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Revolutionary Weapons and Transformed War

Scenario 1

During the second week of May 1972, two strategic bridges in war-torn North Vietnam provided the transportation – both literally and symbolically – into the modern era of aerial conflict.

Both bridges – the Long Bien in the city of Hanoi and the Thanh Hoa, about 150 kilometers south – were high-value targets for American bombers; they served as Ho Chi Minh's principal arteries for road and rail shipments to the south, and clogging those chokepoints would have greatly impeded his effort to reinforce and resupply North Vietnamese and Viet Cong brigades. At the same time, both bridges were frustrating and dangerous to attack; they were so well constructed and well defended that waves of U.S. bombs had failed to penetrate them, and scores of aircraft and crews had been lost in the attempt.

The Thanh Hoa Bridge proved to be an especially alluring target. It was 56 feet wide, 540 feet long, and 50 feet above the water, of steel construction with two spans resting upon a 16-foot reinforced concrete pier in the middle of the Song Me River. The central 12 feet of the bridge fed the main trunk rail line that ran down the Vietnam panhandle; two 22-foot-wide concrete highways that constituted Route 1 were cantilevered on the sides.

But the Thanh Hoa Bridge was also an extraordinarily vexatious target. Construction on the bridge was completed only in 1964; between 1965 and 1968, 800 American sorties had attacked it, unloading some 10,000 tons of high explosives. The bridge withstood all onslaughts and, even when damaged, repair crews had always been able to restore it swiftly to normal functioning. Volumes of near misses with inaccurate bombs produced a myriad of craters pockmarking the approaches to the

bridge, giving it a vivid uninhabitable "Valley of the Moon" appearance. U.S. forces began to refer grudgingly to Thanh Hoa as "the bridge that would never go down."

Part of the reason for the bridge's resiliency was geographic: hills at either end of the span provided solid bracing for the concrete abutments that anchored it. But a bigger part of its stamina was due to the zealous defensive anti-aircraft installations that surrounded what the Vietnamese referred to as "the Dragon's Jaw." Some 104 American pilots were shot down in the 75-square-mile area around the site.

For example, on April 3–4, 1965, during the American "Rolling Thunder" bombing campaign, 77 determined aircraft deposited 504 750-pound bombs and 298 rockets against Thanh Hoa, yet it remained mockingly erect – charred, but still fully functional. Five U.S. aircraft were downed in the effort.

The Long Bien Bridge (also known as the Paul Doumer Bridge, after the French governor general of Indochina, who had conceived the transportation system for the country and had inaugurated the bridge in 1902) was a similarly critical transportation node over the Red River in the nation's capital. Four of the five major rail lines coming from the north (including those conveying all freight from China and the port city of Haiphong) converged to cross the Long Bien, as did much of the truck traffic. Twenty-six trains, carrying 6000 tons of supplies, transited the bridge daily.

To a casual observer, the Long Bien Bridge might have appeared vulnerable or even delicate. At 8500 feet in length, including its terminal viaducts, it was the longest bridge in North Vietnam, with a series of 19 graceful metal segments, and it was designed by the same architect who produced the Eiffel Tower. That stylishness, however, concealed the bridge's deadly aspect – the North Vietnamese defended this unique asset with 300 anti-aircraft guns, 85 surface-to-air missile sites, and several MiG fighters at surrounding bases.

Like the Thanh Hoa Bridge, the Long Bien site had been singled out as a priority target, and whenever the American rules of engagement permitted missions against urban targets in Hanoi, the bridge was struck hard – but never suffered more than temporary disruptions in service. Also like Thanh Hoa, Long Bien had been responsible for sending disproportionate numbers of American pilots to their deaths or to horrific prisoner of war camps.

Everything changed radically for these "indestructible" bridges in 1972. "Operation Linebacker" authorized increased pursuit of northern

targets and – more critically – improved technology brought modern guided aerial bombs into widespread play for the first time.

On April 27, 1972, a flight of eight U.S. Air Force F-4 Phantoms attacked the Thanh Hoa Bridge with five 2000-pound Walleye II electro-optical guided munitions. These bombs were not notably larger than those that had been applied in earlier engagements, but the greater accuracy of their placement inflicted far more damage on the bridge and far less "collateral damage" on the surrounding locations. Additionally, the new weapons permitted safer tactics for the attacking aircraft, affording them a greater "standoff" capability rather than having them fly directly over the superdefended site, and no pilots were lost.

On May 13, the American crews revisited the Thanh Hoa, dropping 15 more electro-optical bombs, nine 3000-pound laser-guided bombs, and 48 conventional bombs. This time, the western span of the bridge was knocked off its struts, and the remainder of the structure was rendered unusable for months. Again, no aircraft were lost.

Between those two strikes, the May 10 action against the Long Bien Bridge was even more dramatic. Sixteen F-4s, accompanied by several other planes to suppress the North Vietnamese defensive fire, launched 29 precision bombs against the site. At least 12, perhaps 16, of these struck the bridge directly, destroying or damaging several of the spans. The next day, four more aircraft undertook a "mop-up" mission, delivering eight more precision bombs, ruining three more sections of the bridge – and again, losing no pilots. The Long Bien Bridge carried no further traffic until the end of the war.

The numerical "box score" of these engagements provides a stunning contrast with the earlier campaigns. In the 1965 raids on the Thanh Hoa, 77 aircraft were used and 189 tons of ordnance were dropped, all with little lasting effect. In 1972, with the debut of precision-guided munitions, only eight aircraft were employed in the two raids, and 33.5 tons of more deft munitions were expended – and this time, the bridge was knocked out of commission. Numerous other northern bridges also quickly fell under the weight of the improved U.S. weaponry and, for the first time – at the moment when the war was already effectively lost – American bombers were able to interdict vital traffic routes faster than the North Vietnamese could repair them.[1]

[1] A.J.C. Lavalle (ed.), The Tale of Two Bridges, US Air Force Southeast Asia Monograph Series, Vol. 1, Monograph 1, 1976; Melvin F. Porter, Linebacker: Overview of the First 120 Days, U.S. Air Force, Project CHECO Report, September 27, 1973; George Friedman and Meredith Friedman, The Future of War: Power, Technology, and American

The introduction of precision-guided aerial bombs in 1972 was a discontinuity – an abrupt break with prior technology – and it inaugurated distinctly new military capabilities and helped reform the way modern wars would be fought. The sudden innovation came too late to alter the outcome of the Vietnam War, but it illustrates the phenomenon of occasional, dramatic big bursts in revising weapons technologies and military operations. This chapter analyzes those episodic nonlinear moments and describes the current metamorphosis already under way.

WORLD AT WAR

War is a tragic but remarkably persistent fact of the human experience. Historians Will and Ariel Durant calculated in 1968 that the world had witnessed only 268 war-free years in the previous 3421.[2] Another leading authority, the Stockholm International Peace Research Institute (SIPRI), annually reports on the number of ongoing major armed conflicts: the tally for 2007 revealed 14 active wars, a relatively low number given that 33 miscellaneous conflagrations, many persisting for many years, had raged somewhere or another between 1998 and 2007.[3] Another source, the Friends Committee on National Legislation, applying slightly different criteria, found 14 significant current armed conflicts (each inflicting 1000 or more battle deaths) at the start of 2008 and another 21 precarious hot spots around the globe that could quickly slide into or revert to open war.[4]

One more sanguinary statistic helps us translate those overall numbers into a more human scale: during the twentieth century, there were more than 100 million warfare-related deaths.[5]

World Dominance in the 21st Century, 1996; Eduard Mark, Aerial Interdiction: Air Power and the Land Battle in Three American Wars, 1994; Michael Russell Rip and James M. Hasik, The Precision Revolution: GPS and the Future of Aerial Warfare, 2002.

[2] Will and Ariel Durant, The Lessons of History, 1968, p. 81. See also William Eckhardt, Civilizations, Empires and Wars: A Quantitative History of War, 1992.

[3] Lotta Harbom and Peter Wallensteen, Patterns of Major Armed Conflicts, 1998–2007, in Stockholm International Peace Research Institute, Yearbook 2008: Armaments, Disarmament, and International Security, p. 72. See also Lotta Harbom and Peter Wallensteen, Patterns of Major Armed Conflicts, 1997–2006, in Stockholm International Peace Research Institute, Yearbook 2007: Armaments, Disarmament, and International Security, p. 79; Lotta Harbom and Peter Wallensteen, Patterns of Major Armed Conflicts, 1990–2005, in Stockholm International Peace Research Institute, Yearbook 2006: Armaments, Disarmament, and International Security, p. 108.

[4] Daniel Smith, World at War, 37 Defense Monitor No. 1, Special Issue, January/February 2008, p. 3.

[5] Ruth Leger Sivard, World Military and Social Expenditures 1996 (16th ed.), 1996, p. 7.

To support that frenzied activity, nations of the world have routinely invested major slices of their respective treasuries in the various implements of war – research, development, and procurement of weapons have always been booming businesses. Global military spending now tops an inconceivable $1.3 trillion annually, and armaments production accounts for approximately one-quarter of that total.[6]

Not only have human beings demonstrated an enormously voracious appetite for the hardware of warfare, they have manifested an insatiable curiosity about developing new types of military toys – perhaps a creativity and persistence unparalleled in other aspects of human activity. As George Bernard Shaw put it in "Man and Superman" (speaking through the character of the devil):

> I tell you that in the arts of life, man invents nothing; but in the arts of death, he outdoes Nature herself, and produces by chemistry and machinery all the slaughter of plague, pestilence, and famine. . . . In the arts of peace, Man is a bungler . . . his heart is in his weapons.[7]

Most of the time, this energized inventiveness aims to promote weapons of ever-increasing lethality and destructive power. That is, the warfighters and their political masters seek augmented capacities for inflicting death and obliterating enemy property – that is often the whole point of fighting a war – and the combatants prize any tools that can accomplish those apocalyptic missions more effectively, more swiftly, and on a wider scale.

There are, of course, other desiderata in weapons design, too – defense establishments simultaneously prefer armaments that are inexpensive, simple to maintain, sufficiently rugged to withstand battlefield conditions, and easy to transport. And weaponry alone does not begin to tell the whole story of a nation's military effectiveness – British military historian J. F. C. Fuller argued in 1919 that weapons account for 99 percent of victory, but most other observers would contest that assessment, citing

[6] Peter Stalenheim, Catalina Perdomo, and Elisabeth Skons, Military Expenditure, in Stockholm International Peace Research Institute, Yearbook 2008: Armaments, Disarmament, and International Security, p. 175. See also Peter Stalenheim, Catalina Perdomo, and Elisabeth Skons, Military Expenditure, in Stockholm International Peace Research Institute, Yearbook 2007: Armaments, Disarmament, and International Security, p. 267; J. Paul Dunne and Eamon Surry, Arms Production, and Peter Stalenheim, Damien Fruchart, Wuyi Omitoogun, and Catalina Perdomo, Military Expenditures, in Stockholm International Peace Research Institute, Yearbook 2006: Armaments, Disarmament, and International Security, p. 387, 295; International Institute for Strategic Studies, The Military Balance, 2006.

[7] George Bernard Shaw, Man and Superman: A Comedy and a Philosophy, Act 3, pp. 142–43, 1903.

the centrality of training, discipline, morale, logistics, leadership, and other features.[8]

Still, efforts to increase the lethality of armaments are typically at or near the top of the military's "wish list." New generations of military hardware typically feature bigger bangs for the bucks, and the abilities to exert a lethal or destructive force over a wider area, strike more suddenly or for a longer time, or overcome defensive battlements are major sales points.

Attempts to document empirically this ever-increasing destructive power are doomed to frustration over the full array of definitional issues. (How does one measure lethality precisely? How does one interpolate antipersonnel and antimateriel devices?) But as Trevor Dupuy has demonstrated, even crude subjective judgments reflect a rising trend line, from ancient swords, pikes, and battle axes, to various adaptations of bows and arrows, to primitive firearms. The popularization of gunpowder makes his historical trend line of violence bow upward, with the emergence of a series of arquebuses, flintlocks, muskets, and rifles of increasing range, accuracy, and power, and a sequence of ever-more-devastating types of cannons and other artillery. In the twentieth century, this notional "lethality curve" arcs even more sharply upward, with relatively rapid injections of modern machine guns and automatic weapons, tanks, bombers, missiles, and, of course, nuclear devices.[9]

Even more dramatic, within each particular category of weaponry there seems to be an inexorable pressure for each new generation to outdo its predecessor in deadly effectiveness. New types of hand grenades, for example, or assault rifles, or battle tanks secure funding and earn the right to deployment and use when they command greater destructive force. Likewise, new bombers or new battleships are not necessarily larger than their forerunners, but in the effervescent international arms races, each new weapon seems almost automatically to advertise itself as possessing greater lethal firepower. In the same vein, it is no accident that as bad as mustard gas, lewisite, phosgene, and the rest of the witches' brew of chemical toxins were in the trenches of World War I, the next generation

[8] J.F.C. Fuller, Armament and History: A Study of the Influence of Armament on History from the Dawn of Classical Warfare to the Second World War, 1945, p. 18.

[9] See, for example, Trevor N. Dupuy, The Evolution of Weapons and Warfare, 1984, p. 92, 286–89; Max Boot, War Made New: Technology, Warfare, and the Course of History, 1500 to Today, 2006, p. 300 ("the lethality of weapons increased roughly two-thousand-fold between the Peloponnesian Wars and World War II, between the days of spears and those of tanks").

of chemical weapons – the nerve gases sarin, soman, and tabun pioneered (but not widely used) for World War II – were much worse.

It is unnecessary to be crudely reductionist in describing this progression – obviously, there is a lot more going on in the military–industrial complex. But one unmistakable tendency is the introduction, dissemination, and use of military artifacts of ever-increasing deadliness and destructiveness. Weapons capable of greater explosive power, inflicting their effects over a wider area or for a longer period of time or against more resistant targets, have continuously displaced their earlier, smaller, simpler, and less devastating antecedents.

REVOLUTIONS IN MILITARY AFFAIRS

These boosts in weapons technology do not necessarily occur at a smooth pace or a predetermined rate. To the contrary, it often appears that technological innovation in military matters is marked by episodic discontinuities – sudden jumps in weapons capabilities that inject radically new performance possibilities. These seismic shifts, characterized as "revolutionary moments," not only jumble the weapons inventories themselves, they also provide occasion for radical revisions in the organization of military structures, in the concepts of operation for the forces, and in the roles and missions assigned to them.

Important spurts of creativity of this kind do not occur often; historians disagree about which breakthroughs have achieved sufficient magnitude in opening new modes of military operation to qualify as genuine revolutions.[10] Among the most salient historic paradigm-shifting global

[10] Boot, supra note 9; Andrew F. Krepinevich, Cavalry to Computer: The Pattern of Military Revolutions, National Interest, Fall 1993/1994; Theodor W. Galdi, Revolution in Military Affairs? Competing Concepts, Organizational Responses, Outstanding Issues, Congressional Research Service Report for Congress, 95–1170 F, December 11, 1995; MacGregor Knox and Williamson Murray (eds.), The Dynamics of Military Revolution 1300–2050, 2001; Colin S. Gray, Strategy for Chaos: Revolutions in Military Affairs and the Evidence of History, 2002; Jeffrey McKitrick, James Blackwell, Fred Littlepage, George Kraus, Richard Blanchfield, and Dale Hill, The Revolution in Military Affairs, in Barry R. Schneider and Lawrence E. Grinter (eds.), Battlefield of the Future: 21st Century Warfare Issues, Maxwell Air Force Base, Air Chronicles, 1995; Dupuy, supra note 9, at 286–307; Williamson Murray, Thinking About Revolutions in Military Affairs, Joint Forces Quarterly, Summer 1997, p. 69; Stephen Biddle, Military Power: Explaining Victory and Defeat in Modern Battle, 2004; Michael J. Mazarr, Jeffrey Shaffer, and Benjamin Ederington, The Military Technical Revolution: A Structural Framework, Center for Strategic and International Studies, March 1993; Clifford J. Rogers (ed.), The Military Revolution Debate: Readings on the Military Transformation of Early Modern Europe, 1995.

transformations – the articulation of new things and ideas that interrupt preconceived notions of how to fight – we may plausibly include the following dramatic illustrations:

- The six-foot yew longbow, exploited by a vastly outnumbered English army in the Battle of Crecy in 1346 in northern France at the turning point of the Hundred Years' War. The archers employed this revolutionary technology – featuring longer range and double the rate of fire of existing crossbows – to devastate a vaunted French corps of armored knights, overnight displacing heavy mounted cavalry as the dominant force in land warfare.
- Sail-powered warships armed with cannons, which in the sixteenth century proved faster and more maneuverable than oared galleys and were capable of destroying an enemy fleet from afar without the peril of boarding the victim's vessel and engaging in hand-to-hand combat. Naval vessels and naval warfare, which had not evolved much in the two millennia since classical Greek archetypes, were suddenly transformed by French and Venetian leadership, converting ships from mere floating garrisons of soldiers to mobile artillery platforms.
- The Napoleonic revolution, through which the French were able to mobilize a vastly larger army than their opponents (via the *levee en masse* (mass uprising or conscription)), to motivate that populist cadre with the scent of patriotism, and to improve and standardize the organization and command structure of their formations.
- The adaptation to military operations of Industrial Revolution breakthroughs in communications, transportation, and manufacturing, such as the telegraph, the railroad, and the mass-produced rifled firearm. As illustrated during the American Civil War of 1861–1865, these advances enabled unprecedented speed and coordination in shuttling well-armed troops, equipment, and supplies rapidly to remote theaters of battle.
- A second naval revolution in the late nineteenth century and early twentieth century, as ironclad ships, steam turbine power, and large rifled cannons (and slightly later, submarines and torpedoes) radically altered the structure of engagements at sea and enabled new modes of combat, such as the strategic blockade. The British 1906 launch of the *HMS Dreadnought* triggered a naval arms race, as all major powers sought to mimic the breakthrough pulsed by the leading seafaring state of the day.

- The cluster of deadly innovations in World War I, in which different experts would identify tanks, aircraft, radios, or chemical weapons as the most important cutting edge of the modern implements of war. The popular image of stagnant armies mired in incessant trench warfare obscures appreciation of the novel military technologies introduced in that era.
- The even more deadly innovations of World War II, through which the debut of *blitzkrieg* (lightning war), aircraft carriers, amphibious warfare, radar, and long-range bombing vividly demonstrated the advantages of speed and the sudden assemblage of mass firepower.[11]
- The nuclear weapon, especially when mated to the long-range ballistic missile, which exposed enemy societies – indeed, the entire world – to the specter of mass annihilation within 30 minutes after the push of a button. Although earlier societies had often feared that military innovation would threaten to destroy all human life, by the 1960s or 1970s, that specter became a realistic possibility – and our utter defenselessness swiftly led to altered concepts of war, deterrence, and peace.
- The space age, which creates the conditions for instantaneous global reconnaissance and communications, improving leaders' abilities at command and control over the forces in the field and dissipating much of the "fog of war" that has always obscured battlefield conditions.
- The contemporary computer or information revolution and associated quantum leaps in microelectronics, sensors, laser- and other directed energy devices, and automated control technologies, which thoroughly alter both the strategic (big picture, long range) and tactical (localized) aspects of battlefield management and conduct.

These illustrations suggest that a true revolution in military affairs is a rare, complex phenomenon, without standardized features. Sometimes,

[11] William H. McNeill captures the spirit of the moment and the concomitant burst of military inventiveness, writing, "World War II was different. The accelerated pace of weapons improvement that set in from the late 1930s, and the proliferating variety of new possibilities that deliberate invention spawned, meant that all the belligerents realized by the time fighting began that some new secret weapon might tip the balance decisively. Accordingly, scientists, technologists, design engineers, and efficiency experts were summoned to the task of improving existing weapons and inventing new ones on a scale far greater than ever before." William H. McNeill, The Pursuit of Power: Technology, Armed Force, and Society Since A.D. 1000, 1982, p. 357.

multiple innovations occur nearly simultaneously, altering combat across a wide range of venues. Sometimes, the revolutionary moment is protracted, as decades are required for countries to recognize the value of the incipient transformation and to inculcate their fighting forces with new understandings and modified technologies. Sometimes, a revolution is driven by, or associated with, a particular agent or sponsor, as with Napoleon's eponymous innovations; at other times, the change benefits from multiple parents. Often a viable offset or countermeasure will spring up almost as soon as the novel breakthrough itself is registered, swiftly rebalancing offenses and defenses in new equilibria. Frequently, a revolution is not confined solely to the military apparatus, as relevant inventions bleed from the civilian sector into the arena of combat and back again.

Primacy in a revolutionary era can confer significant advantages upon the successful entrepreneur. By effectively marshaling a new weapon, a revised strategy, or a novel concept of operations, even a relatively small country can succeed against more formidable opposition – at least until the rivals also adapt, aping or even improving upon the innovation. Whoever first succeeds in exploiting the chariot, the stirrup, or the iron sword can acquire at least a transitory advantage over larger, wealthier foes – and even ephemeral advantages may be worth seizing.

In all of this, it is a mistake to focus exclusively on new weapons hardware; the novel equipment may be the most visible manifestation of a revolution in military affairs, but even more important is a transformed mode of thought or analysis, a reformation in understanding how modern armies, navies, and air forces can be wielded to maximum effect. Organization, structure, and missions must be revised to accommodate the new hardware, and it is frequently observed that the most important revolution in military affairs must occur in people's minds and not in their equipment. It is instructive to note, for example, that tanks, mobile artillery, and radios were generally available to many countries prior to World War II, but only in Germany did the leadership seize proper insight regarding revised operational concepts and the new culture of command necessary to create the devastation of the *blitzkrieg*.

TODAY'S REVOLUTION(S)

The application of precision-guided munitions (PGMs) in 1972 against the North Vietnamese bridges, as described in Scenario 1, provides a recent, handy illustration of a modern revolution, and it ushered in an era