Atlantic Council
BRENT SCOWCROFT CENTER
ON INTERNATIONAL SECURITY

ISSUEBRIEF

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Disrupt or Be Disrupted: How Governments Can Develop Decisive Military Technologies

MAY 2014

Just what makes a military technology disruptive? How does one know who will disrupt, and who will be disrupted? How can we aim to develop disruptive technologies, and how can we spot them before others use them to disrupt our security? Recent studies suggest that five factors matter most in developing those technologies into real military capabilities: financial resources, industrial readiness, systems integration, cultural receptivity, and organizational capacity. Prototyping and field experimentation leverage all these factors, and help make the potentially disruptive ultimately decisive in war.

Defining Disruption

A *disruptive* technology changes the dynamics of competition in ways that are both profound and unexpected. The concept comes from business competition, as first proposed by Clayton Christiansen of Harvard Business School in his 1997 book *The Innovator's Dilemma.*[1] The alternative is a *sustaining* technology, whose development reinforces existing patterns of competition. Today, citing Christiansen's work on disruption in business has become popular among almost anyone studying military innovation.[2] But defining *disruption* is important, lest pundits abscond with the term in the same manner as *transformation*—applied to anything fashionable in the Rumsfeld era. In the military context, a disruptive technology radically alters the strategic balance. Cases from the turbulent hundred years after 1850 readily come to mind: railroads, steamships, machine guns, aircraft, and nuclear weapons.

In most instances, another military technology was supplanted. But the disruption induced can extend well beyond armaments, bringing unforeseen alterations to the very makeup of society.[3] This is because disruptive technology "offers capabilities that were not available—and were in many ways unimaginable—a generation earlier, and in so doing provokes deep questions whose answers are not readily available."[4] The historical narrative is familiar: the stirrup increased the social importance of horse-owning

Disrupting Defense

This issue brief is part of the Atlantic Council's conference **Disrupting Defense: Dynamic Security in an Age of New Technologies**. The conference hosts leaders from government, business, media, and the think tank community to explore technology's disruptive impact on geopolitics, efforts by public and private investors to fund technological breakthroughs, the changing ways the United States and its allies equip their forces for wars of the future, and how best to leverage the creativity of artists to envision those wars and continue this important dialogue. The Disrupting Defense conference forms part of the Emerging Defense Challenges practice area of the Council's Brent Scowcroft Center on International Security, of which George Lund is the principal sponsor.

1 Clayton Christiansen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston: Harvard Business Review Press, 1997). Christiansen's work built on Henderson and Clark's work on *architectural* product innovations. See Rebecca M. Henderson and Kim B. Clark, "Architectural Innovation: The Reconfiguring of Existing Product Technologies and The Failure of Established Firms," *Administrative Science Quarterly*, vol. 35, no. 1, 1990, pp. 9–30. Note also that Joseph Schumpeter's concept of *creative destruction* may have been the earliest forerunner to the idea.

2 Michael Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton: Princeton University Press, 2010), p. 45. See also Peter Dombrowski and Eugene Gholz, *Buying Military Transformation: Technological Innovation and the Defense Industry* (New York: Columbia University Press, 2006), pp. 18, 26–29; and Terry C. Pierce, *Warfighting and Disruptive Technologies: Disguising Innovation* (London: Frank Cass, 2004).

3 John Ellis, *The Social History of the Machine Gun* (Baltimore: Johns Hopkins University Press, 1986).

4 Peter W. Singer, "Foreword," in Shawn Brimley, Ben FitzGerald and Kelley Sayler, *Game Changers: Disruptive Technology and US Defense Strategy*, (Washington, DC: Center for a New American Security, September 2013).

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nobility, the longbow checked it, and the power of cannons finally killed it in favor of the centralized state.

Spotting a Coming Disruption

As former Secretary of Defense Robert Gates observed in his recent memoirs, "in the forty years since Vietnam, our record in predicting where we will be militarily engaged next, even six months out, is perfect: we have never once gotten it right."[5] Finding the weapons needed for those wars may be scarcely less challenging. A framework can help, and a host of recent studies suggests five factors:

Financial resources are essential. More expensive technologies lend an advantage to wealthier countries, or those with less costly strategies.[6] The threat of disruption is thus less when militaries have simpler tasks, or fewer constraints on resources. Consider the lagging British response to unrestricted submarine warfare in the First World War. The U-boats derived cover from the German High Seas Fleet, even as a mere fleet-in-being. Counterfactually, if the Royal Navy had more money, it might have maintained its lead in dreadnoughts and built enough destroyers to protect both the battle line and merchant shipping.[7]

Money can also be spent strategically to induce unaffordable reactions by potential opponents. Consider one Cold War argument: economist Alain Enthoven calculated that the entire nuclear mission could be most cost-effectively undertaken with ballistic missiles. Glenn Kent, the Air Force general, argued that aircraft would greatly complicate the defense of the huge expanse of the Soviet Union, forcing Moscow to spend money it did not have.[8] More revolutionary technologies would later induce greater trepidation. As the *Economist* noted in its memorable 1995 survey of military technology, "Russia had neither the resources nor the technology to realize all of Marshal Ogarkov's ideas. America has."[9]

Of course, more money is not strictly better. Disruption often comes from firms whose products fill a market need below the performance of products from the established firms. Honda's motorcycles are a classic example. Today, Apple spends far less on research and development than Microsoft, but is scarcely less innovative. In the fourteenth century, longbows had to be cheaper than plate mail and horses, as Medieval England was never as wealthy as Medieval France.

Industrial readiness forges latent technologies into actual weapons. Consider how France was a leader in aircraft design during the First World War. France's industry was ravaged by the Depression, but Germany's literally started from scratch after Versailles. Yet, France poured most of its postwar resources into its army, never catching up in aviation, even though it had access to the same technologies as Britain and Germany. Resource allocation and poor industrial organization contributed to its defeat.[10] Later, Germany invested heavily in potentially disruptive technologies: cruise missiles, ballistic missiles, and jet-powered fighters. But German industry could not produce those bleeding-edge weapons in sufficient quantities, and was hampered by too-close supervision by military and political authorities, who imposed too-frequent design changes. The result was chaos, craft production, and stunted capacity.[11]

When military-industrial readiness is not enough, governments may look to commercial technologies for disruptive options. Aircraft design was a commercial business before the First World War, and military designs drew on commercial advances in the Interwar period. Today, improvisation of Afghan explosives draws from Pakistani fertilizer plants. Even in the United States, a range of new weapons has derived from technologies of commercial provenance: the first Predator drones flew with snowmobile engines, and the Navy's *Spearhead*-class transports are militarized catamaran car ferries.[12] Of course, not all commercial analogs to military technologies will be battle-ready, as military needs are often more demanding.[13] The key is ascertaining which requirements can be reasonably relaxed.

Systems integration fuses discrete technologies, which are rarely war-winners in their own right. Proximity fuses, radar, and heavy bomber engines may be counterexamples from the Second World War, in that they added important capabilities without requiring years of integration to mate them to existing systems. It should be noted that although atomic weapons were important in winning the war against Japan, they were not the sole reason for

5 Robert M. Gates, *Duty: Memoirs of a Secretary at War* (New York: Alfred A. Knopf, 2014), p. 590.

6 Horowitz, *The Diffusion of Military Power*.

7 Mukunda, "We Cannot Go On," p. 158.

8 Glenn A. Kent, *Thinking about America's Defense: An Analytical Memoir* (Santa Monica: RAND, 2008), pp. 153–158. We thank John Pinder and W. Alex Vacca of Northrop Grumman for suggesting this example.

9 "The Softwar Revolution," *Economist*, June 10, 1995.

10 Robin Higham, *Two Roads to War: The French and British Air Arms from Versailles to Dunkirk* (Annapolis: Naval Institute Press, 2012).

11 Richard Overy, *Why the Allies Won* (New York: W.W. Norton & Company, 1995).

12 James Hasik, *Arms and Innovation: Entrepreneurship and Alliance in the Twenty-First-Century Defense Industry* (Chicago: University of Chicago Press, 2008), chapters 3 and 5.

13 Dombrowski and Gholz, *Buying Military Transformation.*

victory. Furthermore, the history of atomic weapons is a reminder that monopolies can be fleeting. The US monopoly lasted just four years—until 1949, when the Soviets exploded their own weapon. What mattered much more in the Cold War was the superior Western capacity to combine multiple technologies—particularly in electronic systems—into integrated war-fighting systems.[14]

With many recent weapon programs, integrating the electronic hardware and software has often required a decade or more. In development, time is money, but around NATO, member states' military budgets have been at best flat. Defense production seems to be globalizing, so tapping into skills and capacity around the world is appealing.[15] This broader supply base is yet to motivate weapons buyers in the Pentagon, but it may provide less wealthy actors greater access to advanced technologies.[16] If so, the advantage of the first movers may be fleeting.

Cultural receptivity brings the flexibility for organizational thinking about disruption.[17] But even as it opens some avenues for change, culture closes others.[18] A service's culture "screens out some parts of 'reality' while magnifying others."[19] Different military services within a single nation can have quite different cultural outlooks.[20] Consider how the US Air Force's acceptance of armed drones took much longer than the US Navy's embrace of cruise missiles. The surface admirals wanted an offensive weapon, but the fighter generals were not interested in flying missions from a cubicle. Serious adoption took direction from Defense Secretary Gates and his appointment of Norton Schwartz, a transport pilot, as chief of staff.

Cultural dispositions can affect not just rates of adoption, but even fundamental interest in change.[21] Consider how Ottoman Turkey and Manchu China totally failed to adopt the innovations of the nineteenth century, while Meiji Japan "spectacularly made the transition."[22] Willingness to tolerate social change may account for the difference. The Ottomans rejected Western practice as they feared Christian influence on Islamic society.[23] Like Napoleon's early opponents, the samurai couldn't imagine arming peasants, but reformers in France and Japan alike embraced the idea as modernity.[24] Instead, the security policies of the *anciens régimes* were focused internally, in forlorn efforts to shore up their existing orders.[25] This is why, even in the modern context, disruptive innovations may be best disguised as sustaining ones lest they encounter too much political resistance.[26]

Organizational capacity is the human analog to systems integration. Troops must be trained, tactics devised, and procedures mastered before a new technology can be employed effectively. The likelihood of successful adoption varies strongly with the operational complexity of the weapon system. For example, proliferation of ballistic missiles is threatening in part because it is administratively simple. Organizing, training, and equipping a Scud brigade is a task that even Iraq managed before 1990. In contrast, despite the huge surplus of carriers after the Second World War, only a handful of countries have ever convincingly operated them with fixed-wing aircraft. The choreography of flying, deck, and hangar bay operations is truly difficult to master.[27]

Wealthy countries do have greater resources to bring to challenges, but they sometimes fail to force the necessary changes on military bureaucracies.[28] The question encompasses not just technologies, but how they are applied. Consider tanks in the 1930s: the British organized all-tank armored brigades, the French penny-packeted them as infantry support, but the Germans created combined arms *panzer* divisions. British and French tanks were actually better than the German models of 1940, but they were organized badly, as interwar British and French doctrine permitted nothing better.

14 Thomas P. Hughes, *Rescuing Prometheus: Four Monumental Projects That Changed the Modern World* (New York: Pantheon, 1998).

15 Stephen G. Brooks, "The Globalization of Production and the Changing Benefits of Conquest," *Journal of Conflict Resolution*, vol. 43, no. 5, 1999, pp. 646–670.

16 Eugene Gholz, "Globalization, Systems Integration, and the Future of Great Power War," *Security Studies*, vol. 16, no. 4, 2007, pp. 615–636; Eugene Gholz and Daryl G. Press, "The Effects of Wars on Neutral Countries: Why It Doesn't Pay to Preserve the Peace," *Security Studies*, vol. 10, no. 4, 2001, pp. 4–22.

17 Mukunda, "We Cannot Go On."

18 Theo G. Farrell and Terry Terriff, "The Sources of Military Change," in *idem*, *The Sources of Military Change: Culture, Politics, Technology* (Boulder: Lynne Rienner, 2002), pp. 12–17.

19 Elizabeth Kier, *Imagining War: French and British Military Doctrine between the Wars* (Princeton: Princeton University Press, 1997), p. 28.

20 See Carl H. Builder, *The Masks of War: American Military Styles in Strategy and Analysis* (Baltimore and London: Johns Hopkins University Press, 1989).

21 See 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: Stanford University Press, 2010).

22 Emily O. Goldman and Richard B. Andres, "Systemic Effects of Military Innovation and Diffusion," *Security Studies*, vol. 8, no. 4, 1999, p. 80.

23 David B. Ralston, *Importing the European Army: the Introduction of European Military Techniques and Institutions into the Extra-European World, 1600-1914* (Chicago and London: University of Chicago Press, 1990), p. 48.

24 William H. McNeill, *The Pursuit of Power: Technology, Armed Force, and Society Since A.D. 1000* (Chicago: University of Chicago Press, 1982), pp. 220-221.

25 Emily O. Goldman, "Cultural Foundations of Military Diffusion," *Review of International Studies*, vol. 32, no. 1, 2006, pp. 70-71.

26 Pierce, *Warfighting and Disruptive Technologies.*

27 Horowitz, *The Diffusion of Military Power*, chapters 3 and 4.

28 Horowitz, *op. cit.*

Thus, "successful military innovators must master the art of bureaucracy even as they attempt to circumvent its most anti-reformist tendencies."[29] Leaders can help them by organizing intellectual conduits for identifying, prototyping, acquiring, and experimenting with candidate technologies. Leveraging a formal process for internal dissemination of lessons learned can help immensely. Until the 1990s, this had been largely missing from the US armed forces, but great progress has been made since.[30]

Evaluating Technologies

The modern problem with identifying possibilities is that the host of technologies can be bewildering. Should military leaders thus dread becoming a modern-day shogunate? There is real concern that the diffusion of inexpensive communications technologies—Internet multimedia, wireless phones, commercial encryption, big data, GPS, etc.,—is indeed leveling the military playing field.[31]

The rest of the list of usual suspects is easily recounted, but who is advantaged with each is not always clear. Additive manufacturing could dramatically lower the minimum efficient scale of production operations. Cyberattacks are now practiced by several states, and electronic espionage has become easier in that globally integrated economy. Robotics have burgeoned in the US arsenal since the 1990s, but the Iranian Shahed drones over Damascus today are looking a lot like American Reapers.[32] Stealth has endured as a US monopoly for thirty years, though largely for the economic inability of the Soviet Union and, later, Russia to compete. Directed energy may someday permit robust defenses against ballistic missiles, but this may also allow well-funded enemies to decimate waves of strike aircraft. Rail guns could render long-range bombardment a trivial expense on the margin, but the futility of intercepting hypersonic solid slugs would make worries over China's DF-21D missile seem trifling.

Disrupting, Before Being Disrupted

War is a matter of life and death, so innovations should naturally diffuse as a matter of survival, and the speed of emulation should depend strongly on the severity of the threat.[33] Eventually, the weapons and strategies of competing powers might converge around the world.[34] But the process is not automatic: even successful militaries occasionally need external motivation for action, and institutional reinforcement of change, as bureaucracies are designed to be hard to change.[35] In wartime, that threat may be the specter of defeat or the trauma of a high casualty count. In peacetime, the impetus can be harder to summon, as staff need a conviction that the leadership will stand by its reforms.[36] One could emphasize organizational capacity, which is foremost for building the flexibility needed to respond in crisis, but the long gestation period of some weapon systems makes this a problematic way of mitigating technological surprise.[37] Technical intelligence and cooperation with sophisticated allies can help, but someone must ultimately invest and build capacity. In particular, national security leaders should consider two under-appreciated steps:

Prototyping builds the needed industrial readiness and tests the possibility for systems integration. Science-fair experiments spur thinking, but ultimately only real weapons help the troops. The contractors supplying those weapons also need the prospect of earning a return on their investments. Defense ministries thus need to spend vigorously on not just research, but development. Applying monies at what the Pentagon calls the 6.4 (Demonstration & Validation) and 6.5 (Engineering & Manufacturing Development) levels is important, for these are where actual prototypes are funded. Another approach may be to devote a portion of research budgets to promising off-the-shelf purchases.

Field experimentation is then needed to test the new systems and the ideas behind them. While this happens to some extent in the cyber realm, it is largely adhocracy elsewhere. One option would be to establish permanent battalions or squadrons as small-scale "opfors" (opposing forces) equipped with potentially

29 Stephen J. Cimbala, "Forward," in Brett Steele, *Military Reengineering between the World Wars* (Santa Monica: RAND, 2005), p. xi.

30 Janine Davidson, *Lifting the Fog of Peace: How Americans Learned to Fight Modern War* (Ann Arbor: University of Michigan Press, 2010).

31 Paul K. Davis and Peter A. Wilson, *Looming Discontinuities in U.S. Military Strategy and Defense Planning: Colliding RMAs Necessitate a New Strategy* (Santa Monica: RAND, 2011). See also Michael R. Rip and James Hasik, *The Precision Revolution: GPS and the Future of Aerial Warfare* (Annapolis: Naval Institute Press, 2002).

32 Dave Cenciotti, "Iranian Shahed 129 Drone Appears over Damascus," *Aviationist*, April 10, 2014.

33 John A. Lynn, "The Evolution of Army Style in the Modern West, 800-2000," *International History Review*, vol. 18, no. 3, 1996, p. 509; João Resende-Santos, "Anarchy and the Emulation of Military Systems: Military Organization and Technology in South America, 1870–1930," *Security Studies*, vol. 5, no. 3, 1996, pp. 193–260.

34 Kenneth N. Waltz, *Theory of International Politics* (Reading: Addison-Wesley, 1979), p. 127.

35 Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca and London: Cornell University Press, 1984), p. 226; Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca and London: Cornell University Press, 1994), p. 2.

36 Conrad Peter Schmidt, *Changing Bureaucratic Behavior: Acquisition Reform in the United States Army* (Santa Monica: RAND, 2000).

37 Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Redwood City: Stanford University Press, 2011).

disruptive systems. In exercises against conventional units, they could test the theories about future combat and develop the accompanying tactics and procedures. Actively working out the details in the field builds organizational capacity for not just one technology, but in a repeatable fashion for future systems. And demonstrating the art of the possible helps bake new ideas into operating concepts and ultimately military culture.

Enough prototyping and experimentation might just make the operationally disruptive strategically decisive. But the game does not end there. Without a lasting occupation or an acceptable armistice, defeated powers can return to fight another day, or another decade, with the disruptive weapons they copy from the victors.[38] The globalized economy and its information flows have made many technologies and tactics available to enemies around the world. Advantage remains with actors who work to integrate new technologies into broad war-fighting systems, but only if they work.

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38 Michael Howard, "When Are Wars decisive?" *Survival*, vol. 41, no. 1, 1999; and Howard, "The Transformation of Strategy," *RUSI Journal*, vol. 156, no. 4, 2011, p. 16.

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