Back to the Future

The Challenge of Disruptive Military Innovation

Testimony Submitted to the Subcommittee on

Cyber, Information Technologies, and Innovation

Armed Services Committee

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by

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Victory will smile upon those who anticipate changes in the character of war, not upon those who wait to adapt themselves after changes occur.

General Giulio Douhet

He who will not apply new remedies must expect new evils.

Sir Francis Bacon

Chairman Gallagher, Ranking Member Khanna, Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the challenge of disruptive military innovation,[1] with an eye to the lessons learned from successful efforts in the Industrial/Information Age.[2]

Background

The world is in a period of disruptive change in the character of warfare. This is primarily the result of geopolitical and military-technical change. The return of China and Russia as active, revisionist great military powers finds the military competition escalating to a level not seen since the Cold War. Simultaneously, the advance of a

[1] As used in my testimony, "innovation" refers to efforts designed to develop and introduce new capabilities and ways of operating that yield an increase in military effectiveness within an existing way of waging war. Such an innovation may be the result of an advance in technology, such as the proximity fuse invented by the British and developed along with the Americans in World War II. It could also emerge from a new way of operating, such as the "Thach Weave" to deal with Japan's superior Zero fighter during the Pacific War, or from a novel way of organizing or structuring one's forces, such as in the U.S. Army's concentration of large numbers of helicopters into an Airmobile Division in the early 1960s. "Disruptive innovation," on the other hand, involves efforts designed to realize a discontinuous leap in military effectiveness, thereby introducing what is sometimes referred to as a military revolution. Examples of disruptive innovation are found in the U.S. Navy's shift between the world wars from a fleet centered on the battleship to one centered on the fast carrier task force, and the introduction of nuclear weapons. Or consider a notional example of innovation in the transportation industry at the turn of the 20th century. An innovation would have involved developing a better horseshoe, one that lasted twice as long as those then in use. A disruptive innovation would see the introduction of the automobile. The former effort would have marginally improved the effectiveness of the *existing way* of "doing business," while the latter effort realized a dramatic boost in effectiveness by introducing a radical *new way* of doing business.

[2] This testimony is based on findings from my new book, *The Origins of Victory*, published by Yale University Press.

range of new military-related technologies offers the promise of waging war far more effectively than ever before.[3]

This situation finds the U.S. military especially challenged, as it has spent most of the last three decades focusing on waging war against minor powers like Iraq, Libya and Serbia, and on counterinsurgency and counter-terror campaigns against non-state groups. On the other hand, during this time its great power rivals, China and Russia, devoted intense effort to offsetting the United States' dominant position what some call precision warfare, and others refer to as employing a reconnaissance-strike complex.[4] Their efforts have paid off. The United States no longer enjoys a near monopoly in this form of warfare, and must therefore adapt to compete effectively under new and very different circumstances.

This dramatic change in the competitive environment presents a compelling need to pursue disruptive innovation. As history shows, militaries that succeed in leading the way into a new and far more effective way of waging war can realize an enormous benefit over their rivals. Correspondingly, those that fail to keep pace can find themselves operating at a severe disadvantage.

Given the implications for U.S. security, senior defense policy-makers should be particularly interested in knowing how to exploit disruptive shifts in the competition to their advantage. Simply put, they should want to know: How well is the U.S. military, and those of its principal rivals, positioned to exploit the "next big thing" in warfare?

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[3] For an overview of these technologies and their potential to support disruptive military innovation, see Andrew F. Krepinevich, Jr., *The Origins of Victory* (New Haven, CT: Yale University Press, 2023), pp. 85-140.

[4] The Precision Warfare Revolution was introduced by the U.S. military in the form of a nascent reconnaissance-strike complex in the First Gulf War. The precision-warfare regime has matured in the sense that there are other militaries, China's People's Liberation Army (PLA) in particular, that have fielded their own version of a reconnaissance-strike complex. Thus, while once the U.S. military held a rough monopoly in precision-warfare operations, this is no longer the case. For its part, the PLA has come to view modern warfare as a competition between opposing "operational systems," supplanting the paradigm of war between opposing mechanized military forces. This is similar to Russian descriptions of reconnaissance-strike complexes and American views of "multi-domain warfare." China's operational system (or reconnaissance-strike complex) comprises five subsystems: the *information-confrontation*; *reconnaissance-intelligence* (scouting or ISR); *command*; *integrated support* (or battle network); and *firepower-strike* (strike) systems. The PLA sees the military competition centering on deconstructing the enemy's reconnaissance-strike complexes—what it calls "systems destruction warfare."

The answer to this question may be found, in part, by studying militaries that led the way in generating quantum leaps in military effectiveness through disruptive innovation. With this in mind, I assessed the experiences of four militaries, encompassing different time frames, national military organizations, and branches of the armed forces:

- Britain's Royal Navy during the so-called Dreadnought Revolution of the late 19th and early 20th centuries;
- The U.S. Navy during the period between the world wars that saw it position itself to shift from a fleet centered on battleships to one built around fast carrier task forces;
- Germany's military that, during the interwar period, developed mechanized air-land operations ("*Blitzkrieg*"); and
- The U.S. Air Force during the period between the Vietnam and First Gulf Wars that saw it developing a rudimentary reconnaissance-strike complex.

This assessment revealed characteristics common to these militaries relating to disruptive innovation. The balance of my testimony provides a brief summary of these characteristics, with emphasis on the U.S. military's experience.

A Guiding Vision

In each case where a military organization led the way to a disruptive shift in the competition, it enjoyed the benefit of a clear understanding of it was trying to do, how it would go about accomplishing it, and the anticipated end state.

The vision of the end state is relatively brief and unambiguous, serving to focus and inform the organization's efforts. The U.S. Navy was blessed with its own visionaries in the years between the world wars. One was Vice Admiral William Sims, who, in 1925, nearly a decade before the United States launched its first purpose-built aircraft carrier, asserted "A small, high-speed carrier alone can destroy or disable a battleship alone . . . . [A] fleet whose carriers give it command of the air over the enemy fleet can defeat the latter. [Consequently], the fast carrier is the capital ship of the future." Sims'

vision was shared by Rear Admiral William Moffett, head of the Navy's newly established Bureau of Aeronautics (BuAer), who proclaimed, "We can hardly visualize today the potential power of aircraft, not so much for scouting and spotting, but for bombing and torpedoing. It may readily be the deciding factor in a war."

The U.S. Air Force's leading visionary in the decade following the Vietnam War was General Wilbur ("Bill") Creech. The general was convinced that a different way had to be found to address the integrated air defense system (IADS) threat that had inflicted such high casualties on the Air Force and Navy during the Vietnam War, and on the Israeli Air Force in the 1973 Yom Kippur War. Creech's vision was of an all-day, all-night, all-weather, integrated force that could wage a campaign whose goal was to suppress enemy air defenses, not "fly past" them.

Emerging Technologies: Key Enablers

In each of the four cases, disruptive innovation was either driven or enabled by significant advances in military-related technologies. Advances in aviation technology were fundamental to the shift from a battleship-centered fleet to one organized around the carrier as its capital ship, and the fast carrier task force as the successor to the line of battle. Long-range radio and radar further transformed war at sea by providing the carrier task force with early warning of approaching enemy aircraft and a means to coordinate friendly aircraft operations over extended ranges. In a similar vein, advances in mechanization, aviation and radio enabled Germany's military to transform its World War I era "storm troop" tactics to *Blitzkrieg* operations.

In the quarter century prior to the First Gulf War, the U.S. Air Force's dramatic change in the character of air operations found it relying heavily on the information technologies (IT) revolution, which was just then gathering momentum. The introduction of solid-state electronics, enhanced sensors and laser technology in the late 1960s made effective precision-guided weapons possible. The IT revolution also proved crucial in fielding stealth aircraft. Nascent battle networks were enabled by the GPS satellite constellation and by advanced scouting and airborne command-and-control systems, such as the Airborne Warning and Control System (AWACS) and Joint

Surveillance and Target Attack Radar System (JSTARS) aircraft that provided U.S. forces with an enormous boost in situation awareness.

Operational Challenges: "What Are We Trying to Do?"

Each of the four military organizations examined addressed this fundamental question: What key operational challenges do we confront? As used here, "operational challenges" are *compelling real-world problems posed by adversaries at the operational (or campaign) level of war*.

Success in disruptive military innovation is closely associated with the particular challenge a military sets for itself, as operational challenges can vary widely. This is important, as disruptive innovation that enables a military to meet one operational challenge will not necessarily prove as effective in addressing others. Moreover, since a military organization does not have unlimited resources, it cannot prepare for every significant threat. Thus hard choices must be made as to which will be accorded priority, for as Frederick the Great warned, "He who defends everything, defends nothing."

The four militaries engaged in disruptive innovation examined were focused on addressing specific problems, or challenges, at the operational level of war. These problems were overcome thanks to their ability to identify, develop and exploit major new sources of competitive advantage. That being said, the new forms of warfare that emerged from their innovations, while remarkably effective in certain aspects of the overall competition, were considerably less effective in other situations.

These limitations appear in *form* and/or *scale*: either the form of military challenge was materially different from the one that was the focus of disruptive innovation, or the magnitude of the challenge was so great that the new form of warfare could not be executed at the necessary scale to address it successfully.

For example, *Blitzkrieg* operations proved enormously successful in defeating Poland and France in short campaigns. Having succeeded, the German military was confronted with a challenge quite different in *form* from that which it was designed to address—conducting a seaborne invasion of the British Isles. When, in 1941, Adolf

Hitler declared war on Soviet Russia, the German armed forces achieved great initial successes against the Russian forces. Yet Germany proved unable to prevail in large measure because its military lacked the size to defeat a modern military on the *scale* the Russians could field. Nor could Germany's army adequately secure an area an order of magnitude greater than that of Poland or France.

There should be no more than five or six core operational challenges—not every challenge can be a "core" challenge. And even core challenges must be prioritized to inform resource allocation choices.[5]

In brief, each of the four militaries examined were the first to engage in disruptive innovation to realize a major boost in its competitive advantage for *a particular operational challenge*. Hence the importance of military organizations focusing on addressing the questions: What is it we are trying to do? What is the particular challenge at the operational level of war that we are trying to address?

To use a medical analogy, pinpointing the key operational challenges is akin to arriving at a correct "diagnosis." The more accurately and precisely a military can define it, the greater the chances that it will be able to arrive at the right "prescription" of how to address it successfully.[6]

[5] Given the current geopolitical environment, a contemporary set of core operational challenges for the U.S. military might include the following:

- Deterring and, if necessary, defending the U.S. homeland and its treaty allies from catastrophic strategic attack, to include by weapons of mass destruction, as well as by advanced conventional and cyber weapons (i.e., against technically advanced, numerically comparable enemies).
- Deterring and, if necessary, defending U.S. allies and security partners in the Western Pacific, especially those along the First Island Chain, from Chinese aggression and coercion (i.e., against a technically advanced, locally numerically superior enemy) without resorting to nuclear weapons use.
- Deterring and, if necessary, defending NATO's Eastern European frontiers from Russian aggression and coercion (i.e., against a technically advanced, locally numerically superior enemy) without resorting to nuclear weapons use.
- Deterring and, if necessary, defending against attempts to sever lines of communication via the global commons linking the United States to key overseas theaters of operation and essential trading partners/resources (i.e., against technically advanced numerically comparable enemies) without resorting to nuclear weapons use.

Innovative Operational Concepts: The New "Way of War"

The particular operational challenge identified informs thinking about operational concepts, which provide the basis for planning at the theater or campaign level of war, to include describing how forces will operate to achieve strategic goals. As such, they offer possible solutions to existing and emerging operational challenges. Dramatic shifts in the character of military competitions, such as described in the four cases examined, find successful military organizations developing and refining operational concepts that are very different from those that characterize the existing warfare regime.

These concepts guided analysis, war gaming, field and fleet exercises and experiments, and were in turn informed by them. The effect was to create a "virtuous cycle" that enabled candidate operational concepts to be evaluated, refined, and enhanced or, in some cases, discarded. Those that "made the cut" shaped their military's doctrine, as well as its size, force mix, organization, structure and investment priorities. Absent a clear statement of the operational challenge and an operational concept that describes how it will be addressed, it truly is a case of "If you don't know where you want to go, any road will get you there."

During the Cold War, for example, Central Europe was the location of the key military competition between NATO and the Soviet-led Warsaw Pact. Consequently, the U.S. military's principal operational challenge was *defending NATO's Central European frontiers against a technologically advanced, numerically superior foe (Soviet Russia and its Warsaw Pact allies) in a high-intensity conflict environment while avoiding employing nuclear weapons*. This clear statement of the problem enabled the U.S. military, over the course of the forty-year standoff between the two superpowers, to develop a series of integrated operational concepts that informed the crafting of military doctrine. These concepts were adapted and, at times, even abandoned, as circumstances required.

One such concept, AirLand Battle, envisioned the U.S. Army and Air Force defeating successive "waves" of enemy forces advancing out of the Soviet Union through Eastern

Europe. Generally speaking, the Army, supported by the Air Force, sought to block the advance of Soviet frontline forces while a combination of U.S. air and ground-based forces—combat aircraft, missiles, and rocket artillery—attacked the second and third waves of enemy ground forces advancing toward NATO's borders.

Simultaneously, the U.S. Navy planned to employ attack submarines beyond the Greenland-Iceland-United Kingdom (GIUK) maritime gaps to protect allied shipping moving across the Atlantic from commerce-raiding Soviet submarines, while the fleet's Outer Air Battle concept set forth how its aircraft carriers' air power would be used to defeat Soviet strike aircraft. To preclude the Soviets from using Norway as an advance base, the U.S. Marine Corps prepared to deploy quickly to that country and secure its airfields. Not only did these concepts guide U.S. and allied military thinking and planning; they also helped establish clear defense program and budget priorities. Yet no comparable set of operational concepts exist today with respect to defending the First Island Chain from aggression by China.[7]

In each of the four histories examined, innovative operational concepts enabled the militaries to realize far more effective ways of fighting at the campaign level of war. For example, after World War I the U.S. Navy was focused on addressing the operational challenge of conducting a campaign extending across the Pacific Ocean to Japan's home waters, where it envisioned fighting a decisive battle against the Imperial Japanese Navy. Lacking forward bases, Navy leaders knew the fleet would need to bring its own air power with it. The Navy exploited advances in aviation and radio, as well as radar, in developing the fast carrier task force that would, in the months following the attack on Pearl Harbor, see the line of battle rendered obsolete and the carrier emerge as the fleet's new capital ship.

In the 1960s and 70s modern air forces confronted the growing challenge of rapidly improving enemy integrated air defense systems (IADS). At the time, the U.S. and Israeli air forces were conducting offensive air operations, but at a high cost in actual

[7] A point-of-departure set of operational concepts to address the threat posed by China to U.S. allies and security partners along the First Island Chain can be found in Andrew F. Krepinevich, Jr., *Archipelagic Defense 2.0* (Washington, DC: Hudson Institute, 2023).

and virtual attrition, even against minor powers like North Vietnam and Egypt, respectively. General Creech envisioned a campaign centered on suppressing the enemy's IADS, not bypassing it. In addition to introducing high-fidelity training, the Air Force drew upon the IT revolution that enabled advances in guided weapons, fielding stealth aircraft, conducting effective night operations, and achieving advanced situation awareness. The combination of capabilities that emerged from this effort formed the foundation of the nascent reconnaissance-strike complex that made Creech's concept a reality.

Different Measures of Effectiveness (MOEs)

In each of the four histories examined, new problems at the operational level of war and the novel operational concepts developed to overcome them changed thinking about what mattered most with respect to military capabilities, or their "measures of effectiveness."

Dramatically altered MOEs characterized the U.S. Navy's shift from a battleship-centric to a carrier-centric fleet. In the battleship era, emphasis was on the weight of a broadside that could be fired at the maximum range of the largest guns. As long as this measure of merit prevailed, the battleships would always compare favorably with carriers.[8]

Those naval officers who envisioned the carrier as the fleet's capital ship advocated different metrics. They valued the carrier air wing's advantage in *extended-range* fires over the battle line's superior *volume* fires. They conceded that a carrier's planes could only deliver a fraction of the firepower inherent in the line of battle—but argued that this was trumped by the fact that they could do so at a range ten times greater.

Moreover, during the 1930s it was also becoming clear that, in carrier warfare, the key to success was to find and sink the enemy's carriers before it found yours. This led the Navy to emphasize long-range scouting aircraft (to find the enemy carriers) and

[8] As late as 1940, the Naval War College was informing its students that "it takes 108 planes to carry as many large torpedoes as one squadron of destroyers and 1,200 to carry as many large bombs or large projectiles as one battleship."

various types of strike aircraft (to sink them). Consequently, the Navy sought to maximize the number of aircraft on its carriers, and their launch and recovery speed.

The First Gulf War yielded a major shift in several key MOEs used by the Air Force to determine military effectiveness. The combination of stealth and guided weapons produced a shift away from "mass"—large strike packages where a majority of aircraft were in support roles (such as jamming)—and toward small numbers of stealthy aircraft armed with guided weapons. Thus the MOE for strike operations shifted from the number of aircraft that could be assigned to strike a target, to the number of guided weapons employed on stealth aircraft. Similarly, emphasis on bomb tonnage dropped gave way to bomb accuracy. This can be seen by the rapidly growing percentage of guided weapons relative to unguided bombs employed in Air Force operations following the First Gulf War. Precision-guided munitions comprised less than 10 percent of the munitions employed by the U.S. aircraft in the First Gulf War. This figure grew to roughly 30 percent in the 1999 Balkan War, exceeded 50 percent in air operations in Afghanistan in 2001-02 (Operation Enduring Freedom), and surpassed 60 percent in the Second Gulf war.

Exercises and Experimentation

Although important in their own right, professional analysis, simulations and war games can only go so far in identifying, developing and validating new concepts of operation and military system requirements. They lack the level of detail provided by well-designed and executed field exercises and maneuvers conducted at the operational level of war. This is critical since, in war, the "devil is often in the details," and Murphy's Law is often the order of the day. For example, war games conducted at the Naval War College in the early 1920s identified the importance of maximizing the number of aircraft on a carrier, as well as aircraft sortie rates. It was not, however, until the Navy's first carrier, *Langley* (actually a converted collier), was launched and participated in exercises that the Navy could determine precisely *how* this goal was to be achieved (or, indeed, *whether* it could be achieved at all). The *Langley* conducted a series of exercises and experiments that led to such innovations as crash barriers and

the deck park, enabling the ship to more than double its aircraft complement while dramatically increasing its sortie rate.

Field and fleet exercises also proved indispensable in maintaining an awareness of significant shifts in the character of military competition that sometimes occur during periods of disruptive change, but which are not themselves revolutionary. This was the case with the American Navy and Air Force. The U.S. Navy's fleet problems and experiments identified several such shifts. Tests with the battleship *Texas* in 1919 showed that aircraft acting as spotters greatly enhanced the battle line's gunnery accuracy at extended ranges. Ten years later, Fleet Problem IX revealed that carriers could function as an independent strike force by conducting raids, even though they still had not displaced the battle line as the arbiter of sea control. In the absence of fleet exercises and experiments, it is doubtful the Navy would have either identified these shifts in the military competition as soon as it did, or adapted to them as quickly or as well as it did. Similarly, the U.S. Air Force benefitted considerably from its own experience and that of the Israeli Air Force (IAF) in several wars—the ultimate "field exercises." The Vietnam War showed that guided weapons could enable the existing form of air operations—large strike packages focused on individual missions at the tactical level of warfare—to be executed more effectively. The IAF's 1982 operation in Syria's Bekaa Valley demonstrated the boost in effectiveness that operations employing unmanned aircraft could provide.

Investment Strategies: Options and Hedges

To various degrees, through serendipity or design, each of the four military organizations examined pursued investment strategies emphasizing "hedging" against the uncertainties inherent in a highly dynamic competitive environment. They did this in part by creating options in potentially revolutionary capabilities that could be exercised quickly if they proved out, while also avoiding, to the degree possible, locking themselves in to major investments in existing capabilities that might rapidly depreciate in value, or new capabilities whose value was as yet unproven.

To the maximum extent possible, a hedging strategy avoids locking-in, via large production runs, to current or emerging military systems. Two of the four military organizations avoided locking in to large production runs of major military systems that would greatly depreciate in value, or in systems that visionaries believed would enable a major boost in combat effectiveness.[9] In the case of the U.S. Navy this was facilitated in part by treaty obligations. The Washington Naval Treaty prohibited the construction of battleships and placed a relatively low ceiling on carrier tonnage. Nevertheless, with respect to naval aviation, the Navy consciously tried to limit its purchase of large numbers of aircraft that, since the rapid advances being made in aviation technology, ensured they would become quickly outdated.

The four militaries examined also recognized, to a lesser or greater extent, the dangers of "false starts" and "dead ends," as well as the value of "wildcatting."

False starts occur when systems or capabilities are purchased in quantity before they have reached the point where they prove themselves. In the American Navy's case, the Washington Naval Treaty and the Great Depression kept it from investing heavily in the *Ranger*-class of carriers, which proved a false start—the right *kind* of ship, but the *wrong ship design* for the operational challenge posed by the Imperial Japanese Navy in the Pacific.

Dead ends are those systems and capabilities that may appear attractive, but never fulfill their promise within a military's planning horizon. Admiral Moffett's proposed flying-deck cruisers—half cruiser and half flight deck—were "dead end" ships that, despite the admiral's affection for them, fortunately were never built.

Wildcatting prioritizes exploring a wide range of potentially attractive systems and capabilities that have the potential to advance disruptive innovation, but producing them in limited numbers. In so doing wildcatting expands opportunities for exploring

[9] The two great power militaries that did produce large quantities of major systems were the Royal Navy and the U.S. Air Force. Both confronted immediate threats from other great powers and thus had to maintain large standing forces. (Both, however, also incorporated "hedging" into their investment strategies.) The German military between the world wars also faced similar threats, but for most of this time was severely limited in size and capabilities by the Versailles Treaty.

new operational concepts in joint exercises, enabling military organizations to buy options, or "insurance," against an uncertain future, thereby reducing risk.

For example, despite the limits imposed by the Washington Naval Treaty and the severe fiscal austerity imposed by the Great Depression, in the years prior to World War II the U.S. Navy successfully pursued a wildcatting procurement strategy of sorts that saw it introduce four different carrier classes into the fleet: two converted cruisers (the *Lexington* Class at 33,000 tons), the *Ranger* (13,800 tons), three carriers of the *Yorktown* Class (roughly 20,000 tons), and the *Wasp* (14,900 tons). The Navy also hedged against the uncertainties associated with the development of air power, investing in various types of attack aircraft, including those designed for horizontal- and dive-bombing attacks, as well as torpedo bombers.

In the two decades preceding the First Gulf War, the U.S. Air Force fielded the basic elements of its battle network and missiles that would enable a shift to beyond-visual-range (BVR) air-to-air engagements, while enhancing its counter-scouting efforts by fielding a wing of stealth aircraft—the F-117 Nighthawk. It also created a major alternative to its "smart pilot-dumb bomb" strike arm in the form of precision-guided munitions.

Time-Based Competition: The First- and Second-Move Advantage

Like manpower, money and materiel, time is a resource and, as such, can play an important role in determining military advantage, especially in periods of disruptive change that require a far greater degree of adaptation than is the case in periods of evolutionary change. The ability to compete based on time involves employing time more efficiently and effectively than one's rivals. Militaries that develop a world-class competence in time-based competition are more agile than their rivals. They introduce new capabilities more rapidly, and can alter their force structure and doctrine more quickly than their competitors. The faster a military can introduce new capabilities into the force, the less need it has to field a large standing military.[10] This is particularly

[10] Of course, in order to maximize their effectiveness the troops that operate military systems must be familiar with them and the operational concepts they are intended to execute. The four militaries

important in periods of disruptive change, when existing military capital stock is prone to depreciate at an accelerated rate.

Military organizations enjoying an advantage in time-based competition are well placed to adopt strategies based on exploiting the first- and second-move advantage. This was a significant factor in several of the military histories examined.

As the term suggests, the first-move advantage involves shifting to a new, more effective way of competing before rivals can react and keep pace. The U.S. Air Force offers a good example of a military organization pursuing the first-move advantage. In the 1970s the American military under Defense Secretary Harold Brown explicitly sought to leverage the country's IT advantage over Soviet Russia by developing stealth and battle management aircraft, precision-guided weapons, advanced sensors, and a space-based positioning, navigation and timing system. In combination, they enabled the Air Force in particular, and the U.S. military more broadly, to exploit the first-move advantage and gain a dramatic boost in effectiveness, as revealed in the First Gulf War.

An even better example is found in the Royal Navy in the 20th century's first decade. Britain's First Sea Lord, Admiral John Fisher, oversaw the building of the first modern battleship—*HMS Dreadnought*. With its uniform complement of big guns and new age turbine engines, the ship possessed far greater firepower and was significantly faster than any battleship afloat.

But Fisher wanted to do more than effect a major shift in the character of fleet engagements—he wanted to shape it. Fisher leveraged Britain's advantage in time-based competition to dramatically compress the *Dreadnought's* construction time. A year and a day after construction start, *Dreadnought* began her sea trials. Fisher had

examined, however, suggest this does not necessarily require a lengthy period of time to achieve. Within five years the U.S. Navy, which until the late 1930s had a carrier force comprising a converted collier, two converted cruisers, and one undersized purpose-built carrier found itself operating over 80 carriers of all types while waging a fundamentally new type of war at sea on the way to destroying the formidable Imperial Japanese Navy. The same can be said of the German military prior to World War II. It began openly rearming in 1935 and did not field test the first Panzer Division until 1937. Yet it mastered *Blitzkrieg* in less than five years.

cut the normal building time for a battleship—in this case, *a radically different and more powerful battleship*—by more than half.

As he intended, Fisher's gambit *Dreadnought* disrupted the plans of Britain's principal naval rival, Germany. As *Dreadnought* was emerging from the drawing board, the German Navy was launching *Deutschland*, the first in a class of five new German battleships—ships that *Dreadnought* made obsolete. Consequently, as news of the planned size, speed, and armament of *Dreadnought* reached Germany, near panic ensued. Fisher's German counterpart, Admiral Alfred von Tirpitz, secluded himself for months with his most trusted advisors to determine how best to respond.[11]

The second-move advantage finds a military organization confronting a situation where a rival has begun fielding new capabilities, forces and operational concepts with an eye toward effecting a disruptive shift in the competition in its favor. If the lagging military enjoys an advantage in time-based competition, it can use it to catch up—and surpass—the rival that is seeking to exploit the first-move advantage.

The benefits associated with the second-move advantage are several. For one, it allows the "second mover" to see with relative clarity the "first mover's" plans for gaining a competitive advantage. This reduces considerably the uncertainty confronting the second-mover. Another benefit accruing to the second mover occurs in situations where it enjoys a dominant position in the existing competition, and thus has no need to introduce new capabilities that would lead to the premature depreciation of a considerable portion of its existing military capital stock.

The U.S. Navy found itself enjoying a second-move advantage when following in the Royal Navy's wake after World War I. At that time the British enjoyed a monopoly on

[11] To Fisher, disrupting the naval plans of his rivals was not intended to be a one-time affair, but an ongoing practice. He hoped his successor battle cruiser ships would continue promoting chaos in his adversaries' shipbuilding schemes. Later, Fisher would summarize his thinking on "plunging" (as he termed it) to Winston Churchill, who became First Lord of the Admiralty in 1911. By launching ships that were substantially superior in quality to anything then afloat, Fisher declared, the Admiralty could compel other navies to reconsider their own ship building plans. If the Admiralty's plans were not revealed until the last possible moment, the disarray produced among Britain's rivals could enable the Admiralty to slow its own naval construction program for a year and perhaps longer, providing economies to the naval estimates. The "secret" of successful naval administration, Fisher declared, "is 'plunging'—it stupefies foreign Admiralties." Krepinevich, *Origins of Victory*, pp. 218-21.

aircraft carriers. This conferred a near-term advantage for the Royal Navy, but it proved ephemeral, as aviation technology was advancing at breakneck speed. This found the Royal Navy's carriers' value depreciating at an accelerated rate. Moreover, tight budgets, combined with a desire to get full value out of the relatively new carriers, found British political leaders reluctant to fund additional flattops. The U.S. Navy, on the other hand, was better able to keep pace with advances in naval aviation owing to its late arrival to the competition.

Interestingly, in the mid-19th century the Royal Navy exploited its world-class competence in time-based competition to pursue a second-move strategy during a period of disruptive change in the character of war at sea, in this instance the shift from wooden ships propelled by sail to ships with iron hulls and steam engines. Then, as during Fisher's time, Britain possessed the world's largest, best-equipped and most technically advanced warship industry. It enabled Britain to build ships of cutting-edge design, faster and in greater numbers than her rivals. Thus, it was France, not Britain, which first moved to launch steam-propelled warships and ironclads. Even though Britain was fully capable of leading the transition it held back so as to maximize its advantage in existing warships. Once the French acted, the British quickly offset their efforts by launching more (and better) of the new style warships before their adversaries could realize an advantage.[12]

Extended Tenure and Institutionalization

In each of the four cases examined the senior leaders most associated with disruptive innovation enjoyed what in today's U.S. military would be considered an unusually long tenure. This makes intuitive sense, as disruptive innovation is not accomplished overnight; rather, it requires an extended period of time—typically a decade or longer—to bring about.

Admiral Moffett, arguably the key figure in the development of U.S. naval aviation, served as head of the Navy's Bureau of Aeronautics for an astounding twelve years,

[12] Similarly, the Royal Navy "ignored" the development of submarines until a major naval rival introduced this new form of war at sea.

from its inception in 1921 until 1933.[13] General Creech headed the Air Force's Tactical Air Command for six years, from 1978 to 1984. Both leaders also cultivated officers who shared their vision and worked to advance their careers. Admiral Moffett succeeded in ensuring that all aviators were officers, and that certain commands, such as those of naval air stations and aircraft carriers, were reserved for pilots, creating a pathway to senior rank for naval aviators. The BurAer staff provided slots for aviators and a place for them to gain experience. During the 1920s future Navy admirals such as Marc Mitscher and John Towers found a home in BurAer. The chief of naval operations during World War II, Fleet Admiral Ernest King, whom Moffett convinced to transfer to naval aviation, succeeded Moffett as head of BurAer in 1933.

Similarly, a remarkable number of Air Force future leaders worked for General Creech during his tenure as head of the Tactical Air Command. All six of the Air Force chiefs of staff that served from 1986 through 2001 were either a wing commander or served on Creech's staff during the time he headed the Tactical Air Command. Over time 21 of the officers Creech had a hand in developing rose to the rank of full general.

Little Things Mean A Lot

The shift from one warfare regime to another that marks the success of disruptive innovation often occurs after a relatively small shift in a military's structure and equipment. Put another way, the phenomenon is highly nonlinear: even a relatively small percentage of the total force capable of waging the new form of warfare can achieve levels of effectiveness far greater than much larger forces fighting within the construct of the passing regime.

With the possible exception of the Royal Navy, each of the militaries examined in the case studies brought about a disruptive shift in the military balance with a small shift in the composition of its capital stock. For example, only around 12 percent of the German Army that defeated the combined Belgian, British, Dutch and French forces in a campaign lasting but six weeks was mechanized or motorized. In late 1941, the U.S. Navy comprised 352 major combatants, of which only seven were aircraft carriers,

[13] His tenure would have been even longer had he not perished in an airship crash.

which proved the key to turning the tide of war in the Pacific and introducing a new form of war at sea. During the First Gulf War the U.S. Air Force's 59 F-117 Nighthawk stealth aircraft represented less than 3 percent of combat aircraft in the theater, and flew only 2 percent of the sorties Yet they struck roughly 40 percent of the strategic targets. And while less than 10 percent of the bombs dropped by the Air Force were precision-guided weapons, they produced over 75 percent of the damage inflicted on Iraqi targets.[14]

The Incomplete Revolution

In all of the instances where a military organization's disruptive innovation produced a dramatic boost in its effectiveness, significant parts of its vision of future warfare remained unfulfilled.

For example, the U.S. Navy's carriers had limitations. Carrier aircraft dominated the daylight hours, but at night surface combatant engagements were the norm. Following their devastating success against Japanese carriers in the Battle of Midway, the American flattops withdrew during the night, while Japanese surface ships pressed ahead, attempting to engage them. Although the carrier had clearly displaced the battleship as the capital ship, the latter did not quickly go the way of the horse cavalry. In a number of maritime engagements during World War II, the battleship dominated.

The U.S. Air Force's introduction of precision-warfare in the First Gulf War also had its limitations. The stealthy F-117 aircraft only operated at night. Its laser-guided bombs were generally ineffective in poor weather, including conditions involving rain, smoke and cloud cover. Furthermore, in early 1991 GPS coverage was limited, and there were times when it was unavailable. Finally, the Air Force's ability to strike mobile or "time-sensitive" targets in near-real time was exceedingly modest.

[14] The Air Force concluded that "Two raids of 300 B-17 bombers could not achieve with 3,000 bombs what two F-117s can do with only four [PGMs]."

In summary, while war provides the ultimate validation of the vision of a dramatically new and more effective form of military operation, it typically also reveals gaps in the vision that remain to be addressed. The need for innovation is enduring.

Concluding Thoughts

The histories of our four militaries that led the way in effecting disruptive innovation yield valuable insights for contemporary military organizations anticipating discontinuous shifts in warfare. That being said, the findings are not definitive. At best, they are highly suggestive. We are well served by remembering Richard Feynman's injunctions that, even in the hard sciences such as physics, the "laws" stated in textbooks are really approximations, and are always subject to revision. So, too, with the study of war and military innovation. Still, as conditional as these findings are, they are arguably more useful than simply "awaiting events," or "muddling through."[15]

[15] Indeed, the characteristics derived from the four militaries examined here also correlate remarkably well to those identified as resident in business organizations that successfully pursued disruptive innovation. While military and businesses organizations have important differences, research reveals that corporations, like their military counterparts, are constantly on the lookout for new sources of competitive advantage while maintaining a vigilant eye on products, services and other sources of existing advantage that risk becoming wasting assets. Krepinevich, *Origins of Victory*, pp. 423-27.