The US Military's Approach to Strategy and the Implications for Military Technology

A Monograph

by

MAJ Sean Dunstan
US Army

School of Advanced Military Studies
US Army Command and General Staff College
Fort Leavenworth, KS

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This study considers the applicability of Arthur Lykke's ends-ways-means strategic framework to the maintenance and development of US military technological endeavors. Predicated on the belief that technological superiority provides the surest means of achieving battlefield success, the US military continues to invest heavily in more complex and expensive weapon systems. While this argument seems to justify the development of an overarching strategy for military technology, if for no other reason to avoid waste, analysis of the distinctive evolutionary paths of technology and strategy supports the supposition that military strategy and technology follow different, often conflicting rationales. As a result, applying Lykke's model in this regard could in fact hinder the military's understanding and evaluation of current or emerging technologies.

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Name of Candidate: MAJ Sean Dunstan

Monograph Title: The US Military's Approach to Strategy and the Implications for Military Technology

Approved by:

_____, Monograph Director
G. Scott Gorman, PhD

_____, Seminar Leader
James M. Depolo Jr., COL

_____, Director, School of Advanced Military Studies
James C. Markert, COL

Accepted this 24th day of May 2018 by:

_____, Director, Graduate Degree Programs
Robert F. Baumann, PhD

Abstract

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This study considers the applicability of Arthur Lykke's ends-ways-means strategic framework to the maintenance and development of US military technological endeavors. Predicated on the belief that technological superiority provides the surest means of achieving battlefield success, the US military continues to invest heavily in more complex and expensive weapon systems. While this argument seems to justify the development of an overarching strategy for military technology, if for no other reason to avoid waste, analysis of the distinctive evolutionary paths of technology and strategy supports the supposition that military strategy and technology follow different, often conflicting rationales. As a result, applying Lykke's model in this regard could in fact hinder the military's understanding and evaluation of current or emerging technologies.

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Acronyms

CENTCOM	United States Central Command
CEP	Circular Error Probability
DARPA	Defense Advanced Research Projects Agency
LGB	Laser Guided Bomb
NDRC	National Defense Research Committee
NDS	National Defense Strategy
NSS	National Security Strategy
SAC	Strategic Air Command
SAM	Surface-to-Air Missile
TRADOC	US Army Training and Doctrine Command
USAF	United States Air Force

Chapter 1: Introduction

> If we continue to develop our technology without wisdom or prudence, our servant may prove to be our executioner.
>
> —General Omar Bradley, "Armistice Day Speech, 1948"

This monograph explores the evolution of military strategy and technology to answer the formal research question: How might Arthur Lykke's model help the US military develop, implement, and assess technology initiatives? The basic premise underlying this question is that, without strategic direction, the US military's considerable investment in technology may not adequately address the multiple dilemmas it faces across the globe. That the US military lacks a governing strategic framework for its modernization efforts despite the enormous expenditures in terms of both manpower and materiel that these endeavors continue to require is, according to the Army Science Board, both disconcerting and potentially dangerous.[1] This monograph assesses the applicability of a strategic framework to military technology initiatives in an effort to mitigate this danger.

This research question is predicated on several assumptions associated with modern conceptions of strategy and technology. First, it assumes that the strategic framework is adaptable to military technological pursuits. In this paper, the framework in question derives from retired US Army Colonel and War College professor, Arthur Lykke's definition of strategy, as a method for articulating the ends, ways, and means designed to achieve a certain objective.[2] The research question also assumes that Lykke's model has utility beyond the realm of traditional political-military strategy and thus, may prove useful in formulating a strategy for military technology. This assumption forms the basis of the monograph's hypothesis.

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[1] *Army Science Board: 2013 Final Report* (Washington, DC: Government Printing Office, 2013), 2, accessed August 8, 2017, www.dtic.mil/docs/citations/ADA571038.

[2] Arthur F. Lykke, "Toward an Understanding of Military Strategy," in *US Army War College Guide to Strategy*, ed. Joseph R. Cerami and James F. Holcomb (Carlisle Barracks: Strategic Studies Institute, 2001), 180.

Extrapolating from the evolving interaction between technology and strategy in the context of late-twentieth century conflicts, the monograph hypothesizes that Lykke's model could indeed provide strategic direction to and enhance the efficacy of Army technology initiatives. Those familiar with the spate of recent criticism concerning the simplicity, rigidity, and reductionism of Lykke's framework might contend that this model does not have broader applications. However, as noted learning theorist Donald Schön argues in his work, *Educating the Reflective Practitioner*, disconfirming a hypothesis we know or strongly assume is wrong still provides opportunities for learning.[3]

Both the research question and hypothesis necessitate a broader interpretation of the term, "technology." Not simply the artifacts of human manipulation such as an aircraft carrier or Abrams tank, technology, according to Melvin Kranzberg co-founder of the Society for the History of Technology and Alex Roland a history professor at Duke University, comprises the complex, dynamic interaction between humans and the material world.[4] Understanding technology's properties and influences therefore requires an appreciation for complex systems.

While no universally agreed upon definition exists, theorists Yaneer Bar-Yam and Jamshid Gharajedaghi contend that a system derives its complexity not from the properties of its individual parts, but from the arrangement of the interactions of those parts.[5] According to Bar-Yam and Gharajedaghi, the measure of a system's complexity stems from the interdependence of its parts, or the degree to which changes in one part of the system produce multiple unanticipated effects in other parts of the system.[6] Thus, systems thinking elicits a more comprehensive

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[3] Donald Schön, *Educating the Reflective Practitioner* (San Francisco: Jossey-Bass, 1987), 69-71.

[4] Alex Roland, "War and Technology," Foreign Policy Research Institute, February 27, 2009, accessed August 10, 2017, http://www.fpri.org/article/2009/02/war-and-technology/.

[5] Yaneer Bar-Yam, *Making Things Work: Solving Complex Problems in a Complex World* (Cambridge: Knowledge Press, 2004), 23; Jamshid Gharajedaghi, *Systems Thinking: Managing Chaos and Complexity*, 3rd ed. (Burlington: Elsevier, 2011), 45.

[6] Bar-Yam, *Making Things Work*, 23-24; Gharajedaghi, *Systems Thinking*, 45.

appraisal of technology's significance, from a mere instrument of war to encompassing how the US military plans, prepares, and organizes for operations.

For contemporary military professionals, this research question is significant for several reasons. First, no other factor, except perhaps human behavior, has changed warfare more than technology.[7] Second, for almost fifty years after World War II, US military technology initiatives focused almost exclusively on deterring or defeating the Soviet Union and its proxies. However, according to Training and Doctrine Command (TRADOC) pamphlet 525-3-1, *Win in a Complex World*, the twenty-first century strategic operating environment presents a myriad of dynamic threats.[8] Third, the recent inability of Congress to provide the military with consistent and predictable funding has, as Chairman of the Joint Chiefs of Staff, General Joseph Dunford remarked in testimony before the Senate Armed Services Committee, materially damaged the US military's technological edge, further jeopardizing the military's ability to effectively address this global uncertainty.[9] Lastly, the US political-military establishment's core strategy documents, namely the National Security Strategy (NSS) and the National Defense Strategy (NDS), apart from extending a certain deference to technology and technological advancement, articulate competing views of technology. For example, the 2017 NSS claims that for the defense industrial base to maintain its competitive advantage, it must field new technologies as rapidly as possible.[10] Alternatively, the 2018 NDS proposes improving integration of technology with existing warfighting capabilities, not necessarily developing new technological systems, as the

[7] Martin van Creveld, *Technology and War: From 2000 B.C. to the Present* (New York: Free Press, 1991), 311.

[8] US Department of the Army, US Training and Doctrine Command (TRADOC) Pamphlet 525-3-1, *The US Army Operating Concept: Win in a Complex World* (Washington, DC: Government Printing Office, 2014), 10-11.

[9] Ryan Browne and Barbara Starr, "Dunford: Military Risks Losing its Competitive Edge," *CNN*, June 13, 2017, accessed February 08, 2018, https://www.cnn.com/2017/06/13/politics/dunford-trump-military-budget-senate/index.html.

[10] US President, *National Security Strategy of the United States of America* (Washington, DC: The White House, 2017), 21.

US military's path forward.[11] Prominent senior defense analyst and policy advisor Dr. James Blackwell claims that this reflects the US political-military establishment's continued struggle to understand the process of technological change.[12] Blackwell maintains that this has engendered a haphazard approach to technological advancement, which could prove costly and dangerous, particularly given the first three points above.[13]

Understanding the relationship between strategy and technology is crucial if technological superiority is to remain a pillar of US military strength. Technology and technological advancement have strongly influenced wars throughout history, setting parameters for the social, political, and economic drivers of armed conflict.[14] Underpinning the US military's post-World War II great power status, technology, and technological advancement have penetrated virtually every aspect of the American military establishment and its combat style.[15] In fact, the US military's increasing reliance on developing and maintaining a technological edge over its adversaries has produced several distinctive side effects.

Foremost, and much to the chagrin of President Dwight Eisenhower, the US military's pursuit of technological domination has spawned a massive and powerful industrial complex capable of entrenching the military and government in costly, decades-long commitments. In 2011, the US military's investment in this industrial complex exceeded the defense outlays of the

[11] US Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America* (Washington, DC: Government Printing Office, 2018), 10.

[12] James Blackwell, "Prospects and Risks of Technological Dependency," in *Strategic Concepts in National Military Strategy Series: Strategy and Technology* (Carlisle Barracks: Strategic Studies Institute, 1992), 33.

[13] Ibid., 33-34.

[14] Alex Roland, *War and Technology: A Short Introduction* (New York: Oxford University Press, 2016), 1.

[15] Martin van Creveld, "War and Technology," Foreign Policy Research Institute, October 24, 2007, accessed August 24, 2017, https://www.fpri.org/article/2007/10/war-technology-2/.

next thirteen nations combined.[16] Second, it sparked an acceleration in both domestic and global technological innovation.[17] Ironically, the pace of innovation the US military helped to foster, it now struggles to keep up with. Lastly, it has altered the cognitive lens through which multiple generations of senior civilian and military leaders solve problems, with technology-driven solutions having primacy. Paraphrasing former Deputy Defense Secretary Robert Work's 2015 speech to the Center for a New American Security, technological superiority determines the manner in which the US military projects power, deters adversaries, and assures allies.[18]

The monograph's argument is presented in three parts. Chapter 2, entitled "The Evolution of a Theory of Strategy," describes the origins of Arthur Lykke's strategic theory, including recent criticisms of the model. While the ends-ways-means strategic framework as presented in the next chapter follows a relatively linear path, Chapters 3, 4, and 5 attempt to replicate the dynamic complexity and interdependence intrinsic to technology's evolution through an historical narrative covering the development of three paradigmatic military technologies: nuclear weapons, precision guided munitions, and stealth systems. Chapter 6, the conclusion, compares the evolution of military strategy with technology, discusses the implications for developing and implementing a technology-focused military strategy, and because of the shortcomings inherent to Lykke's model, offers alternatives to the ends-ways-means framework.

[16] Brad Plumer, "America's Staggering Defense Budget, in Charts," *Washington Post*, January 07, 2013, accessed August 31, 2017, https://www.washingtonpost.com/news/wonk/wp/2013/01/07/everything-chuck-hagel-needs-to-know-about-the-defense-budget-in-charts/?utm_term=.1aac27bb05fb.

[17] Roland, *War and Technology*, 14.

[18] Robert Work, "The Third U.S. Offset Strategy and its Implications for Partners and Allies" (lecture, Willard Hotel, Washington, DC, January 28, 2015), accessed August 31, 2017, https://www.defense.gov/News/Speeches/Speech-View/Article/606641/the-third-us-offset-strategy-and-its-implications-for-partners-and-allies/.

Chapter 2: The Evolution of a Theory of Strategy

The modern day formulaic understanding and depiction of strategy represents the convergence of two efforts. First, it reflects the myriad of interpretations of military theorists, attempting to scope and define a broad and complex term in order to give it meaning. Second, to reconcile this complexity with the major military affairs of their day, these same theorists' tended to break the term down into generally accepted components, typically articulated as ends, ways, and means. Thus, the emergence of a simple, yet elegant framework for understanding and developing strategy resulted from both an evolution and a synthesis of more than two centuries of strategic theorizing. This chapter begins by tracing the evolution of the ends-ways-means conception of strategy, culminating in Colonel Art Lykke's theory, and concludes with critiques of his model by contemporary strategic theorists.

Over the centuries, the meaning of the term "strategy" has evolved and as a result, theories of strategy have had to grapple with defining a subject of increasing scope and complexity. Attributed to a myriad of Classical-era root words, including the Byzantine term "strategos," or "general," the modern Western definition and conception of strategy as a relationship between ends, ways, and means, only began to take shape in the mid-nineteenth century, in the writings of preeminent military theorists, Antoine Henri Jomini and in particular, Carl von Clausewitz.[19] While Clausewitz, in his famous treatise, *On War,* is most noted for his musings on the nature of war, he is also credited with describing the relationship between ends and means expressed as a series of military engagements designed to obtain a political aim.[20]

[19] David Jablonsky, "Why is Strategy Difficult?" in *US Army War College Guide to National Security Issues. Vol. 1, Theory of War and Strategy,* ed. J. Boone Bartholomees (Carlisle Barracks: Strategic Studies Institute, 2008), 3.

[20] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton: Princeton University Press, 1989), 128-129.

For Clausewitz, strategy was the act of organizing and directing individual actions toward the political objective.[21] Writing in the midst and immediate aftermath of the Napoleonic Wars, which upended the traditional order of continental Europe, Clausewitz articulated the distinction between political and military objectives that for so long were considered one and the same. He asserted that policy determined strategy and that military strategists must understand the political objectives to have any chance at developing a military strategy that achieved these aims. Clausewitz's concept of civil-military relations and his emphasis on deriving military objectives, resources, and courses of action from the political objective had enormous influence on the development of the modern ends-ways-means paradigm, particularly from a US military perspective.[22]

However, Clausewitz's theory of war and fledgling formulation of a strategic framework came to an abrupt end with his sudden passing in 1831. Coming on the eve of the Industrial Revolution, Clausewitz's death left many of his acolytes wondering just how his political-military genius would have wrestled with the tremendous social, political, and economic upheaval wrought by industrialization. Indeed, the Industrial Revolution's effects on war reverberated throughout the early twentieth century, notably in two World Wars, having profound implications for strategy.

From the 400-mile long trench line in the Western Front during World War I, to the Allied island hopping campaign in the Pacific in World War II, the belligerents of the twentieth century waged war on an unprecedented scope and scale. Noted for developing the doctrine of the indirect approach in reaction to the carnage that resulted from the more direct approaches taken during the two World Wars, British military historian and theorist, B.H. Liddell Hart, popularized

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[21] Clausewitz, *On War*, 129.

[22] J. Boone Bartholomees, Jr., "A Survey of the Theory of Strategy," in *US Army War College Guide to National Security Issues. Vol. 1, Theory of War and Strategy,* ed. J. Boone Bartholomees (Carlisle Barracks: Strategic Studies Institute, 2008), 19.

strategy and reinvigorated the ends-means concept espoused by Clausewitz a century earlier. Arguing that political and military leaders throughout history, but in particular during World War I, failed to fully understand the implications of technological and social changes and concomitant limitations in warfare, Hart introduced the notion of strategizing through rational calculation.[23] Likely shaped by trauma suffered while serving as an infantry officer on the Western Front, Hart, departing from the German Romantic tendencies of his forebear Clausewitz, viewed strategy as more of a scientific endeavor with ends and means as quantifiable factors relative to the potential costs or gains of a strategy.[24] However, Hart still viewed strategy as a bipartite construct of ends and means and it would take another brutal and controversial conflict before the current conception of strategy as ends, ways, and means fully materialized.

The Vietnam War had an enormous impact on the US military's understanding of strategy.[25] In a series of lectures reflecting on Vietnam, former Chairman of the Joint Chiefs of Staff and US Ambassador to South Vietnam, General Maxwell Taylor, advocated for the development of a theory of strategy as a stopgap against future errs in planning and decision-making. Taylor, a decorated soldier who served with distinction in World War II, where he helped pioneer airborne infantry operations, and in the Korean War, where he facilitated prisoner exchanges as part of the armistice, had been a prominent figure in senior political, military, and diplomatic circles since the mid-1950s.[26] Dismayed by Washington's growing infatuation with nuclear weapons and the policy of massive retaliation, Taylor abruptly retired as Army Chief of Staff under President Dwight Eisenhower.[27] In retirement, he penned *The Uncertain Trumpet*, a

[23] B.H. Liddell Hart, *Strategy*, 2nd ed. (New York: Praeger, 1967), 356-357.

[24] Ibid., 357.

[25] J. Bartholomees, "A Survey of the Theory of Strategy," 19.

[26] Albin Krebs, "Maxwell D. Taylor, Soldier and Envoy, Dies," *New York Times*, April 20, 1987, accessed February 08, 2018, http://www.nytimes.com/1987/04/21/obituaries/maxwell-d-taylor-soldier-and-envoy-dies.html?pagewanted=all.

[27] Ibid.

treatise on the doctrine of flexible response. In the context of building military forces and capabilities to counter a growing Communist threat, Taylor's work portrays strategy as a process of balancing means and ends. This approach caught the attention of President Eisenhower's successor, John F. Kennedy, who recalled Taylor to active service. Taylor served Presidents Kennedy and Johnson as a key policy advisor, and is widely regarded as one of the architects of the American war in Vietnam.[28]

Taylor spent much of his late life attempting to come to terms with the lessons of Vietnam, routinely meeting with military professionals and historians to share his insights. During his second retirement, Taylor continued to refine a general concept of strategy, expanding his framework beyond ends and means to include ways.[29] For Taylor, this third element was crucial to matching the first two, and essential to preempting the strategic missteps that, in his opinion, had plagued US military efforts in Vietnam. Intrigued by Taylor's argument, one student at the US Army War College would codify this concept into a theory of strategy.

During the 1980s, Colonel Arthur F. Lykke, Jr. popularized a theory of strategy that for the next three decades would influence the strategic thinking of countless senior military leaders, especially those in the US Army.[30] Apart from General Taylor, Lykke's concept also drew inspiration from a number of other sources in particular, Hart's contention that, strategy was, "the art of distributing and applying military means to fulfill the ends of policy."[31] Moreover, Lykke adopted the Clausewitzian notion that the political aim of a conflict determined the amount of resources allocated by a belligerent to achieve that aim.

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[28] Krebs, "Maxwell D. Taylor, Soldier and Envoy, Dies."

[29] Robert T. Foley, "Can Strategy Be Reduced to a Formula of S = E W M?" Defence-In-Depth, October 31, 2014, accessed October 14, 2017, https://defenceindepth.co/2014/11/03/can-strategy-be-reduced-to-a-formula-of-s-e-w-m/.

[30] Harry R. Yarger, "Toward a Theory of Strategy: Art Lykke and the U.S. Army War College Strategy Model," in *US Army War College Guide to National Security Issues. Vol. 1, Theory of War and Strategy*, ed. J. Boone Bartholomees (Carlisle Barracks: Strategic Studies Institute, 2008), 48.

[31] Hart, *Strategy*, 339.

In his seminal article for *Military Review* entitled, "Defining Military Strategy = E + W+ M," Lykke expounded on Clausewitz's, Hart's, and Taylor's ideas, giving coherent form to a theory of strategy. When expressed as an equation, according to Lykke, "Strategy equals Ends (objectives towards which one strives) plus Ways (courses of action) plus Means (instruments by which some end can be achieved)."[32] The article, published in 1989, reflected a formula that Lykke, as a professor at the US Army War College, had championed since 1980.[33] Lykke envisaged strategy as a three-legged stool with the ends, ways, and means each signifying one of the stool's legs. Misalignment of the legs results in tilt, which represents the strategy's risk. Successful strategizing in Lykke's formulation therefore requires attaining a balance between ends, ways, and means.[34]

The simple logic of Lykke's model in theory however, belies the complexity of balancing a strategy's resources, approach, and goals in practice. For Lykke, strategy followed a relatively linear and straightforward logic. Using Lykke's construct, establishing the ends or objectives is the first and most important step of the process. The ends describe what to accomplish. Determining ends or objectives requires an assessment of the available resources or means required. Typically, these resources including, money, people, and technology, are tangible in nature. However, means can also be intangible. Examples of intangible resources include courage, will, and creativity. The availability of both tangible and intangible resources informs the capability of any strategy or planning effort to accomplish the objectives.

Within Lykke's framework, strategizing also requires an evaluation of the range of options or ways to achieve the desired objectives or ends. Ways establish how something will be accomplished given the resources available. Estimates of both the means available and the

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[32] Arthur F. Lykke, Jr., "A Methodology for Developing a Military Strategy," in *Military Strategy: Theory and Application*. ed. Arthur F. Lykke, Jr. (Carlisle Barracks: US Army War College, 1993), 3.

[33] Foley, "Can Strategy Be Reduced to a Formula of S = E W M?"

[34] Lykke, "Toward an Understanding of Military Strategy," 182.

environment inform the development of the ways or courses of action of a strategy. Because of limits in resources and methods available to achieve an objective, strategies usually entail a certain measure of risk. Risk not only reflects the disparity between the desired ends and resources available, but the potential for the proposed courses of action to fail to meet those ends. A strategy assumes more risk as the gap between its objectives, and the courses of action and resources designated to achieve those objectives, grows. Since risk is inherent, at least to some degree, within any strategy, strategists must either accept it, or by tempering the ends or augmenting the ways and means, mitigate it.[35] Ultimately, Lykke's formula reduces strategy to a simple process of balancing the interaction between ends, ways, and means.

Critics have maligned Lykke's model for its purported oversimplification of a complex, dynamic process. Because of its simplicity and ease of application, Lykke's model initially gained wide appeal especially among US Army War College graduates. However, the US military's understanding of strategy has undergone something of a transformation over the last twenty-five years, which has prompted contemporary strategic theorists to question the validity and continuing relevance of the ends-ways-means construct.[36]

Much of the criticism leveled at Lykke's model focuses on its linear, reductionist slant. Critics, including National Defense University professor Jeffrey Meiser, argue that by separating the components of strategy into ends, ways, and means, Lykke's formula reduces strategy to a mechanical planning exercise.[37] Designed to apportion resources to a particular action, the resulting emphasis that this approach to strategy places on quantifying resources to balance means and ends has two notable side effects. First, instead of embracing uncertainty and complexity, Lykke's model stifles critical and creative thinking by prescribing actions intended to

[35] Lykke, "Toward an Understanding of Military Strategy," 183.

[36] Yarger, "Toward a Theory of Strategy," 47.

[37] Jeffrey Meiser, "Are our Strategic Models Flawed? Ends + Ways + Means = (Bad) Strategy," *Parameters* 46, no. 4 (Winter 2016-2017): 88-90.

align resources with goals. Second, by adopting a one-sided view of strategy, this approach ignores the influence that both the environment and potential adversaries have on the strategy-making process. Perhaps the most famous, though often misquoted, statement regarding the need to recalibrate a strategy in response to enemy action came from Helmuth von Moltke the Elder, who in his treatise *On the Art of War* wrote that, "no plan of operations extends with any certainty beyond the first contact with the main hostile force."[38] The increasing complexity and disorder of today's global operating environment has brought Moltke's admonition to fruition, challenging not only the linear and reductionist approach of Lykke's model, but calling into question the efficacy of the generic ends-ways-means construct.

Ultimately, Lykke's ends-ways-means framework reflects a pattern of roughly two centuries of incremental change to our understanding of strategy. While initially articulated by Clausewitz as a method for matching military actions to political objects, Hart and Taylor would, because of their experiences in two controversial wars, interpret ends and means more rigidly and quantitatively, turning strategy into what strategic theorist and US Navy Admiral, J.C. Wylie likened to a pure science of rational inquiry.[39] Examining the development of nuclear weapons, precision munitions, and stealth systems, the next three chapters reveal that in contrast to military strategy, which has evolved along a relatively straight path at least until recently, the evolution of military technology on the contrary, has routinely experienced abrupt, profound, and often unpredictable shifts.

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[38] Helmuth von Moltke, *On the Art of War*, ed. Daniel J. Hughes (Novato: Presidio Press, 1995), 45.

[39] J.C. Wylie, *Military Strategy: A General Theory of Power Control* (Westport: Greenwood Press, 1980), 10.

Chapter 3: The One-Two Punch of Precision and Stealth

This is the first of three chapters that examines the complex evolutionary paths of precision, stealth, and atomic weapons to ascertain the efficacy of applying an ends-ways-means framework to implement or guide military technology initiatives. The process of constructing this narrative, what H. Porter Abbott, author of *The Cambridge Introduction to Narrative,* described as a way of organizing reality to give events meaning, reveals several key considerations concerning the study of technology's evolution, particularly as it relates to or rather contrasts with the evolution of strategy presented in the previous chapter.[40] First, presenting the emergence of these technologies in linear, causal order distorts the complex, interdependent nature of their evolution in reality. Rather than simply chronicle events, these chapters highlight the interconnections of these three technologies (precision munitions, stealth, and nuclear weapons) by presenting them out of chronological sequence. Historically speaking, all three technologies emerged in relatively close order. Two of the three (precision munitions and stealth technology) advanced in tandem. Additionally, the systems and processes used to develop and implement these technologies underpins the military's current acquisition system, thereby enhancing the relevance of the findings and recommendations presented in Chapter 6. Second, the evolution of military technology cannot be understood in the context of specific conflicts alone, therefore the ensuing chapters address significant technological, doctrinal, organizational, and strategic developments in peacetime—that is, between wars. Third, while military scholars, analysts, and practitioners consistently noted the profound strategic impact these technologies had on one or more conflicts, the next three chapters show that technologies do not go to war; states, for a variety of complex reasons including politics, economics, and religion go to war.[41] Lastly, from a

[40] H. Porter Abbott, *The Cambridge Introduction to Narrative*, 2nd ed. (New York: Cambridge University Press, 2008), 12; US Department of the Army, Army Doctrine Reference Publication (ADRP) 5-0, *The Operations Process* (Washington, DC: Government Printing Office, 2012), 2-5.

[41] Max Boot, *War Made New: Technology, Warfare, and the Course of History, 1500 to Today* (New York: Gotham Books, 2006), 10.

US strategic perspective, these chapters reveal that technological superiority became ensconced in the military's understanding of and coping mechanisms for today's panoply of global challenges in response to the perceived existential threat of a global communist takeover, beginning more than seven decades ago with the conclusion of World War II.

From the Persian Gulf War to The Great War and Back

Seventeen minutes past midnight on January 17, 1991, a lone aircraft crept silently under the moonless sky of the Mesopotamian desert.[42] Less than fifteen minutes later, the plane dropped its small but potent payload, catching its target, a remote outpost ensconced on the desert floor below, completely by surprise. The incursion and ensuing attack ended as quickly as it began, with the plane quietly slipping back into friendly airspace just after 1:30 a.m.[43] While this relatively discreet affair marked the opening salvo of Operation Desert Storm, the US military's offensive action taken in response to an Iraqi military invasion of Kuwait, it also represented the culmination of a myriad of technological advancements including precision munitions and stealth, developed around a carefully managed strategy of deterrence and limited war in the nuclear age. However, the story of the development of stealth and precision weapons begins not in the Gulf War, but instead traces back to the lessons of the First and Second World Wars and in particular, Vietnam.

The American quest for precision delivery of aerial ordinance is almost as old as the airplane itself, beginning in earnest on the heels of World War I. In the 1920s, an engineering consultant for the US military, while studying the bombing problems of the Great War, developed a then-revolutionary gyro-stabilized bombsight that he claimed was capable of dropping bombs

[42] Boot, *War Made New*, 318.

[43] Richard G. Davis, *Decisive Force: Strategic Bombing in the Gulf War* (Washington, DC: Air Force History and Museums Program, 1996), 29.

from as high as 20,000 feet into a barrel.[44] With war against Germany and Japan imminent, senior military leaders including General Henry "Hap" Arnold believed that Carl Norden's Mark XV bombsight could mean the difference between victory and defeat.[45] By the end of World War II, the US military would invest more than $1.5 billion in this technology, over half what it would spend on the Manhattan Project, equipping three-quarters of its bombers with, and training over 50,000 bombardiers in, the Norden bombsight.[46]

The bombsight's performance in combat however, failed to live up to Norden's promises. Though it performed well enough in trials under ideal conditions, bomber tactics designed to navigate the maelstrom of anti-aircraft fire and poor weather over Central Europe severely compromised the Mark XV's accuracy.[47] Furthermore, overreliance on the bombsight's autopilot function increased the exposure of Allied bomber crews to ground fire.[48] As a result, bomber formations frequently relied on the inputs of the lead plane, and not their own bombardiers to deliver their ordnance.

At first glance, the Norden Mark XV bombsight appeared to offer an unassailable technological edge to the US military. However, Norden's promises, though well intentioned, proved chimeric at best, and for the hundreds of Allied bomber crews that depended on the Mark XV bombsight, these promises often proved fatal. Ultimately, the Norden bombsight, despite its shortcomings, not only determined the tactics of both individual bombers and bomber formations, it underpinned the entire American daylight bombing campaign. One framework potentially explains how a military technology could assume such an expansive role.

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[44] Loyd Searle, "The Bombsight War: Norden vs. Sperry," *IEEE Spectrum* 26, no. 9 (September 1989): 60.

[45] Ibid., 64.

[46] Malcolm Gladwell, "The Strange Tale of the Norden Bombsight," speech, July 17, 2011, accessed August 10, 2017, https://www.ted.com/talks/malcolm_gladwell.

[47] Ibid.

[48] Ibid.

In his landmark work, *The Structure of Scientific Revolutions*, historian and physicist Thomas Kuhn asserted that models of scientific understanding or paradigms constantly compete with one another for recognition and acceptance by members of their respective communities.[49] According to Kuhn, when one model is challenged by a potentially more effective one, that model is abandoned or destroyed in favor of the new one. A variety of circumstances including time and resources force a change, or paradigm shift. He concluded that science progresses not through a linear accumulation of investigation and discovery, but advances episodically.[50] Kuhn also believed that this phenomenon was not exclusive to the field of scientific discovery and could be applied elsewhere.

The development and widespread integration of the Norden bombsight, despite its questionable effectiveness, signaled a shift in the US military's approach to military technology, engendering a unique belief that technology could sway the war's outcome. Not only was this belief outwardly expressed by senior military leaders such as General Arnold, it was reinforced by the enormous investment in the bombsight's development, which rivaled that of the atomic bomb. Unlike the previous paradigm, which viewed military technology as a mere instrument in war, the development and implementation of the Norden bombsight evinced a shift in the US military's attitude and approach toward technology as a potential determinant of a current or future war's outcome.[51]

Part of the challenge to the American's quest for precision during the interwar years and World War II was the introduction of radar in the late 1930s.[52] While Allied B-17 pilots negotiated Axis air defenses in Northern France and the Rhineland, British and American

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[49] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 3rd ed. (Chicago: University of Chicago Press, 1996), 62; Boot, *War Made New*, 6.

[50] Ibid., 62.

[51] Gladwell, "The Strange Tale of the Norden Bombsight."

[52] Bill Sweetman and James Goodall, *Lockheed F-117A Operation and Development of the Stealth Fighter* (Osceola: Motorbooks International, 1990), 8.

engineers began working to make their warplanes less detectable by radar. Their work, which concentrated on experimental camouflage and radical airframe design, met with generally insignificant results. While these efforts failed to materialize during World War II, American military enchantment with stealth blossomed with the dawn of the Cold War.[53]

The military necessity for stealth reached its apogee in the 1970s, during the height of the Cold War. By 1973, the Soviet Union had achieved parity with the United States in nuclear weapons.[54] Moreover, the Soviets since the end of World War II had continued to expand their conventional arsenal such that by 1975, they held a roughly three-to-one advantage over the United States in conventional weapons.[55] Alert to this growing threat, then US Defense Secretary, Harold Brown, tasked his Undersecretary for Research and Engineering, William Perry, with pursuing advanced technological solutions to counter the sheer numerical superiority of Soviet conventional combat power. This approach of developing qualitative advantages to compensate for the Soviet's conventional quantitative advantages became known as the "Offset Strategy."[56]

Secretary Perry's assignment to advance an "Offset Strategy" brought him in touch with numerous clandestine ventures and one in particular, dubbed "Harvey," piqued his interest. Named after a 1950s Hollywood film that featured a giant invisible rabbit, project "Harvey" envisioned an aircraft that was invisible to radar and infrared tracking.[57] Believing that he had found, in the invisible aircraft, a possible solution to the Soviet conundrum, Perry directed the Defense Advanced Research Projects Agency (DARPA) as the organization then overseeing "Harvey," to deliver an operational stealth aircraft by the autumn of 1981. At the time of project

[53] Sweetman and Goodall, *Lockheed F-117A*, 10-11.

[54] William J. Perry, "Technology and National Security: Risks and Responsibilities" (lecture, France-Stanford Center for Interdisciplinary Studies, Stanford, April 7, 2003), 2, accessed October 30, 2017, https://stanford.edu/dept/france-stanford/Conferences/Risk/Perry.pdf.

[55] Ibid.

[56] Ibid.

[57] Ibid.

"Harvey's" commissioning in 1977, DARPA, a firm founded in the late 1950s with the mandate of supporting high risk, high reward technology initiatives with potential military applications, possessed little more than what they had inherited from "Skunk Works."[58] This highly secretive design bureau within the American aerospace company Lockheed had been studying the use of radar camouflaging to protect aircraft from surface-to-air missile (SAM) threats.[59] However, at the time of the project's handover to DARPA, the future of stealth aircraft was nothing more than a technical sketch. Additionally, DARPA lacked both the resources to meet Perry's audacious timeline and the security infrastructure necessary to keep the project secret so, at Perry's direction, DARPA partnered with the US Air Force (USAF).[60] This arrangement enabled Perry to marshal the Defense Department's considerable manpower, materiel, and infrastructure towards the design, development, and construction of a stealth aircraft, while strictly controlling physical and informational access to the program. With virtually unlimited resources at their disposal, the US Air Force-DARPA cooperative fielded the first operational F-117A Nighthawk in the fall of 1981.[61] However, the Nighthawk never saw action in the 1980s and so remained shrouded in secrecy, until Iraqi dictator Saddam Hussein launched a massive military incursion into the tiny Persian Gulf state to his south.

In the same period that stealth progressed from the design board to the flight line, the US military began to realize gains in the development of precision munitions, and a tragic mishap at the end of World War II served, as the strategic catalyst for the US military's proliferation of those weapons. When US Navy Lieutenant Joseph Kennedy Jr. climbed aboard his BQ-8 plane on August 8, 1944, he never could have imagined that the fate of an entire nation traveled with him. Groomed by his father, Joseph Sr., from an early age, Joseph Jr. was destined to take up his

[58] Sweetman and Goodall, *Lockheed F-117A*, 16-18.

[59] Ibid.

[60] Perry, "Technology and National Security," 4.

[61] Sweetman and Goodall, *Lockheed F-117A*, 28-29.

family's rich political legacy.[62] A top-secret US Navy program designated "Operation Anvil" changed all that. Operation Anvil used remotely piloted, explosive-laden aircraft to target hardened facilities such as Nazi submarine pens, and command and control bunkers. Too dangerous to take off by themselves, Operation Anvil called for a skeleton crew to get the heavily modified planes aloft. Upon reaching a safe cruising altitude, the crew would set the explosives, transfer control to a radio operator following in a separate chase plane, and then parachute to safety. During the ascent phase, Lieutenant Kennedy's plane exploded, killing all aboard.[63] With the senior Kennedy's hopes and dreams suddenly dashed, another son emerged to fill the void created by Lieutenant Kennedy's untimely passing. However, Joseph Kennedy Jr. did more than merely participate in one of the US military's early attempts at employing precision guided munitions. Rather, his death helped clear the way for younger brother John to become President of the United States, and John F. Kennedy's presidency would contribute significantly to the emergence of modern precision guided munitions.[64]

In the aftermath of World War II, and the atomic bombings of Hiroshima and Nagasaki, a nuclear arms race between the two remaining global powers, the United States and Soviet Union ensued. For the next fifteen years, nuclear deterrence formed the cornerstone of US diplomacy and military policy. Buzzwords such as "massive retaliation" underpinned national security strategy, particularly during President Dwight Eisenhower's administration.[65] In an effort to keep a campaign pledge to end American involvement in Korea, Eisenhower rebuffed Truman administration efforts to balance nuclear and conventional capabilities, opting instead for a strategy that relied almost entirely on nuclear weapons as a hedge against a reduced conventional

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[62] Edward J. Renehan Jr., *The Kennedys at War, 1937–1945* (New York: Doubleday, 2002), 304.

[63] Hank Searls, *The Lost Prince: Young Joe, The Forgotten Kennedy; The Story of the Oldest Brother* (New York: World Publishing, 1969), 283.

[64] Paul G. Gillespie, *Weapons of Choice the Development of Precision Guided Munitions* (Tuscaloosa: University of Alabama Press, 2002), 10.

[65] Ibid., 63.

military footprint.[66] As is often the case in democratic societies however, the arrival of new leadership in Washington ushered in yet another spate of changes to national military policy.

An outspoken critic of Eisenhower's massive retaliation strategy with its seemingly narrow-minded emphasis on nuclear capabilities, John F. Kennedy campaigned to reform America's military, specifically to expand its capabilities. President Kennedy's strategy of "flexible response," with its mandate to provide "selective, swift, and effective" action using all available means, hinged on the development of both nuclear and conventional forces.[67] As a result, the strategy of flexible response saw enhancements to America's nuclear force while also rejuvenating the Armed Services' pursuit of conventional capabilities, such that when the United States embarked on yet another limited war, this time in Vietnam, precision guided munitions were fast becoming a reality.[68]

After years of developmental hiatus, the unique strategic and tactical problem sets presented by Vietnam provided the impetus for the development and eventual proliferation of precision munitions. During the early stages of the war in Vietnam, the air campaign, encapsulated under Operation Rolling Thunder, exposed a myriad of American doctrinal and technological shortcomings. Designed to disrupt the enemy's lines of communications into South Vietnam, reduce the will of the North Vietnamese people to fight, and bring North Vietnam's leaders to the peace table, Operation Rolling Thunder's efforts largely failed to achieve its stated objectives.[69] North Vietnam routinely stymied an Air Force structured and equipped to face a larger, more conventional Soviet foe. Moreover, the Air Force's approach, reminiscent of the Allied bombing campaign over Germany in World War II, was ill suited for the smaller and more

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[66] Gillespie, *Weapons of Choice*, 63.

[67] Ibid., 68.

[68] Ibid., 97.

[69] Jacob Van Staaveren, *Gradual Failure: The Air War over North Vietnam 1965-1966* (Washington, DC: Air Force History and Museums Program, 2002), 319.

elusive targets presented by the North Vietnamese.[70] Poor weather and a dense jungle canopy served only to exacerbate the Air Force's struggles to accurately detect and effectively destroy North Vietnamese targets. Desperate to avoid an escalation of the conflict, the Johnson administration compounded matters further by centralizing command authority for the bombing campaign under the Chairman of the Joint Chiefs, some 9,000 miles away in Washington DC. Additionally, he imposed severe restrictions on the targeting process, including placing the enemy capital, Hanoi, off-limits.[71] These factors, in particular Johnson's desire to avoid World War III, undermined the US military's interdiction efforts, and ultimately lead Johnson in late 1968 to terminate the operation in favor of diplomatic alternatives.[72] Negotiations never materialized and in 1969, President Richard Nixon inherited an increasingly unpopular war.

Rolling Thunder not only exposed serious deficiencies in US military command structure and Air Force doctrine, it demonstrated the political and military utility of a weapon system capable of precisely delivering lethal effects within the narrow conflict space of limited war. Even when the North Vietnamese launched a massive incursion into the South in 1972, prompting Nixon to order large-scale retaliatory air strikes known as Operations Linebacker I and Linebacker II, indiscriminate bombing remained off the table.[73] Additionally, the Nixon administration continued to juggle its commitment to the American public of ending the war and its promise not to abandon South Vietnam to open predation by the North even if such a move had political ramifications at home. Moreover, Nixon viewed the North Vietnamese invasion as

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[70] Staaveren, *Gradual Failure*, 260-261.

[71] Project CHECO, *Southeast Asia Report Rolling Thunder, January 1967 - November 1968* (Hickam Air Force Base: Headquarters Pacific Air Forces, 1969), xi, accessed October 16, 2017, http://www.dtic.mil/get-tr-doc/pdf?AD=ADA486572.

[72] Gillespie, *Weapons of Choice*, 106.

[73] Mark Clodfelter, *The Limits of Airpower: The American Bombing of North Vietnam* (New York: Simon and Schuster, 1989), 190.

an act of desperation.[74] He believed that airpower could both halt the assault into the south, and by striking targets in the north also bring Hanoi to the negotiating table under conditions favorable to the United States.[75]

During the four-year interlude between Operations Rolling Thunder and Linebacker I, the Paveway Laser Guided Bomb (LGB) emerged as the backbone of the USAF's precision munition inventory. Prohibitively expensive at the outset, by 1972, improvements in manufacturing and production reduced the cost of Paveway bombs from their 1968 price tag of $10,000 each, to less than $3,000 apiece.[76] Meanwhile, over the skies of Vietnam, the USAF continued to gain proficiency with the Paveway. During this four-year span, the USAF had refined its doctrine and tactics to achieve, by 1972, a Circular Error Probability (CEP), the measure of a bomb's precision, to within ten feet.[77] This then unheard of level of precision enabled the USAF to realize tremendous economies of scale, in both the number of bombs and aircrews required to service enemy targets. In four years, LGBs had become the preferred weapon for sorties over Vietnam. As a result, they would figure prominently in the Linebacker operations.

Similar to Johnson's Rolling Thunder, Nixon sought to use the Linebackers to stave off South Vietnam's collapse at the hands of the North, and to coerce North Vietnam into negotiations.[78] Additionally, Nixon also worried about provoking the Soviets, but unlike his predecessor, who constantly wrestled with the possibility of triggering a nuclear war, Nixon's National Security Advisor, Henry Kissinger, quickly dispatched any concerns over a Soviet military response.[79] Also unlike Johnson, who took a graduated approach to the scope and

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[74] Richard M. Nixon, *The Memoirs of Richard Nixon* (New York: Warner Books, 1978), 60; Clodfelter, 153

[75] Ibid., 61.

[76] Gillespie, *Weapons of Choice*, 113.

[77] Ibid.

[78] Clodfelter, *The Limits of Airpower*, 153.

[79] Henry A. Kissinger, *White House Years* (Boston: Little, Brown and Company, 1979), 1445; Clodfelter, *The Limits of Airpower*, 153.

intensity of the bombing, Nixon planned to unleash the full fury of American airpower in swift, decisive fashion. He rolled back Johnson administration era restrictions governing targets in the North, particularly in and around Hanoi, and left much of the campaign's planning and targeting decisions up to military leaders at Strategic Air Command (SAC) and Pacific Fleet Command.

The first Linebacker air campaign was relatively successful, at least from the standpoint of destroying North Vietnam's war making capacity and operational reach. Paveway bombs made short work of numerous high value targets that were originally off-limits because of political restrictions. Furthermore, the bombs proved effective against targets that had previously withstood strikes from unguided iron bombs, including Paul Doumer Bridge, a major thoroughfare for military traffic in to and out of Hanoi, an oil storage facility near Vinh, and the vital Thanh Hoa Bridge, which earned the moniker "indestructible" during Rolling Thunder.[80] Because of the overwhelming effectiveness of the Paveway bombs and the air campaign in general, the North Vietnamese offensive stalled and the South Vietnamese military quickly recovered. Despite the first Linebacker's military successes however, Hanoi continued to negotiate in bad faith and in response, President Nixon prepared to widen the political-military aperture again.

While Linebacker I failed to produce a negotiated settlement, Linebacker II, dovetailing on the successes of its predecessor would provide the impetus for a peace agreement, setting conditions for the US military's complete withdrawal from Vietnam. Frustrated by what he saw as six months of fruitless negotiations with North Vietnam, Nixon ordered a renewed large scale bombing effort in early December 1972. Seeking to impose maximum discomfort on the North Vietnamese people, Nixon expanded Linebacker II to target the enemy's will.[81] After eleven days of around-the-clock bombing, Hanoi agreed to meet in Paris to negotiate a peace settlement.

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[80] Gillespie, *Weapons of Choice*, 116.

[81] Clodfelter, *The Limits of Airpower*, 184.

Bombing of North Vietnamese targets continued throughout the negotiations until President Nixon announced the suspension of offensive operations on January 15, 1973, effectively terminating the US military's presence in Vietnam.[82]

Analysis of Chapter 3

The emergence of precision guided munitions during the Vietnam War stemmed primarily from three factors. First, a dramatic shift in policy focus between the Eisenhower and Kennedy administrations, which required an influx of conventional forces and sparked renewed interest in developing improved conventional weapon systems capable of inflicting destruction tantamount to a nuclear bomb, but on a much more localized scale and without the radioactive fallout. Second, a surfeit of technological creativity spurred by Vietnam's difficult weather and terrain, and an unconventional enemy in the North Vietnamese. Finally, a limited war in which airpower, for various political, military, and economic reasons, evolved into the principal vehicle for wielding the military instrument of power.

Despite the proliferation of laser guidance technology and the renewed interest in conventional ordinance that this technological development sparked, assessing the strategic impact that precision munitions had on the mid to late stages of the Vietnam War remains difficult. Between 1968 and 1972, the bomb proved capable of destroying a mix of highly mobile military targets and fixed infrastructure, presumably while mitigating collateral damage. Within the strategic context of that period however, precision munitions made a small but important contribution, as a means to an indeterminate end. Nixon's resumption of large scale bombing efforts clouds the picture further.

A shift in North Vietnamese tactics late in the war also factored into the outcome. For instance, during the 1972 Spring-Summer Offensive, the North Vietnamese sought to improve

[82] Clodfelter, *The Limits of Airpower*, 163.

their bargaining position in Paris by seizing as much South Vietnamese territory as possible.[83] They deployed tanks, artillery, and infantry in conventional formations, making them easy prey for both guided and unguided bombs.[84] Linebacker I however, failed to produce a negotiated settlement, and it would take further relaxation of targeting restrictions and a combination of guided and unguided bombs during Linebacker II to achieve that aim.[85]

Although the Vietnam War proved the tactical effectiveness of precision guided munitions, a broader American military movement to grapple with the hard fought lessons of that controversial conflict overshadowed the strategic implications of this technological development.[86] For the political establishment as well as the military, the bomb's strategic potential thus went unnoticed. That is, until almost twenty years later when American television news networks broadcast their effects to audiences worldwide.[87] Considering the Vietnam War produced precision guided munitions, it is ironic that those weapons gained notoriety during the Persian Gulf War, since for many senior officials, particularly in the military, that conflict represented an opportunity to cast aside the demons of Vietnam.[88]

Still, the Vietnam War had a profound impact not only on the US military's approach to strategy going into the Persian Gulf, but also its strategic direction for technological initiatives. The Linebacker operations exposed what contemporary military historian and theorist Martin van Creveld described as the disparate rationales of technology and military operations in war.[89] According to van Creveld, technology corresponds to the logic of efficiency or obtaining the

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[83] Clodfelter, *The Limits of Airpower*, 166-167.

[84] Gillespie, *Weapons of Choice*, 124.

[85] Nixon, *The Memoirs of Richard Nixon*, 64; Gillespie, *Weapons of Choice*, 121-122.

[86] Gillespie, *Weapons of Choice*, 124.

[87] Ibid.

[88] John Carlos Rowe, "The 'Vietnam Effect' in The Persian Gulf War," *Cultural Critique*, no. 19 (1991): 121, accessed November 3, 2017, https://www.jstor.org/stable/1354311?seq=1#page_scan_tab_contents.

[89] Creveld, *Technology and War*, 318-319.

maximum return on investment, while military operations in war focus on effectiveness or simply put, actions leading to victory. He concluded that these two logics, though sometimes harmonious, typically clash.

Linebacker II, in particular, highlighted the conflict between the logics of efficiency and effectiveness. Of the eighteen total B-52s lost between 1965 and 1973 to enemy action, fifteen of those were shot down in a twelve-day span covering Linebacker II.[90] While an appraisal of the effectiveness of that operation remains somewhat absolute, it helped facilitate the negotiated settlement that the Nixon administration so desperately sought, changing the assessment metric fundamentally alters the perception of Linebacker II's relative efficiency. When evaluated against the number of crewmembers lost as opposed to the number of successful air-to-ground strikes, Linebacker II hardly appears efficient.

However, the challenges posed by the conflict between the logics of efficiency and effectiveness pale in comparison to the drawbacks of using an ends-ways-means construct, which dominated military strategic thought post-Vietnam, to reconcile this conflict. In particular, the mathematical connotation of ends-ways-means anchored the military in pursuing technological—that is, efficient solutions to tactical or operational setbacks often generated by another technology. During the Linebackers, each bomber required an additional three support aircraft, including fighter escorts and electronic countermeasure aircraft to interdict North Vietnam's robust air defenses.[91] Stealth arose partly as a means to mitigate the capacity-stretching requirements generated by conventional bombers in terms of those enablers. It reflects the urge promoted by ends-ways-means thinking to see direct cause and effect. Nevertheless, the interdependent system of stealth and precision that ends-ways-means thinking helped create in the 1970s and 1980s, has over the last thirty years, stretched the boundaries of such mental models.

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[90] Christopher Hobson, *Vietnam Air Losses: USAF, Navy, and Marine Corps Fixed-Wing Aircraft Losses in SE Asia 1961-1973* (North Branch: Midland Publishing, 2001), 127.

[91] Davis, *Decisive Force*, 6.

In fact, the First Persian Gulf War reinforced, perhaps to a dangerous extent, a sentiment expressed by General Arnold during World War II regarding the pivotal nature of the Norden bombsight, that advanced weapons offered the military an unassailable technological edge over its adversaries.

Where the Mark XV bombsight, which enjoyed the backing of at least one senior military official during World War II, reflected something of Kuhnian crisis to the military's traditional treatment of technology as purely an instrument of war, the advent of nuclear weapons destroyed that paradigm. Moreover, the atomic revolution created the perception of technology as both a means and an end of strategy. That belief, in the overriding supremacy of technological dominance, continues to undergird current technological pursuits.

Chapter 4: Atomic Awakening

At noon on August 15, 1945, the people of Japan stood in shock and disbelief as, for probably the first time in that nation's long history, they heard the sacred voice of their emperor. Virtually incomprehensible to the average Japanese commoner because of his courtly tongue, Emperor Hirohito informed the people of his intent to meet the surrender terms of the Allies. In a veiled attempt to save face, part of a roughly 2,500-year-old Asian tradition of avoiding humiliation, the emperor spoke of the unfortunate position the Japanese people now found themselves in, and he wondered aloud about the fate of humanity.[92] Next, he turned his discontent to the Allies, decrying the horrific violence visited upon his people by some new and utterly devastating weapon, which he likened to an "electronic bomb."[93] That weapon was the atomic bomb.

Japan however, was not the atomic bomb's initial target. In fact, the decision to develop an atomic bomb predated the United States' entry into World War II, originating more than two years earlier, in the summer of 1939. Concerns over recent discoveries in the field of theoretical physics prompted several then little known European physicists to enlist the help of world-renowned scientist, Albert Einstein, in drafting a letter to the President of the United States, Franklin Roosevelt.[94] In that letter, Einstein claimed that the Kaiser Wilhelm Institute in Berlin had secretly formed a new research department devoted to the study of uranium. He beseeched the President to undertake a similar initiative.[95]

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[92] Max Fisher, "The Emperor's Speech: 67 Years Ago, Hirohito Transformed Japan Forever," *The Atlantic*, August 15, 2012, accessed October 12, 2017, https://www.theatlantic.com/international/archive/2012/08/the-emperors-speech-67-years-ago-hirohito-transformed-japan-forever/261166/.

[93] Ibid.

[94] Joseph M. Siracusa, *Nuclear Weapons: A Short Introduction* (New York: Oxford University Press, 2008), 12.

[95] Albert Einstein to Franklin Roosevelt, August 2, 1939, Atomic Archives Historical Documents, accessed October 14, 2017, http://www.atomicarchive.com/Docs/Begin/Einstein.shtml.

When Einstein and his co-authors wrote the letter in July 1939, they had only the recent invasion of Czechoslovakia as evidence with which to divine Germany's intentions for uranium research. By the time the letter reached Roosevelt's desk in October 1939 however, the Nazis had by then invaded Poland, and embarked on a naval campaign against the British in the Atlantic. Already concerned with Hitler's rapidly materializing designs for greater European hegemony, the possibility of such enormous destructive power coming into the hands of the Nazis only further alarmed Roosevelt.[96] On October 19, he ordered the formation of an advisory committee for the study of atomic energy, and by November 1, the project had secured a paltry $6,000 worth of nuclear material from the Army and Navy to begin research.[97]

For the United States however, war was far from a foregone conclusion, and research efforts continued to focus on the power and industry applications of nuclear energy for almost the next two years.[98] Then in the fall of 1941, intelligence reports began matriculating from Great Britain that the Germans had begun working on developing an atomic bomb. The recent fall of Paris and the string of Nazi victories in North Africa served only to exacerbate the Allies' nuclear predicament.[99] Whatever edge the Germans held in the field of nuclear physics quickly evaporated, as the US government reorganized all domestic research into nuclear energy, placing them under the auspices of the National Defense Research Committee (NDRC).[100] Additionally, on December 6, 1941 the director of NDRC, Vannevar Bush, announced the proposal for an "all

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[96] Wilson D Miscamble, *The Most Controversial Decision: Truman, the Atomic Bombs, and the Defeat of Japan* (Cambridge: Cambridge University Press, 2011), 6.

[97] Henry DeWolf Smyth, *Atomic Energy for Military Purposes: The Official Report on the Development of the Atomic Bomb Under the Auspices of the United States Government, 1940-1945* (Stanford: Stanford University Press, 1989), 47.

[98] Smyth, *Atomic Energy for Military Purposes*, 42.

[99] Siracusa, *Nuclear Weapons*, 13.

[100] Smyth, *Atomic Energy for Military Purposes*, 49-50.

out" effort to develop an atomic bomb.[101] The next day, the Japanese bombed Pearl Harbor and the United States entered World War II.

Though originally undertaken in response to the German's foray into nuclear physics, by 1943, War Department and White House concerns over the German's ability to produce an atomic bomb had largely faded given the exorbitant amount of time, money, and effort expended by the Manhattan Project to develop an atomic bomb.[102] Roosevelt continued to view the bomb within the context of the European theater, until late 1943, when the Manhattan Project informed him that it could not promise delivery of a bomb any earlier than the summer of 1945.[103] As the Allied leaders convened in Tehran to finalize the details for a massive Allied incursion into northern Europe and sketch out plans for a postwar settlement, Roosevelt and others in the War Department began to debate the bomb's relevance to the European theater. Nevertheless, the project continued, because despite Allied progress in the European theater, the conflict in the Pacific was only beginning to intensify.

Even as the Allied focus shifted to Japan between mid-1944 and early 1945, the overarching intent for the atomic bomb remained unchanged. For Roosevelt, the atomic bomb represented part of a broader conventional strategy to subdue the Axis powers and conclude the war as quickly as possible.[104] Although Roosevelt periodically checked in on the progress of the Manhattan Project, his detachment from the program widened and he lost sight of the weapon's potential as his health deteriorated in the 12-month period preceding his death in April 1945. Meanwhile, those closest to the project, the administrators, and scientists, began to regard atomic

[101] Smyth, *Atomic Energy for Military Purposes*, 75.

[102] Ibid., 224.

[103] Siracusa, *Nuclear Weapons*, 18.

[104] Miscamble, *The Most Controversial Decision*, 13.

bombs as decisive weapons.[105] Roosevelt's death however, would do little to alter, at least from the Presidency's perspective, the strategic assessment of the bomb.

The decision by Roosevelt's successor, President Harry Truman, to drop the bomb in some ways resembles little more than that of a servant dutifully carrying out the will and mandate of his master. Following three years of research and development and with the first test on the immediate horizon, White House, War Department, and Manhattan Project officials met at the beginning of June 1945 to discuss America's first nuclear strategy.[106] With Germany having surrendered roughly a month prior, debate focused solely on Japan. Secretary of War, Henry Stimson, led the meetings and Truman frequently deferred to Stimson on nuclear-related affairs.[107] After more than two weeks of discussion, the committee presented several points for Truman's approval, all of which bore Stimson's mark. First, nuclear bombs would be used on relatively unspoiled military targets to increase the shock value. Second, the United States would not warn or otherwise issue any ultimatum to Japan in advance of the attack, thereby enhancing the element of surprise. Third, from a strategic perspective, the United States would not share its nuclear secrets with the Soviet Union even after the weapon's deployment.[108] This third point, which sought to strike a balance between secrecy and demonstrating capability as it pertained to military technological innovation, would form the cornerstone of future post-war deterrence strategy.

Apart from sending a strategic signal to the Soviets, Truman, in his decision to release atomic bombs over Japan, seems to have contemplated a panoply of moral, fiscal, and military factors from, accelerating Japanese capitulation, to saving time and sparing lives, to justifying the highly secretive project's enormous expenses. Truman's attitude toward the bomb, evinced by his

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[105] Smyth, *Atomic Energy for Military Purposes*, 224.

[106] Miscamble, *The Most Controversial Decision*, 42-44.

[107] Ibid., 79.

[108] Ibid., 42.

delegation of the Manhattan Project's management, and strategic direction to Secretary Stimson however, demonstrates a synergy with his predecessor's views of the bomb as a tactical instrument of war. The proliferation and increasing destructive power of nuclear weapons and other strategic implications eventually subsumed the tactical mindset, though it persisted into the early days of the Cold War.

Analysis of Chapter 4

With respect to the development of nuclear weapons and the emergence of nuclear strategy at the end of the war, several remarkable factors stand out. Foremost, a cohort of European scientists first called the government's attention to the military applications for uranium fission, convincing the Roosevelt administration of the wide-ranging possibilities. This, according to Manhattan Project archivist and physicist, Henry DeWolf Smyth, astonished US scientists, who were not at all accustomed to pursuing possible military applications for their experiments.[109] Second, only a select few scientists and top-level officials recognized the broader strategic implications for a weapon of such awesome destructive power. A group of these scientists, some of them Eastern European refugees, would later pen a letter to the President condemning the bomb's use against any target other than Nazi Germany. Furthermore, they correctly predicted that using the weapons would spark an arms race.[110] Truman's Secretary of State, James Byrnes, accorded the bomb some diplomatic significance, speculating as to its usefulness in arresting Soviet schemes in Eastern Europe.[111] For the vast majority however, including Truman, the bomb figured into a broader conventional strategy. In other words, Truman viewed the bombs as additional means for achieving the ends of unconditional surrender.

[109] Smyth, *Atomic Energy for Military Purposes*, 45.

[110] Siracusa, *Nuclear Weapons*, 25.

[111] Miscamble, *The Most Controversial Decision*, 30.

Finally, efforts to ascertain the precise strategic effects of the atomic bombings of Hiroshima and Nagasaki are further compounded by the precariousness of Japan's situation in the summer of 1945. The absence of food, shelter, and a looming Soviet invasion placed Japanese leadership in an untenable position. The bombs served only to exacerbate an already existing plight. Still, of all the aforementioned factors, Hirohito chose to cite the threat of future atomic bombings as a principle motive for surrendering.

Whether or not Truman's atomic finale singularly expedited World War II's resolution remains open for debate. Few dispute the effects of "Fat Man" and "Little Boy" on future military operations, strategy, tactics, and rules of engagement, even though resistance to the atomic paradigm survived World War II.[112] In fact, both atomic bombings employed the Norden bombsight, and that apparatus remained a mainstay of the B-29 fleet throughout the Korean War.[113] While using a precision instrument to deliver an atomic weapon might seem absurd, it illustrates both the impact of, and the challenges associated with, adjusting, or adapting to technological change. Moreover, it shows that a specific military technology cannot be considered independently of the other technologies that are used along with it.

[112] Creveld, *Technology and War*, 251-253.

[113] Gladwell, "The Strange Tale of the Norden Bombsight."

Chapter 5: Limited War in the Nuclear Age

The atomic fireballs that engulfed Hiroshima and Nagasaki at the end of World War II created one of the most daunting and existential strategic dilemmas not only for the United States, but for all mankind. This necessitated a fundamental change in the US military's approach to operations, in particular the concept of deterrence, which because of the terrible risks associated with a nuclear war, assumed strategic connotations. The architect of American nuclear strategy, Bernard Brodie, argued that nuclear deterrence "must be absolutely effective, allowing for no breakdowns ever."[114] He furthermore contended that for deterrence to "go permanently unchallenged," a nation must possess the credible, unfailing capacity to respond to a nuclear provocation.[115] Despite the proliferation of nuclear weapons and the growing propensity for nuclear exchange between combatants, Brodie also theorized that nation states would continue to restrain war to achieve limited objectives. He therefore believed that the United States not only had to maintain an advanced nuclear arsenal but an "independent limited war capability."[116] All of the US military's late twentieth century campaigns, from Korea, to Vietnam, to the First Persian Gulf War have operated under the umbrella of Brodie's deterrence theory and its offshoots, such as the policy of flexible response advocated by President Kennedy.

Moreover, nuclear deterrence became something of a benchmark to measure the impact of other potentially disruptive military technologies. Because, as Brodie asserted, limited war remained a viable outlet for advancing political aims or vouchsafing national interests, the US military had to continue investing in the development and implementation of advanced weaponry. Ultimately, the exploration for technological solutions to the problem of limited war in the

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[114] Bernard Brodie, *The Anatomy of Deterrence* (Santa Monica: US Air Force Project RAND, 1958), accessed February 24, 2018, https://www.rand.org/content/dam/rand/pubs/research_memoranda/2008/RM2218.pdf.

[115] Bernard Brodie, *Strategy in the Missile Age* (Santa Monica: The RAND Corporation, 2007), viii.

[116] Brodie, *Strategy in the Missile Age*, x.

nuclear age culminated with the demonstration of those weapons against the Iraqi military in the First Persian Gulf War.

Desperate to restore an economy bankrupted by eight years of war with Iran, and eager to reassert political hegemony both at home and abroad, Iraqi dictator Saddam Hussein, on August 2, 1990 ordered an invasion of Kuwait, the small oil rich emirate located along Iraq's southern border, to seize that country's vast wealth.[117] The Iraqi military routed Kuwait's defense and in less than two days forcibly annexed the country, with Saddam Hussein declaring Kuwait his 19th province a few days later.[118] Hussein's actions drew swift international condemnation and placed him squarely in the sights of American military might.

American President, George Bush reacted immediately to Iraq's belligerency and on August 5, 1990 issued an ultimatum to Iraq's dictator. Hussein refused President Bush's demands and these points including, unconditional withdrawal of all military forces from Kuwait, restoration of Kuwait's legitimate government, and recognition of and adherence to the sovereign borders of other Persian Gulf nations namely, Saudi Arabia, soon became the chief objectives of a US-led military coalition's operation against Iraq. Military operations would however, not take place for another seven months.

In the meantime, under the direction of the Secretary of Defense, the recently appointed commander of US Central Command (CENTCOM), General H. Norman Schwarzkopf, along with the Chairman of the Joint Chiefs, General Colin Powell, started to formulate a plan that translated President Bush's policy to military objectives.[119] As the senior military organization responsible for defense-related affairs in the Persian Gulf, CENTCOM took the lead for the military planning effort. Developing the plan required knowledge of fields such as airpower,

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[117] Lawrence Freedman and Efraim Karsh, "How Kuwait Was Won: Strategy in the Gulf War," *International Security* 16, no. 2 (Fall 1991): 9, accessed October 31, 2017, http://www.jstor.org/stable/2539059.

[118] Ibid., 9-10.

[119] Ibid.

outside General Schwarzkopf's expertise, much less the CENTCOM staff's capabilities.[120] Therefore, with General Powell's permission, General Schwarzkopf utilized the service department staffs at the Pentagon in particular, the USAF Air Staff, to develop the most comprehensive plan possible.[121]

Authorship of the air plan remains hotly contested to this day. Initially, Lieutenant Colonel John Warden, a member of the Air Staff's planning cell envisaged an air campaign lasting six days.[122] To paralyze the Iraqi military, Warden's plan, dubbed "Instant Thunder," called for the targeting of key Iraqi political-military leadership, commonly referred to as command and control nodes, severing of Iraqi supply lines, and destruction of known weapons of mass effect storage facilities.[123] CENTCOM's air component commander, Lieutenant General Chuck Horner, scoffed at this plan, which in his estimation imprudently ignored the need for ground forces by relying singularly on airpower.[124] Where Warden saw airpower alone as the instrument with which to extricate the Iraqi military from Kuwait, Generals Horner and Schwarzkopf intended to integrate airpower into a larger air-ground campaign that would ultimately last six weeks. Some of Warden's emphasis on strategic targets survived, comprising three of General Schwarzkopf's top four objectives per the CENTCOM commander's orders issued on the eve of the US-led coalition's attack.[125]

In many respects, the Iraqi military of 1990 resembled the type of threat that Secretary Perry in 1977 had set about trying to defeat with high technological solutions such as stealth. The fourth largest military in the world, with over 900,000 soldiers, 850 attack aircraft and scores of

[120] Boot, *War Made New*, 339.

[121] Davis, *Decisive Force*, 14.

[122] Ibid., 16-17.

[123] Ibid., 15.

[124] Boot, *War Made New*, 339.

[125] Davis, *Decisive Force*, 26.

tanks, missiles, and heavy artillery, Iraq, at least on paper, looked to be a formidable foe.[126] Undercutting the numerical superiority of Iraq's conventional forces proved a significant obstacle to any air strategy, and so the F-117A at last, emerged from the shadows. Though not widely publicized, even after a training accident involving the crash of one F-117A in the summer of 1986, members of the USAF Air Staff were formally made aware of the aircraft's existence and capabilities between 1987 and 1988 thus, it was thoroughly accounted for in the development and subsequent evolutions of operation Instant Thunder.[127]

The F-117A became Instant Thunder's weapon of choice for a variety of reasons. Virtually undetectable to radar, the F-117A could penetrate an enemy's air defenses, and before air superiority was even achieved, strike hard targets relatively unmolested. Because most of the top line target sets initially identified by Warden and later refined by the CENTCOM leadership were heavily defended command and control, and air defense nodes similar to the one alluded to at the beginning of this section, the F-117A formed the tip of the coalition's spear into Iraq. For these reasons, CENTCOM used the Nighthawk against Baghdad's robust air defenses, which were assessed as between seven and ten times greater than those of Hanoi were, were in 1972.[128] Moreover, the stealth profile and range of the F-117A, together with its complement of precision munitions significantly reduced or outright eliminated the number of support aircraft required in a conventional bombing campaign, where non-stealthy counterparts continued to rely on air defense support packages similar to those used during the Linebackers to punch through Iraq's air defenses.[129]

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[126] Boot, *War Made New*, 337.

[127] Sweetman and Goodall, *Lockheed F-117A*, 82; Davis, *Decisive Force*, 34.

[128] Davis, *Decisive Force*, 25.

[129] Thomas A. Keaney and Eliot Cohen, *Gulf War Air Power Survey.* Vol. IV, *Weapons, Tactics, and Training and Space Operations* (Washington, DC: US Government Printing Office, 1993), 170.

The Gulf War provided demonstrable proof of the effectiveness of stealth and precision weapons. Representing less than three percent of the coalition's air force, F-117As flew 1,300 sorties unscathed, and accounted for the destruction of more than thirty percent of all strategic targets struck during the Gulf War.[130] Meanwhile, the Nighthawk's precision payload, which comprised only eight percent of total bombs expended, accounted for seventy-five percent of the damage incurred during the campaign.[131] Records compiled by the war's end indicated that the effects produced by one F-117A carrying just two precision guided bombs were equivalent to one hundred World War II B-17s dropping 648 bombs.[132]

Analysis of Chapter 5

For some senior officials, war with Iraq figured into the broader tenet within offset or deterrence strategies, such as those espoused by Secretary Perry, of carefully demonstrating capability. While for others like Colonel Warden, it served as the impetus for certain technologies, in particular stealth and precision munitions, to supplant nuclear weapons as the indispensable weapons of modern arsenals. Although the weapons had changed, the views of their respective proponents regarding technology had not evolved. They continued a tradition originated by political and military leaders of the 1950s, who believed nuclear weapons offered the United States an unassailable technological edge over its adversaries.

The First Persian Gulf War illustrates how stealth and precision munitions fit neatly into the construct of limited war by enabling the achievement of national objectives. Within the framework of ends-ways-means however, political and military leaders viewed precision munitions coupled with stealth delivery as virtually risk free. This assumption has had several important and enduring side effects. Foremost, it caused the US military to fixate on staying

[130] Davis, *Decisive Force*, 9.

[131] Keaney and Cohen, *Gulf War Air Power Survey*, 40-42.

[132] Ibid., 87.

ahead of state-based threats. Since no state power could muster the resources to counter the offset that stealth and precision achieved the political-military leadership deemed the threats posed by other non-state actors as irrelevant. Second, it has turned the American polity's casualty aversion into a benchmark for success. Third, it set unrealistic expectations, engendering a zero defects mentality for future military operations. Lastly, in keeping with the shortcomings of ends-ways-means thinking, it has created a perception that the decisive application of technology through the destruction, isolation, or neutralization of a target, is causally linked with changes to an enemy's political calculus.[133] The ongoing conflicts in Iraq in Afghanistan coupled with the increasing disorder of today's global operating environment have begun to erode the validity of this assumption, challenging its underlying arguments.

[133] Gillespie, *Weapons of Choice*, 159.

Chapter 6: Conclusion

Comparing the evolution of strategy over the last two centuries with the evolution of select technologies from the mid-twentieth century through the First Persian Gulf War, this research reveals that Lykke's framework, while useful to framing the strategic context of political-military decisions during wartime, may prove more detrimental than beneficial to US military efforts in understanding and managing technological change. Although Lykke's model from the outset seemed so obviously unsuited to strategizing for technology, this research has several implications for the US military's understanding and future study of the relationship between strategy and technology, and the military's efforts to leverage a strategic framework to maintain technological overmatch. In particular, this research exposes shortcomings to ends-ways-means thinking as it pertains to understanding key attributes of technology including complexity, interdependence, and innovation. As the preceding chapters evince, the limits of ends-ways-means thinking stem in large part from the discordant evolutionary paths of military strategy and technology. This chapter expands on these findings and offers some alternative theories of strategy that may account for this interaction.

The criticisms of Lykke's model introduced in Chapter 2 are particularly salient in the context of the complexity and interdependence that has, as Chapters 3, 4, and 5 showed, historically characterized military technology. Lykke's formula treats concrete and even abstract resources as finite values.[134] Thinking in such existential terms, while arguably pragmatic, constrains strategy, turning it into a planning exercise that aligns resources with objectives. However, the chapters devoted to exploring the evolution of military technology underscore the problems associated with isolating technology, as it extends beyond the realm of a fixed resource to affect military doctrine, tactics, training, and organizational processes and structures. Moreover, none of the technologies reviewed in this study emerged purely independent of the

[134] Meiser, "Are our Strategic Models Flawed?," 87-90.

other. Yet, Lykke's model promotes treating resources as discrete packages. Perhaps the strongest indictment of the ends-ways-means framework stems from the model's own inability to reconcile the interrelations between its component parts. For instance, a myriad of strategy documents including the National Security Strategy and National Defense Strategy invoke "technological advantage" as both an objective or end, and a means to an end.[135] The treatment of technology as a static end is particularly problematic given the rapid pace of change in the commercial and defense sectors. Nevertheless, alternative theories of strategy that are more adaptable to the complexity and interdependence that characterizes technology do exist.

Two strategic theorists, Canadian businessman Henry Mintzberg and professor at the US Air Force's elite School of Advanced Air and Space Studies, Everett Dolman have developed broader, more flexible and more comprehensive conceptions of strategy, which might prove useful in directing or informing the military's approach to technology. In his work *Pure Strategy*, Dolman argues that strategy is an unending process with the goal of gaining and maintaining a continuous advantage.[136] Dolman's thesis, unlike Lykke's model, accounts for strategy's interaction with an adversary. From a technological standpoint, MacGregor Knox and Williamson Murray in their work *The Dynamics of Military Revolution* concluded that successful technological innovations emerged not in response to some notional adversary or hypothetical scenario, but to address concrete military threats or challenges.[137] Dolman's model encourages thinking about technology in terms of its comparative advantage, shifting focus from broad conjecture regarding technology's impact to, in much the same way that Secretary Perry viewed

[135] US President, *National Security Strategy*, 20; US Department of Defense, *Summary of the 2018 National Defense Strategy*, 3.

[136] Everett Dolman, *Pure Strategy: Power and Principle in the Space and Information Age* (New York: Frank Cass, 2005), 4.

[137] MacGregor Knox and Williamson Murray, *The Dynamics of Military Revolution, 1300-2050* (New York: Cambridge University Press, 2001), 172.

stealth systems as a hedge against Soviet hordes, concretely identifying and exploiting the opportunities that a technology presents.

Henry Mintzberg also adopted the notions of strategy as relative and unending. However, Mintzberg believed that because the world is volatile and unpredictable that deliberate efforts to accommodate all the actors or variables in a strategy is both unproductive and impossible.[138] According to Mintzberg, a true strategy emerges over time as a pattern of consistent, albeit unintended actions and behaviors designed to realize some desired future state or condition.[139] His concept of emergent strategy dovetails with the US military's vision of a disordered, dynamic, and unpredictable future as outlined in a panoply of doctrine publications, including most notably in the US Army's Operating Concept.[140] Given such conditions, Mintzberg suggests that effective organizations are both comfortable with biding their time, and capable of developing just-in-time solutions to unexpected challenges or opportunities.[141] The strategic theories of Dolman and Mintzberg, by incorporating concepts of systems thinking such as emergence and interdependence, can help strategists cope with and confront the complex realties of the contemporary operating environment.

In addition to confronting the panoply of challenges posed by today's dynamic and disordered world, a technology strategy that effectively guides the military's acquisition, development, and application of technology for competitive advantage, must address the process of innovation, or the translation of an abstract concept into a practical application.[142] Innovation is the force behind technological change and is replete with its own complexity and uncertainty,

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[138] Henry Mintzberg, *The Rise and Fall of Strategic Planning* (New York: The Free Press, 1994), 25.

[139] Ibid., 23-24.

[140] US Army, TRADOC Pamphlet 525-3-1 (2014), 10-11.

[141] Mintzberg, *The Rise and Fall of Strategic Planning*, 229-231.

[142] N. Bruce Hannay, "Technological Innovation: Its Nature and Significance," *Bulletin of the American Academy of Arts and Sciences* 33, no. 6 (March 1980): 35, accessed January 24, 2018, http://www.jstor.org/stable/3822859.

further challenging the efficacy of applying Lykke's model to technology. From the physicists of the Manhattan Project to the engineers at Texas Instruments and Lockheed's Skunkworks, Chapters 3, 4 and 5 demonstrate that significant technological breakthroughs tend to come from outside the military. Today, the US military relies almost exclusively on a complex network of multinational corporations, some whose sole existence derives from the defense industry, to generate and cultivate innovation. This reflects a broader governmental and societal shift from a hands-off attitude toward innovation, to an approach predicated on the supposition that an organization can control innovation or technological change to maximize opportunities and mitigate penalties.[143]

Although the wisdom, much less the feasibility, of attempting to harness technological innovation as a resource remains a point of contention, this paper has exposed several significant shortcomings of viewing complex variables through an ends-ways-means lens. Attempting to replicate the enormous benefits derived from the Manhattan Project and Skunkworks by drawing defense contractors into closer orbit around the military might seem an appropriate strategy. Still, some senior leaders including, Army Chief of Staff General Mark Milley, who in the fall of 2017, announced a sweeping review of the Army's acquisition process, believe that the relational proximity of defense contractors to the military has paralyzed, rather than promoted innovation.[144] If, as Mintzberg would likely contend, the military is incapable of predicting the source of the next breakthrough, then a closing of ties between the military and defense industry might in fact jeopardize innovation. Perhaps then, the military should focus less on trying to predict the next breakthrough, and instead concentrate its efforts on eliminating the byzantine processes and economic incentives that underpin the current acquisition system. Creating an open

[143] Hannay, "Technological Innovation," 40.

[144] Sydney J. Freedberg Jr., "Milley Announces Biggest Buying Shift in 40 Years: Army Will Get Weapons the SOCOM Way," Breaking Defense, October 9, 2017, accessed December 1, 2017, https://breakingdefense.com/2017/10/milley-announces-biggest-buying-shift-in-40-years-army-will-get-weapons-the-socom-way/.

and flexible system that is conducive to radical innovation and thus, responsive to the complexity and uncertainty of today's global operating environment, might even require dispensing with simple frameworks such as Art Lykke's, which may unintentionally constrain innovation, in favor of broader, more comprehensive or forward-thinking strategic theories, such as those proffered by Dolman and Mintzberg.

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