be organized separately, cooperate only in particular operations, and only at the divisional level. As the armored division evolved over the latter half of the 1930s, the already small representation of supporting arms shrank over time. In the final prewar model, the division contained only one infantry battalion, whereas four battalions eventually became standard in World War II.[141] The armored division was "dominated" by the Royal Tank Corps, "committed to a machine-age vision that tanks by themselves could win battles."[142]

German Innovation in Armored Warfare, 1919–1939

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[137] Liddell Hart, "Armoured Forces in 1928," p. 729.
[138] French, *Raising Churchill's Army*, p. 29.
[139] These pamphlets were *Mechanized and Armored Formations* (1929) and an updated version titled *Modern Formations* (1931). The latter considered possible field artillery support against prepared enemy positions, but assumed these operations would be rare. See Harris, "British Armour," p. 39.
[140] E.K. Squires, "Note on the Composition of the Mobile Division," October 11, 1937, LH 15/11/7, LHCMA.
[141] Richard M. Ogorkiewicz, *Armoured Forces: A History of Armoured Forces and Their Vehicles* (New York: Arco Publishing Company, 1960), pp. 59–60, 73–74.
[142] French, *Raising Churchill's Army*, p. 42.

The Germany army perceived a temporary undermatch between its resources and its commitments, which created a permissive environment for incremental innovation that balanced new and old capabilities with the goal of refighting a total war like World War I. The German army innovated combined-arms maneuver, which essentially mechanized and accelerated the infiltration tactics it developed on the Western Front through mechanization and radio communications.[143]

The German army's singular mission burden was to defend the territorial homeland against Poland and France, and eventually wage another war to overturn the Versailles Treaty and return Germany to its proper position in Europe.[144] The Versailles Treaty, however, limited the structure and strength of the army. Enforced by the Inter-Allied Control Commission, the treaty reduced German armaments and manpower. The treaty prohibited heavy artillery, poison gas, tanks, and submarines, and restricted and eradicated Germany's industrial capacity to produce war materiel; and capped the army at 100,000 men.[145] Yet the army was not in a professional crisis because the Weimar Republic's foreign policy and the army's goals were the same, among them the abolition of all restrictions on national sovereignty, including military regulations.[146] No significant political or cultural group in Germany accepted the legitimacy of the Versailles restrictions.[147]

The army benefited from clandestine then later outright rearmament. When the Inter-Allied Military Control Commission left in 1927, the army set in motion its first clandestine rearmament program, followed by a second in 1932.[148] The army successfully avoided significant budget cuts during the global economic depression in the early 1930s.[149] Once Hitler came to power in 1933, he promised that "all other tasks must cede precedence to the task of rearmament," and military

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[143] Stephen Biddle, "The Past as Prologue: Assessing Theories of Future Warfare," *Security Studies*, Vol. 8, No. 1 (1998), pp. 11–12, 44–50.
[144] Geoffrey P. Megargee, *Inside Hitler's High Command* (Lawrence, Kans.: University of Kansas Press, 2000), p. 12; Wilhelm Deist, "'Blitzkrieg' or Total War? War Preparations in Nazi Germany," in Roger Chickering and Stig Förster, eds., *The Shadows of Total War: Europe, East Asia, and the United States* (Cambridge: Cambridge University Press, 2003), p. 271. The German terms for "general staff" and "army" changed over the interwar period, so I use English terms to avoid confusion.
[145] Richard J. Shuster, *German Disarmament after World War I: The Diplomacy of International Arms Inspection 1920–1931* (London: Routledge, 2006), pp. 56–71, 98–99.
[146] Michael Geyer, "The Dynamics of Military Revisionism in the Interwar Years: Military Politics between Rearmament and Diplomacy," in Wilhelm Deist, ed., *The German Military in the Age of Total War* (Dover, N.H.: Berg, 1985), p. 104.
[147] Deist, *The Wehrmacht and German Rearmament* (London: Palgrave Macmillan, 1981), pp. 9–17.
[148] Matthias Strohn, *The German Army and the Defence of the Reich: Military Doctrine and the Conduct of the Defensive Battle 1918–1939* (Cambridge: Cambridge University Press, 2011), pp. 157–159.
[149] Wilhelm Deist, "The Rearmament of the Wehrmacht," in Militärgeschichtliches Forschungsamt, ed., *Germany and the Second World War*, Vol. 1: *The Build-up of German Aggression* (Oxford: Clarendon Press, 1990), p. 384.

spending increased significantly year-on-year.[150] By September 1939, the personnel and number of German active units matched and even slightly exceeded army plans for 102 divisions.[151]

The temporary undermatch ultimately meant a lower reliance on innovation to bridge the commitment-resource gap. In fact, the army contemplated two radical innovation proposals but rejected them as infeasible. The chief of the general staff, General Hans von Seeckt, promoted a "modern army" concept in which a small, well-trained professional army could conduct mobile operations with mechanized troops, and strike decisively before the enemy fully mobilized.[152] The Ruhr crisis of 1923, however, convinced the army that Seeckt's plans and concepts were based on exaggerated estimates and flawed assumptions.[153] In an alternative known as people's war (*volksrieg*), guerrillas would delay invading French or Franco-Polish forces to buy time for negotiations and conventional mobilization.[154] People's war was never officially implemented because guerrilla warfare failed in exercises between 1927 and 1929.[155]

German armored warfare therefore developed within an army that planned to fight under-financed and outnumbered, but that never accepted this could be done successfully without rearmament to wage industrialized total war akin to World War I.[156] There was widespread support for mechanized and armored units among the general staff and its interwar chiefs, but the army maintained the basic architecture of its organization and doctrine while mechanizing and motorizing key components, which incrementally over the course of the interwar period took on increasingly important roles.[157] These changes coalesced around combined-arms maneuver—the

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[150] Quoted in Deist, "'Blitzkrieg' or Total War," pp. 274–275. See also Adam Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy* (New York: Penguin, 2006), pp. 86–89.
[151] Deist, "The Rearmament of the Wehrmacht," p. 454; Deist, "'Blitzkrieg' or Total War," p. 275.
[152] Deist, "Road to Ideological War," p. 363; Jürgen Förster, "Evolution and Development of German Doctrine 1914–45," in John Gooch, ed., *The Origins of Contemporary Doctrine* (Camberley: Strategic and Combat Studies Institute, 1997), p. 20; Strohn, *The German Army and the Defence of the Reich*, p. 98.
[153] Michael Geyer, "German Strategy in the Age of Machine Warfare," in Peter Paret, ed., *Makers of Modern Strategy: From Machiavelli to the Nuclear Age* (Princeton, N.J.: Princeton University Press, 1986), pp. 556–557.
[154] Gil-li Vardi, "Joachim Von Stülpnagel's Military Thought and Planning," *War in History*, Vol. 17, No. 2 (2010), p. 197.
[155] Geyer, "German Strategy in the Age of Machine Warfare," p. 561; Förster, "Evolution and Development of German Doctrine," p. 20. For critiques of people's war by contemporary officers, see Strohn, *The German Army and the Defence of the Reich*, pp. 153–159.
[156] Geoffrey P. Megargee, "The German Army after the Great War: A Case Study in Selective Self-Deception," in Peter Dennis and Jeffrey Grey, eds., *Victory or Defeat: Armies in the Aftermath of Conflict* (Canberra: Big Sky Publishing, 2010), p. 107; Strohn, *The German Army and the Defence of the Reich*, pp. 150–151; Deist, "'Blitzkrieg' or Total War," p. 274.
[157] Mathew Cooper, *The German Army: 1933–1945* (New York: Stein and Day, 1978), p. 138. On the spectrum of German officer views on tanks, see Mary R. Habeck, *Storm of Steel: The Development of Armor Doctrine in Germany and the Soviet Union, 1919–1939* (Ithaca, N.Y.: Cornell University Press, 2003), pp. 36–76, 99–103.

idea that the close cooperation of all arms was necessary for an armored formation to move rapidly on the battlefield.[158]

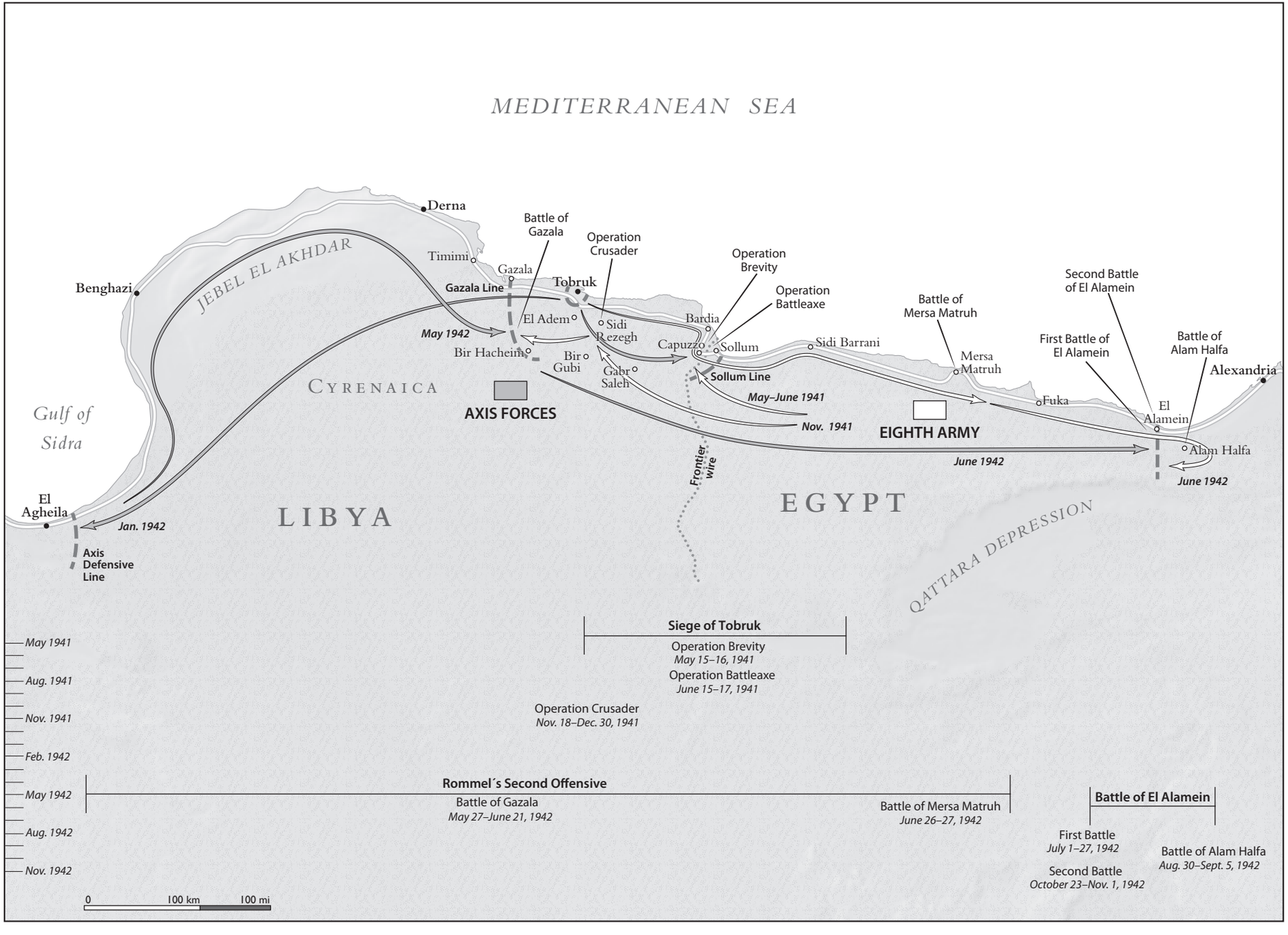
In contrast to British armored maneuver, the German army sought to preserve infantry and artillery capabilities developed in World War I. Prewar training in the panzer arm emphasized familiarity with combining tanks, infantry, artillery, and engineers, and their functions and capabilities.[159] Motorized or mechanized infantry supported tanks in the attack, reduced bypassed points of resistance, and held seized territory. Artillery supported every attack, and anti-tank units were positioned well forward.[160]

German ideas about anti-tank defenses also remained consistent with its World War I practices. The Germans used anti-tank guns rather than tanks as the best defense against enemy armor. German anti-tanks defenses were based on a combination of gun batteries and machine-guns deployed in depth in a mutually supporting pattern, along with minefields and other obstacles—again, resembling Western Front techniques. If a tank-versus-tank clash was required, panzers were trained to withdraw and lure the enemy onto a hidden screen of anti-tank weapons.[161]

By 1932, the army was committed to employing tanks as part of a mechanized combined-arms force.[162] To be sure, much like the British armored division, World War II revealed that the proportion of tanks in panzer divisions was too large, but they had a better balance of support arms, and their doctrine emphasized close cooperation with infantry, artillery, and engineers.[163] Instead of a radical break with the past, an undermatch encouraged the German army to create units with high mobility to achieve short-term successes through surprise and avoid trench warfare, but also permitted it to integrate armor into its existing set of traditional capabilities.

Variation in British Army Effectiveness in the Desert War, 1941–1942

[158] Megargee, "The German Army after the Great War," p. 111; Deist, "The Rearmament of the Wehrmacht," p. 435; Förster, "Evolution and Development of German Doctrine," p. 23.
[159] Richard L. DiNardo, *Germany's Panzer Arm* (Westport, Conn.: Praeger, 1997), pp. 57, 110; Manfred Messerschmidt, "German Military Effectiveness between 1919 and 1939," in Allan R. Millett and Williamson Murray, eds., *Military Effectiveness*, Vol. 2: *The Interwar Period* (New York: Cambridge University Press, 2010), pp. 243–244.
[160] On the employment of panzer divisions, see Robert M. Citino, *The Path to Blitzkrieg: Doctrine and Training in the German Army, 1920–1939* (Boulder, Colo.: Lynne Rienner, 1999), pp. 242–243.
[161] DiNardo, *Germany's Panzer Arm*, pp. 82–83.
[162] Citino, *The Path to Blitzkrieg*, p. 252.
[163] DiNardo, *Germany's Panzer Arm*, p. 95.


MEDITERRANEAN SEA
Derna
Battle of Gazala
Operation Crusader
Timimi
Gazala
Tobruk
Operation Brevity
Operation Battleaxe
Second Battle of El Alamein
Battle of Mersa Matruh
Benghazi
JEBEL EL AKHDAR
Gazala Line
El Adem
Sidi Rezegh
Bardia
Capuzzo
Sollum
Sidi Barrani
Mersa Matruh
First Battle of El Alamein
Battle of Alam Halfa
Alexandria
May 1942
Bir Hacheim
Bir Gubi
Gabr Saleh
CYRENAICA
Sollum Line
May–June 1941
Fuka
El Alamein
Gulf of Sidra
AXIS FORCES
Nov. 1941
EIGHTH ARMY
June 1942
Alam Halfa
June 1942
Frontier wire
El Agheila
Jan. 1942
LIBYA
EGYPT
QATTARA DEPRESSION
Axis Defensive Line
Siege of Tobruk
Operation Brevity
May 15–16, 1941
Operation Battleaxe
June 15–17, 1941
Operation Crusader
Nov. 18–Dec. 30, 1941
May 1941
Aug. 1941
Nov. 1941
Feb. 1942
May 1942
Aug. 1942
Nov. 1942
Rommel´s Second Offensive
Battle of Gazala
May 27–June 21, 1942
Battle of Mersa Matruh
June 26–27, 1942
Battle of El Alamein
First Battle
July 1–27, 1942
Second Battle
October 23–Nov. 1, 1942
Battle of Alam Halfa
Aug. 30–Sept. 5, 1942
0
100 km
100 mi

British armored maneuver and German combined-arms maneuver came head-to-head in the Desert War. Three months after Italy invaded Egypt in September 1940, Britain's Western Desert Force launched a counterattack (Operation Compass) that resulted in a complete rout of the Italian Tenth Army as it retreated westward toward Tripolitania. In February 1941, the Afrika Korps under Lieutenant General Erwin Rommel's command arrived in North Africa to make sure that Tripoli was not abandoned without a fight.[164] Over the next two years, the Desert War unfolded across a 1,200-mile stretch of land between Tripoli in the west and Alexandria in the east.

British military performance for the first 16 months was poor—it repeatedly failed to achieve mission objectives at acceptable cost—followed by a noticeable improvement first in successful defensive operations at the First Battle of El Alamein and the Battle of Alam Halfa, then an effective offensive at the Second Battle of El Alamein. Battlefield results are not monocausal outcomes, but the theory expects, and the evidence shows, that British armor innovation played a significant role in undermining military effectiveness. When the principles of armored maneuver held sway, British forces were ineffective, but as British commanders gradually unlearned armored maneuver and restored traditional capabilities—specifically those associated with the infantry-artillery team from the Western Front—performance improved.

BRITISH ARMY INEFFECTIVENESS IN THE DESERT WAR, 1941–1942

From March 1941 to June 1942, British forces suffered a string of defeats. In March, Rommel's first offensive (March 28–May 30, 1941) reversed Italian territorial losses from Operation Compass and pushed the British out of Libya, except for the garrison at the port city of Tobruk. The British and Commonwealth allies tried to relieve the siege of Tobruk three times. Operation Brevity (May 15–16, 1941) and Operation Battleaxe (June 15–17, 1941) failed to reach Tobruk and British armor suffered shocking losses. On the third attempt, in Operation Crusader (November 18–December 30, 1941), the Western Desert Force had expanded into the Eighth Army and finally relieved Tobruk with overwhelming material superiority. But again, the British bore an unacceptable cost to its armored forces, while Rommel and his staff were satisfied with their army performance.[165] Shortly thereafter, Rommel launched his second offensive and again chased

[164] Martin Kitchen, *Rommel's Desert War: Waging World War II in North Africa, 1941–1943* (Cambridge: Cambridge University Press, 2009), p. 51; Lewin, *The Life and Death of the Afrika Korps*, p. 14.
[165] Jonathan Fennell, *Combat and Morale in the North African Campaign: The Eighth Army and the Path to El Alamein* (Cambridge: Cambridge University Press, 2011), p. 60; Carver, *Tobruk*, p. 149.

British and Commonwealth forces across Lybia. The offensive slowed just west of Tobruk, around Gazala. During the subsequent Battle of Gazala (May 26–June 21, 1942), Rommel's divisions again forced Eighth Army into retreat, but this time seized Tobruk and pushed onward into Egypt.

British army ineffectiveness can be traced to the radicalism of its armor innovation: the new capability failed to deliver on its promises, but the army could not rely on its traditional capabilities either. The central principle of armored maneuver was tank primacy—the mistaken idea that tanks would be war-winning weapons if they were unencumbered by the complicated tasks of cooperating with infantry and artillery. But British armored divisions conducting armored maneuver found their tank numbers fall at an astonishing rate for the very reasons raised by interwar critics. Mechanical reliability of tanks remained a problem.[166] The chief culprit, however, was German use of anti-tank guns—a plausible countermeasure that armor innovators downplayed by appealing to high tank mobility and surprise attacks.

British campaign plans expected tanks to search and destroy the German panzer force in decisive tank battles that would determine the outcome of any land campaign.[167] But German combined-arms maneuver posited tanks as the primary anti-tank weapon as was done in World War I. German tactics pushed anti-tank guns forward to prepare the way for panzer regiments and to cover their flanks in combat. Rommel drew British armor on to anti-tank guns while reserving his own armor for maneuver against more vulnerable targets such as supply columns, dismounted infantry, or a formation's headquarters.[168]

When confronted with these tactics, British armored divisions struggled to overcome enemy defenses because they lacked traditional capabilities. Traditionally, infantry spotting and artillery fire would be used to suppress enemy defenses, but the armored division's artillery and infantry were left in the rear to man defensive positions or conduct mop up operations.[169] The artillery lacked a standard technique to support fast tank forces, and mobile infantry battalions did not know how to cooperate with tanks.[170] For example, although Eighth Army held a decisive advantage in field artillery in Operation Crusader, panzer divisions typically enjoyed a local

[166] Daniel Todman, *Britain's War*, Vol. 2: *A New World, 1942–1947* (New York: Oxford University Press, 2020), pp. 262–263.
[167] Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, p. 35.
[168] Fraser, *Knight's Cross*, p. 253; Pitt, *The Crucible of War*, p. 302.
[169] Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, p. 46.
[170] Bond, *British Military Policy*, p. 187.

superiority in artillery support against British armor attacks.[171] And after the Battle of Gazala, the chief of staff of Middle East Headquarters criticized the handling of British armor, which "fought without its vital motor infantry component."[172] With little fire support from other arms, British tanks repeatedly charged German anti-tank gun screens to their own demise.[173] When the British tried to work around the German flank, they were lured on to German guns.[174]

Commanders on both sides eventually recognized the causal relationship between British armored maneuver, the loss of traditional capabilities, and military ineffectiveness.[175] From Rommel's perspective, "the British armoured divisions—in contrast to our own—were 'pure in race', that is to say, they consisted of armour throughout."[176] Similarly, Lieutenant General Sir Henry Wilson, who commanded the Western Desert Force, sought to "check a pernicious doctrine … that tank units were capable of winning an action without the assistance of the other arms."[177] Field Marshal Sir Claude Auchinleck, Commander-in-Chief Middle East and commander of Eight Army, bemoaned "the idea that the Royal Armoured Corps was an army within an army."[178]

The root problem was innovative deviation from combined arms principles. One German staff officer compared the German panzer division, "a highly flexible formation of all arms, which always relied on artillery in attack or defense," to the British forces, which "failed to make adequate use of their powerful field artillery, which should have been taught to eliminate our anti-tank guns."[179] Major General William Gott, commander of the 7th Armored Division, attributed German effectiveness and British weakness to the way the German, in "every phase of battle …

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[171] Michael Carver, *Dilemmas of the Desert War: A New Look at the Libyan Campaign, 1940–1942* (London: B. T. Batsford, 1986), pp. 52–53; Carver, *Tobruk*, 39; Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, p. 53.
[172] Quoted in Barr, *Pendulum of War*, p. 57.
[173] Some historians attribute this charging habit to the influence of horsed cavalry, but Royal Tank Regiments differed little in their desert tactics from tank regiments formed from cavalry. See Harris, *Men, Ideas and Tanks*, p. 260; Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, p. 35.
[174] Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, p. 47.
[175] For historiography that emphasize the lack of inter-arm cooperation, see J.C. Scoullar, *The Battle for Egypt* (Wellington: Oxford University Press, 1955); Francis Tuker, *Approach to Battle* (London: Cassell, 1963); Williamson Murray, "British Military Effectiveness in the Second World War," in Allan R. Millett and Williamson Murray, eds., *Military Effectiveness*, Vol. 3: *The Second World War* (New York: Cambridge University Press, 2010), pp. 110–113, 124–126.
[176] Quoted in Agar-Hamilton, *Crisis in the Desert*, p. 13.
[177] Field Marshal Lord Wilson, *Eight Years Overseas, 1939–1947* (London: Hutchinson, 1950), p. 28.
[178] Field Marshal Sir Claude J. E. Auchinleck, *Despatch* (London: HMSO, 1948), p. 368.
[179] Quoted in Corelli Barnett, *The Desert Generals* (London: Kimber, 1960; second ed., Bloomington: Indiana University Press, 1982), p. 108.

co-ordinates the action of his anti-tank guns, Field Artillery and Infantry with his tanks."[180] Auchinleck blamed the fiasco at Gazala in part on armor's "failure to co-operate closely with infantry and artillery."[181] And General Bernard Freyberg, commander of the New Zealand Division, concluded that British failures up through 1942 were not for want of a good tank, but artillery support for British armor.[182]

The heavy reliance on armored maneuver also weakened the effectiveness of infantry divisions. Since the tank was the principal anti-tank weapon, infantry commanders expected and demanded fast tanks be stationed nearby to defend them against panzers. This warped campaign plans. For instance, in Operation Crusader, due to infantry demands, Eighth Army sub-optimally dispersed its overwhelming number of tanks and positioned them to guarantee protection to infantry divisions that refused to move until the armored battle was underway.[183] But later experience demonstrated that an infantry division with adequate artillery could repel a panzer attack and even inflict heavy damage.[184]

Poor inter-arm cooperation also plagued infantry assaults on prepared defenses. In the First Battle of El Alamein, described in the next section, Axis forces established in-depth defensive systems like those of the Western Front, but the British army had lost the traditional capabilities needed to attack a position held in depth.[185] Infantry mounted night attacks and successfully seized their objectives by daybreak, but supporting arms got lost in the night, were held up by enemy posts the infantry had bypassed, or never departed from the starting line. Shorn of supporting arms, entire infantry brigades were destroyed by the panzer divisions' inevitable counterattacks at dawn. Infantry commanders expected too much from tanks, whereas tank commanders were not trained to cooperate closely with infantry.[186]

IMPROVEMENT IN BRITISH ARMY EFFECTIVENESS, 1942

After the Battle of Gazala, the Axis forces' momentum petered out near a defensive line prepared by Eighth Army, running south from El Alamein. It was here that British forces began to show

[180] Quoted in ibid., p. 109.
[181] Quoted in Carver, *Dilemmas of the Desert War*, p. 58.
[182] Agar-Hamilton, *Crisis in the Desert*, p. 11.
[183] Carver, *Tobruk*, pp. 28, 36; Pitt, *The Crucible of War*, p. 346.
[184] Agar-Hamilton and Turner, *The Sidi Rezeg Battles*, pp. 64–66.
[185] Barr, *Pendulum of War*, pp. 141–142.
[186] Scoullar, *The Battle for Egypt*, pp. 210, 218; Playfair, *The Mediterranean and Middle East*, pp. 351–352; Tuker, *Approach to Battle*, pp. 161, 173; Barr, *Pendulum of War*, pp. 122–123.

signs of improvement. From July 1942 to January 1943, the Eighth Army mounted two effective defenses and an effective offense, achieving mission objectives at acceptable cost. At the First Battle of El Alamein (July 1–27, 1942), Eighth Army successfully repelled Axis advances, though its counterattacks failed to make headway against enemy defenses. Rommel again tried to breakthrough British defenses in the Battle of Alam Halfa (August 30–September 5, 1942) but was similarly repulsed. This time, instead of an immediate counterattack, British forces reorganized and retrained for almost two months before initiating the Second Battle of El Alamein (October 23–November 4, 1942), the British army's first truly effective offensive against German forces.

What were the British doing here that they had not done before? The evidence suggests that British military effectiveness improved as the army reversed innovation, unlearned armored maneuver, and restored traditional capabilities: the infantry-artillery team supported by tank forces. British commanders restored traditional capabilities first on the defense. Eighth Army learned to coordinate and concentrate artillery fire to peel apart the all-arms organization of attacking panzer divisions. Infantry learned to defend themselves as they received more anti-tank weapons, and to act as forward infantry observers for artillery fire. And British armor learned to lure the enemy into combined-arms fire delivered by artillery, infantry, and tanks in hull-down position, as opposed to charging forward against attacking panzer formations.[187]

At the First Battle of El Alamein, Rommel tried to outflank Eighth Army's positions and force it back to the Suez Canal. On the first day, an infantry brigade, supported by nine heavy tanks and artillery, blunted the attack at Deir el Shein.[188] The next day, Rommel redirected his attack, but coordinated artillery fire pinned down his forces. By the third day, attacking forces dug in and transition to the defensive, and eventually withdrew. After a month's rest, at the Battle of Alam Halfa, Rommel tried once more to swing south of the British defensive line. British armor and anti-tank gunners hid in the folds of Alam Halfa Ridge and laid down fire on the advancing panzers once they were within 300 yards, followed by heavy concentrated fire from over 100 field guns.[189] After two days, Rommel was forced to withdraw.

During the two-month lull between Alam Halfa and Second Alamein, Eighth Army restored traditional offensive capabilities. Lieutenant General Bernard Montgomery was in

[187] Barr, *Pendulum of War*, p. 217.
[188] F.W. von Mellenthin, *Panzer Battles: A Study of the Employment of Armor in the Second World War*, trans. H. Betzer (Norman, Okla.: University of Oklahoma Press, 1956), p. 128.
[189] Tuker, *Approach to Battle*, pp. 195, 199; Barr, *Pendulum of War*, p. 230.

command, having replaced Auchinleck after First Alamein. He reorganized and retrained the infantry, armor, and artillery to carry out coordinated set-piece battles fit for the Western Front.[190] Each infantry division and its components underwent full-scale rehearsals to form a bridgehead: the infantry assault, artillery support, minefield gapping, and cooperation with heavy infantry tanks and the Royal Air Force. British armored divisions practiced the entire formation together, and coordinating tank, artillery, and machine-gun fire to fight as a division rather than independent armored brigades. Finally, Eighth Army returned authority to divisional artillery commanders, reintroduced counter-battery and creeping barrage methods developed in World War I, and adapted a new standardized technique of defensive fire against alternating impromptu targets.[191]

Unlike its previous offensives, the Second Battle of Alamein exhibited all the hallmark qualities of British operations in World War I. It was a rehearsed, infantry-artillery assault, supported by heavy tanks, against fixed defenses and enemy garrisons, designed to destroy the enemy's offensive power through attrition. The battle opened with a counter-battery barrage that destroyed up to half the enemy's anti-tank guns, followed by creeping barrages to suppress enemy fire and guide the infantry forward. The infantry returned to "bite-and-hold" tactics common on the Western Front. And through robust battle drills and proven techniques of consolidation, the infantry defended themselves against counterattack even by enemy panzer divisions. After Second Alamein, a flood of reports promoted a return to the 1918 practice of coordinating massed fires from field artillery in support of infantry advances.[192]

Second Alamein was Britain's first permanent land victory in World War II, and it was achieved at expected costs. Remarkably, Montgomery predicted the battle would last 10 to 12 days and instructed medical services to prepare for 13,000 casualties.[193] From opening salvo to Rommel's official retreat, the battle lasted 12 days and Eighth Army suffered 13,110 dead, wounded, and missing.[194] Lingering vestiges of armored maneuver continued to hamper the armored divisions' performance, but by restoring the traditional infantry-artillery team—reversing the radical innovation of armored maneuver—the British army improved its performance.[195]

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[190] French, *Raising Churchill's Army*, p. 282.
[191] For details of these changes, see Barr, *Pendulum of War*, p. 262–265, 289–293; Tuker, *Approach to Battle*, pp. 249–250; Shelford Bidwell, *Gunners at War* (London: Arrow, 1972), pp. 189–190.
[192] Jon Latimer, *Alamein* (Cambridge, Mass.: Harvard University Press, 2002), p. 178; Barr, *Pendulum of War*, p. 261.
[193] John Keegan, *The Second World War* (New York: Penguin, 1989), p. 336.
[194] Barr, *Pendulum of War*, p. 404.
[195] French, *Raising Churchill's Army*, pp. 274–285; Barr, *Pendulum of War*, pp. 409–410.

In conclusion, the detailed wartime evidence reveals that innovation can have varying effects. German innovation in armored warfare improved effectiveness while British innovation did not. Moreover, reversing innovation played a critical role in improving British combat power.

Evaluating Alternative Explanations

Research on military innovation offers few systematic explanations for variation in innovation's contribution to military effectiveness. But the literature does identify certain variables that in principle could account for harmful innovation. The lack of adequate resources, characteristics of the technology itself, strategic culture, and organizational culture, all might have privileged a harmful innovation trajectory and screened out better pathways.

First, the lack of resources in itself might account for self-defeating innovation because it limits the service's ability to familiarize itself with new techniques and technology.[196] The small army budget and shrinking industrial base prevented the British army from producing a true medium tank, which meant limited experience with a main battle tank.[197] But at least the British army had the well-regarded Vickers Medium tank in healthy numbers during the 1920s. Moreover, by August 1939, British monthly tank production surpassed Germany.[198] The German army, in contrast, not only lacked a medium tank, but it also lacked deep experience with tanks in general because of Versailles restrictions.[199] When Germany finally started producing tanks in the mid-1930s, the army used a light tank for training. The German experience therefore challenges the causal weight of resource austerity.

Second, disruptive technology can improve performance along an unvalued war fighting trajectory, which increases the likelihood that a service uses the technology in suboptimal ways.[200] But the case comparison holds armor technology constant. In fact, it was the British army that undertook disruptive innovation, which the innovation literature tends to argue is a superior mode of competition, whereas the German army incorporated tanks into its existing operational concepts.

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[196] Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies* (Ithaca, N.Y.: Cornell University Press, 1988).
[197] Harris, "British Armour and Rearmament in the 1930s," pp. 228, 239.
[198] Peden, *Arms, Economics and British Strategy*, pp. 123, 144.
[199] The Germans did establish a tank school with the Soviets at Kazan but could not produce large numbers of tanks and developed its armor doctrine based primarily on dummy tank units. See Habeck, *Storm of Steel*, pp. 136–145.
[200] Peter Dombrowski and Eugene Gholz, *Buying Military Transformation: Technological Innovation and the Defense Industry* (New York: Columbia University Press, 2006), pp. 18–28. See also Terry C. Pierce, *Warfighting and Disruptive Technologies: Disguising Innovation* (London: Frank Cass, 2004).

Third, a country's strategic culture could channel a service's innovation efforts toward a nationally preferred mode of warfare instead of the most effective one. Strategic culture refers to a collection of relatively stable beliefs, norms, and patterns of behavior that guide the threat and use of force.[201] British strategic culture centered on the use of naval power to defend lines of communication with its empire, and to use naval interdiction and blockade to exert economic pressure on continental enemies.[202] British innovative energies therefore should have centered on the Royal Navy, not the army. But as I have demonstrated, the army did innovate and did so quite radically.

Finally, the service's organizational culture "shapes its members' perceptions and affects what they notice and how they interpret it."[203] One strain of the organizational culture argument suggests that cognitive blinders prevent innovation. Elizabeth Kier, for example, argues that British army culture valued drills and ceremonial duties befitting of a gentleman-officer, rather than professional skills and technological expertise.[204] But the bulk of the officer corps, including every CIGS, accepted mechanization as the primary way the army could win quickly while avoiding casualties—disagreement centered on the pace of reform.[205] Critics also single out the cavalry's regimental commitment to horses as a major obstacle to mechanization efforts.[206] But when the army decided to mechanize the cavalry, most regimental officers were "determined to make a success of it as the only way of ensuring the future of their regiments."[207]

Organizational culture can also cause the service to develop new capabilities in a way that aligns with its preferred mission goals and methods, but is misaligned with effectiveness.[208] The British regimental system, for instance, could have preventing inter-arm cooperation.[209] But by the late nineteenth century, the War Office significantly professionalized the regimental system and

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[201] For example, see Colin S. Gray, "National Style in Strategy: The American Example," *International Security*, Vol. 6, No. 2 (1981), p. 22.
[202] B.H. Liddell Hart, *The British Way in Warfare* (London: Faber & Faber, 1932), p. 37.
[203] Kier, *Imagining War*, p. 28.
[204] Ibid., p. 120–137. See also Bidwell and Graham, *Fire-Power*, pp. 150, 191–192; Williamson Murray, "Armored Warfare," p. 22; Brian Bond and Williamson Murray, "The British Armed Forces, 1918–39," in Allan R. Millett and Williamson Murray, eds., *Military Effectiveness*, Vol. 2: *The Interwar Period* (New York: Cambridge University Press, 2010), p. 122.
[205] French, *Raising Churchill's Army*, pp. 12, 14–16, 35–36, 43; Liddell Hart, "The Development of the 'New Model' Army," p. 37; Major General Giffard Le Q. Martel, "Mechanization and Trench Warfare," October 1939, GQM 3/1, Imperial War Museum.
[206] Murray, "Armored Warfare," pp. 27–28; Liddell Hart, *The Tanks*, pp. 200, 223.
[207] French, "The Mechanization of the British Cavalry," p. 299.
[208] Kier, *Imagining War*, p. 31; Long, *The Soul of Armies*, pp. 15–17.
[209] Barnett, *The Desert Generals*, pp. 103–104; Bond and Murray, "The British Armed Forces," pp. 111, 121–122.

broke down regimental parochialism through compulsory training, promotion exams, and overseas duties.[210] Or perhaps the army's cultural identity, being rooted in imperial garrisoning, could have prioritized frontier warfare, which contradicted the skills needed for conventional warfare.[211] But the general staff stubbornly prepared for continental involvement; and the army resisted training specifically for small wars as detrimental to preparations for the next great war.[212] All four alternative explanations are plausible, but each falls short in the case of British armor innovation.

Conclusion

Military innovation is more dangerous than generally acknowledged. There is a risk that innovation destroys more than it creates. Facing a wicked mismatch between ambitious commitments outstripping austere resources, the British army developed armored maneuver and cannibalized traditional capabilities, placing a big bet on a radical vision of future warfare while ignoring plausible vulnerabilities. In contrast, Germany's interwar army innovated amid a temporary undermatch, never accepted innovation as a silver bullet, and incorporated armored fighting vehicles into more traditional organization and doctrine developed in World War I. Prevailing wisdom suggests that innovation improves military power, and the more disruptive the change the more effective the resulting combat forces. But in wartime, British armor radicalism did not deliver on its promises, the enemy exploited vulnerabilities left open by the loss of traditional capabilities, and commanders returned to older methods of warfare as a backstop to shore up combat power.

Exhaustive testing of my theory requires further analysis, but if it hold up under continued testing, it has critical implications for the study and practice of military innovation. If innovation is not *always* beneficial for combat performance, then identifying the conditions under which innovation occurs is insufficient. By truncating the universe of cases to power-enhancing innovation, current theories under-specify why the identified causes of innovation should improve

[210] David French, *Military Identities: The Regimental System, the British Army, and the British People, c. 1870-2000* (New York: Oxford University Press, 2005), pp. 153–60.
[211] Bond, *British Military Policy*, pp. 117, 124, 181, 188.
[212] J.P. Harris, "The British General Staff and the Coming of War, 1933–39," in David French and Brian Holden Reid, eds., *The British General Staff: Reform and Innovation, C. 1890–1939* (London: Frank Cass, 2002), pp. 177–181; T.R. Moreman, "'Small Wars' and 'Imperial Policing': The British Army and the Theory and Practice of Colonial Warfare in the British Empire, 1919–1939," *Journal of Strategic Studies*, Vol. 19, No. 4 (1996), pp. 125, 127.

combat performance and how innovation relates to military power. Therefore, military innovation research needs to refocus on the quality of the innovation process.

For those concerned with the future character of war, the theory and findings offer practical intuitions for navigating current policy debates. First, innovation does not necessarily improve combat performance. Second, what may be lost in an innovation process is as important as what is created. In the United States today, innovating new capabilities for a China contingency will come at a cost to capabilities the U.S. military has spent the last two decades creating in Iraq and Afghanistan, thus accepting a higher level of risk in ground force readiness.[213] This may or may not be prudent. But whatever the case may be, it is important to recognize and prepare for downside risks.

Finally, it is not a coincidence that the topic of military innovation is so popular in U.S. defense discourse. Ever since World War II, the United States has accumulated expansive interests abroad, while being reluctant to invest the necessary resources to sustain these commitments.[214] But there is a particularly foreboding sense today that the U.S. military is overstretched, that resources and commitments are misaligned. Part of this stems from the fact that U.S. security commitments are more expansive than those of its adversaries. Meanwhile, resources are also more constrained than top line figures suggest: the U.S. military has not been smaller since the end of World War II; its share of combat forces has declined relative to support forces; and the rising cost of military equipment exceeds inflation and growth in the defense budget.[215]

In 1942, the strategist Bernard Brodie warned that the United States was "under the sway of a dogma of innovation, just as blind and as dangerous as that there is nothing essentially new in war."[216] The warning remains relevant today.

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[213] For example, see Mark F. Cancian, "Don't Go Too Crazy, Marine Corps," *War on the Rocks*, June 24, 2020; Blake Herzinger, "Give the U.S. Navy the Army's Money," *Foreign Policy*, June 24, 2021.
[214] Colin Dueck, *Reluctant Crusaders: Power, Culture, and Change in American Grand Strategy* (Princeton, N.J.: Princeton University Press, 2006), p. 27.
[215] John A. Alic, *Trillions for Military Technology: How the Pentagon Innovates and Why It Costs So Much* (New York: Palgrave Macmillan, 2007), pp. 49–106; Daniel R. Lake, *The Pursuit of Technological Superiority and the Shrinking American Military* (New York: Palgrave Macmillan, 2019), pp. 17–56.
[216] Bernard Brodie, *A Layman's Guide to Naval Strategy* (New York: Oxford University Press, 1942), p. 177.