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THESIS

WHAT IS TECHNOLOGY STRATEGY?

by

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June 2022

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WHAT IS TECHNOLOGY STRATEGY?

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The purpose of this thesis is to explore and define the framework for a type of military development strategy that links technological decisions to strategic effects—technology strategy. This study is novel, as most approaches to technology strategy focus on producing technology as an end in itself instead of focusing on technology development and acquisition as the principal means for achieving strategic effects. By placing technology as the means and strategic effects as the ends, this study deduces an original, perhaps seminal, description of technology strategy and a framework for its formulation. Arms-racing case studies and an exploration of offense-defense theory structure this exploration and enable the observation of technology strategy's core characteristics, which are its relationships to doctrinal innovation and organizational design, forms or templates, approaches to acquisition, and potential pitfalls. The structural components of the technology strategy concept illuminated are then arranged in a proposed taxonomy that fits within the U.S. military's joint concept development process. Beyond the descriptive and structural components, this study also identifies notable best practices in the application of technology strategy, particularly those that an effective technology strategy should encompass—both the decisions surrounding which weapons, transportation, and information systems to invest in, and their implications, in practice, for organization and doctrine.

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EXECUTIVE SUMMARY

Maintaining a technological edge is a key component of the U.S. military's approach to warfare. The shift to Great Power Competition (GPC) places a renewed emphasis on maintaining the technological lead. However, the overwhelming majority of the so-called technology strategies to help the U.S. maintain its lead treat the concept as a document that simply answers the question, "what technologies should the military develop or adopt?" This narrow view of technology strategy does little to tie the means (technology acquisition decisions) to strategic ends and often treats the development of the technology as an end in itself—a misguided concept that can lead to maladaptive or stagnant strategies and wasted resources.

This thesis seeks to aid in bringing efficiency and focus to technological decision-making by defining a concept and framework of technology strategy that sets technology emphasis and acquisition as the means and strategic effects as the ends. This approach is descriptive of technology strategy instead of prescriptive. The output serves as a foundation for recognizing, analyzing, and structuring a technology strategy.

The first key finding is that military technological decisions are strategic when they result in a deliberate flow from a way-of-war paradigm to a warfighting concept, then to a portfolio of required capabilities, and finally to choices about **technology** acquisition (technology strategy), **organizational** structures, and **doctrinal** innovation (the "*DOT triad*"). At a minimum, the contents of the technology strategy guide the decisions about the acquisition, development, and/or refinement of weapons, delivery, and information technologies by identifying the technological capabilities required in the warfighting concept, acquisition approaches, and the primary technological emphasis.

The second key finding is a taxonomy to organize force development strategies. Understanding each level is key to technology strategy formulation and analysis. The taxonomy is displayed in Figure 1 and further explained thereafter.

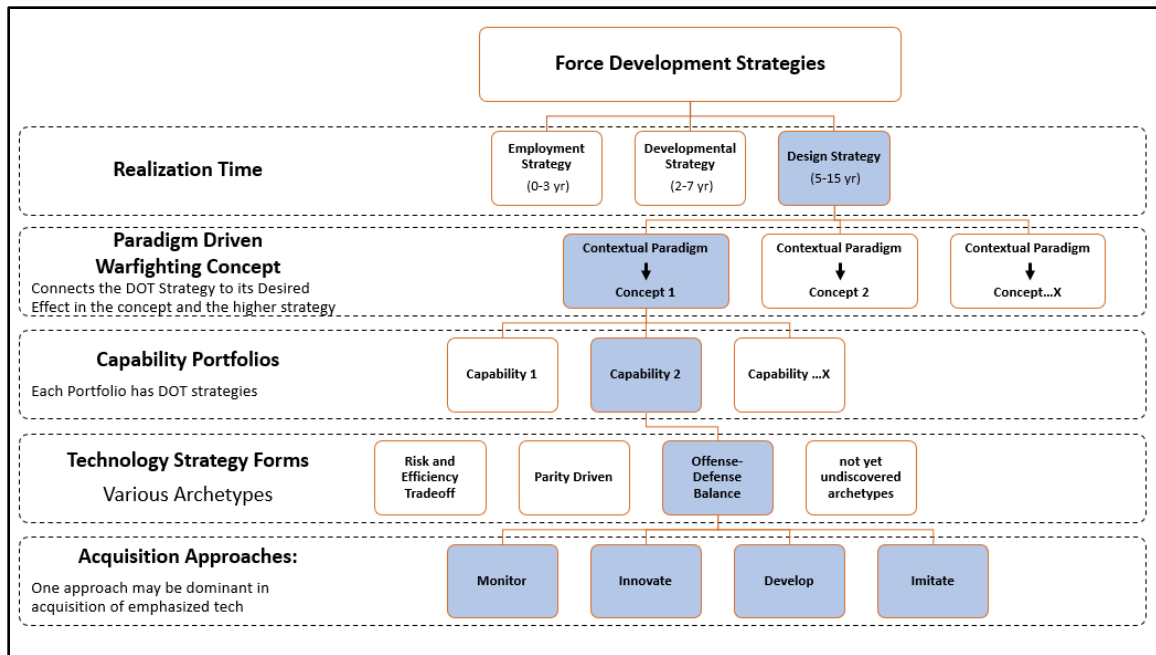


Figure 1. Proposed Technology Strategy Taxonomy

The *realization level* categorizes technological and accompanying DOT triad pursuits by the time horizon in which they are designed to meet their strategic end state. Synchronizing the realization time of the technology strategy (and other DOT components) with the desired realization time of the warfighting concept is the primary purpose of this level.

The *warfighting concept level* shows the connection between the paradigm and concept and organizes technological pursuits by their strategic end in the grand strategy (i.e., how the technology will create effects in the strategic environment). The warfighting concept is how the military envisions war being fought in a particular context and how that military will fight it (i.e., Mosaic Warfare or AirLand Battle).

A *capability portfolio* is a grouping of all DOT triad components and their DOTMLPF-P counterparts needed to achieve a capability in the warfighting concept (i.e., autonomous aircraft or swarm drones to support the JADC2 capability in the Mosaic Warfare concept). The principal benefit of viewing technology and its accompanying DOT strategies in this manner is that it keeps the DOT decisions linked to a specific concept, and thus to its desired strategic effects.

The *strategic form level* (Figure 2) describes the way in which the strategist meets the technological requirements of the capability. Technology strategy forms serve as patterns or templates and describe the methodology the strategist uses to achieve the desired capability. These are the templates of technology strategy and bear a similarity to the way one might think of types of strategies such as a Fabian delaying strategy. Three archetypes, displayed below, categorize the forms of technology strategy: *Risk vs Efficiency*, *Parity-Driven*, and *Offense-Defense Based* forms.

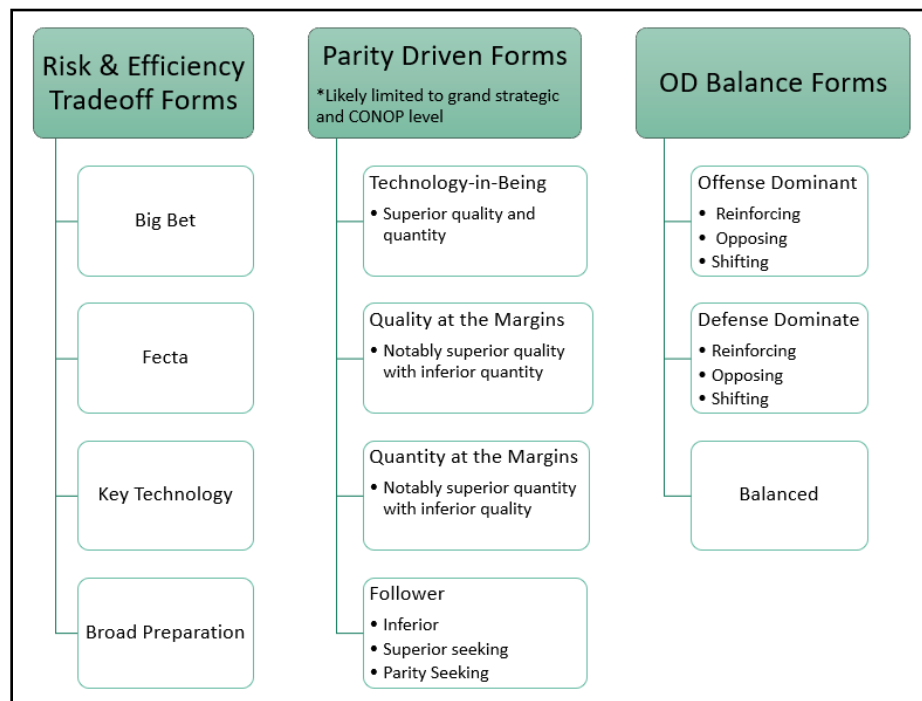


Figure 2. Observed and Derived Technology Strategy Forms

The *acquisition approach level* identifies the way the strategy will direct the acquisition of the technology used to meet the capability portfolio requirements. These choices have a strong effect on the form of the strategy. Four types of approaches are identified. *Imitative* acquisition approaches focus on copying technology already in use by another nation. *Developmental* acquisition approaches focus on the invention of new technologies, exploitation of emerging technologies, and/or the reimagining of established (but not emphasized) technologies. The *innovative approach* relates to purchasing

technologies and combining them with the military's own or other purchased technologies to create something new. The *monitoring approach* assumes that the military has at least some means and reason to pursue technological change, but has chosen to continue typical upgrading along present lines. The strategic form and approach levels are the primary areas of focus of the technology strategist.

The final key finding is that a clearly articulated description and structure of technology strategy highlights a set of pitfalls: the *Comparison Trap* (mirror-imaging); *Iceberg* (suggesting highly capable covert capabilities); *Crossover Point* (misappropriated technological development); *Opportunity Cost* (each yes is also a no to something else); *War and Technology Relationship* (technology development can change the character of war and conflict); *Focused Development* (trying to build one technology for all missions), and *Ruthless Investor* behavior (strategically misaligned technological pursuits). This small sample of lessons learned may prove just the beginning of a wealth of knowledge to be gained from the continual study and refinement of the concept of technology strategy. In a time of fierce competition among closely matched rivals, we must be focused, deliberate, and strategic in our technological pursuits. The observations and suggestions that this study provides may aid in such an endeavor.

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I. INTRODUCTION, PROBLEM, AND METHODOLOGY

A. INTRODUCTION

When Charles Dickens sat down to write *A Tale of Two Cities*, he had a most perplexing problem: how to describe his view of late-18th century France and Britain. During this time, the extremes of men and their environments were on visual display. The good that men can do and the evil they can wreak painted an exciting, yet somber picture of modernizing societies. This duality led Dickens to his shining example of poetic parallelism: “It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness.”¹ It is perhaps the same duality that describes technology’s role in war. Indeed, a brief sample of many historians’ and analysts’ views about technology over the last century gives a Dickens-like sense of the role of technology in war:

Tools or weapons, if only the right ones can be discovered, form 99 percent of victory.²

Most of the really important variance in combat outcomes has stemmed not from technological change but from the failure of particular states to implement the ... methods called for by the modern system.³

The Nazis failed because they tried to win a war of the 1940s “with the weapons of the 1950s ... a technical disaster.”⁴

¹ Charles Dickens, *A Tale of Two Cities*, Everyman’s Library ; No. 102 (London: Dent, 1906), 1.

² John Frederick Charles Fuller, *Armament and History: The Influence of Armament on History from the Dawn of Classical Warfare to the End of the Second World War*, 1st ed. (New York: Da Capo Press, 1998), 31.

³ Stephen D. Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, N.J: Princeton University Press, 2004), 196.

⁴ John Arquilla, “A Study in Technology Strategy: The Curious Case of Alfred von Tirpitz,” *Comparative Strategy* 36, no. 2 (March 15, 2017): 143–52, <https://doi.org/10.1080/01495933.2017.1317540> Here Arquilla is quoting Richard Overly, *Why the Allies Won* (New York: W.W. Norton., 1996), 243.

Technology has long been a deciding factor on the battlefield.⁵

[other than the atom bomb] ... no weapon in the history of mankind ... has been as important to the winning of battles or wars as the men who controlled them.⁶

Technology is now in complete command.⁷

The high-tech, high-precision, high-cost suite of networked systems that won the Gulf War ... is no longer working ... our enemies have render [ed] it irrelevant.⁸

Our mechanical triumph may have produced a mechanical atmosphere we can't stand. So, we may have reached a point where the design of our technology must take into greater account our interior needs.⁹

Given the duality depicted by the above analysts, Dickens might say, "Technology can win a war; it can lose a war; it can have the greatest effect, it can have no effect; it is of the utmost importance, it is meaningless." Such is the complex and confusing guidance provided to those who attempt to incorporate technologies and practices in the hopes of achieving strategic outcomes. These *technology strategists* have reference literature studying war and technology, war and strategy, and even strategy and technology, but little literature exists that studies the art of connecting technological choices to strategic ends—the appropriate meaning of *technology strategy*. This work is among the first to seek a conceptual description of the military art of technology strategy and offer a framework for its application, categorization, and inclusion into military doctrine.

⁵ Jackie Mansky, "Operation Desert Storm Was Not Won by Smart Weaponry Alone," *Smithsonian Magazine*, 2016, <https://www.smithsonianmag.com/history/operation-desert-storm-was-not-won-smart-weaponry-alone-180957879/>.

⁶ Trevor Nevitt Dupuy, *The Evolution of Weapons and Warfare*, 2nd ed. (Indianapolis: Bobbs-Merrill, 1980), 315–16.

⁷ Fuller, *Armament and History*, 157.

⁸ David Kilcullen, *The Dragons and the Snakes: How the Rest Learned to Fight the West*, Illustrated (Oxford: Oxford University Press, 2020), 5.

⁹ Elting E. Morison, Rosalind Williams, and Leo Marx, *Men, Machines, and Modern Times* (Cambridge, MA: The MIT Press, 2016), 161.

B. THE PROBLEM

With the United States' shift to Great Power Competition, there is a growing discourse calling for the creation of technology strategies to maintain the West's technological edge in warfare. While a technological focus is characteristic of the U.S.' approach to warfare, as a concept, "technology strategy" is undefined in doctrine and often misused. As a result, discourse and often strategic analysis, treats the concept as a document that simply answers the question, "what technology should the military develop adopt?" This simplistic view of technology strategy does little to answer the traditional ends, ways, and means architecture for strategy formulation and ignores the accompanying organizational and doctrinal implications that are frequently highlighted in military innovation studies. While the U.S. military has certainly evolved technologically, organizationally, and doctrinally, this thesis claim that this process can be increased in efficiency and focus with a better understanding of the framework that connects technological decision making to strategic effects—the framework of *technology strategy*.

C. RESEARCH QUESTION AND METHODOLOGY

The expanded concept of technology strategy put forth requires a clear definition, structure, and description. Because the subject lacks these basic descriptive components, the overarching question of this work is: "What is technology strategy?" The following chapters answer the research question with a description based on expert literature, a suggested location of it in the military system, its structural characteristics, strategic forms (templates), observed pitfalls and corresponding stratagems, and a suggested taxonomy. A heuristic case study approach is the chosen methodology to guide the exploration.¹⁰

Chapter II reviews existing literature and provides definitions for key terms, a derived working description of technology strategy, and deduces what it means to choose a technology strategically. The chapter serves primarily as a literature review and as a way to frame the following exploration. Key elements are the identification of three categories

¹⁰ The heuristic case study approach is ideally suited for the broad nature of this exploration. See Harry Eckstein, *Regarding Politics: Essays on Political Theory, Stability, and Change* (Berkeley: University of California Press, 1992), 143–47.

of military technology; a technology strategy description that enables the following chapters to identify it in practice; the proposal of three basic approaches to acquiring technology; and the identification of a continuing close association between technology, doctrine, and military organization.

Chapter III explores technological adoption decisions as the independent variable in two historic arms-race case studies. The arms-race phenomenon and case studies examine how strategists may choose to modify their strategic environment through their technological choices. It is natural to assume that for any type of strategy to be valid, it must enable the strategist to create external effects. Observing technological decisions through the lens of arms-racing places technology strategy as the independent variable and allows observation of changes in the environment—giving an inside-to-out viewpoint.

Chapter IV explores technological decision making as the dependent variable in an exploration of offense-defense theory and a case study of the 1919–1940 French military. Offense-defense theory argues, generally, that there is a state of balance between offensive or defensive-leaning technologies which can increase or reduce the efficiency of one's technologies. Thus, observing technological decision making through an offense-defense theory lens, observes how the technological environment affects internal decision making—giving an outside-to-in viewpoint. While the offense-defense theory and arms races are often examined as casually related, this thesis observes the two separately in order to focus on the effect of technological decision-making on the environment.

Chapter V merges the observed characteristics from the preceding chapters with U.S. developmental doctrine to provide the final piece—allowing for a concluding definition and structural description of technology strategy. In overlaying doctrine and observation, the chapter suggests where the concept of technology strategy belongs in Western military systems, identifies a starting point for its construction, and proposes a taxonomy for application and future study.

II. DEFINITIONS AND STRUCTURE

Enjoyment lies in the search for truth...

—Leo Tolstoy¹¹

Any inquiry should begin by defining what the investigation seeks to find. As such, this chapter surveys the literature on military technology and warfare to find preliminary descriptors for technology, strategy, types of military technology, and what it means to choose technology strategically. The descriptions enable the construction of a working description of technology strategy to guide the forgoing exploration in Chapters III and IV. As an additional aid to identifying technology strategy in historical case studies, the second section of this chapter begins to deconstruct the technology decision by suggesting three ways a strategist may choose to acquire technology, identifying an observation methodology, and outlining the characteristics of technology strategy.

A. TECHNOLOGY STRATEGY KEY DESCRIPTORS

A working description of military technology strategy is necessary to enable recognition of it in the forthcoming analysis. This section begins by listing several partial definitions in the military literature. Building on these observations, the literature turns to a deconstructivist approach to understand the underdefined concept. Strategies with an accompanying adjective, such as naval strategy, or armor strategy, denote the means used. Following this standard convention, in technology strategy the adjective must also describe the tools or means used. Therefore, the first task is to understand what the military regards as technology and, given the likely broad nature of the definition, what are the main categories of technology that concern this exploration. The second task is to define what a strategic act looks like in observation. Combining these definitions, creates a working description of technology strategy that enables identification in the case studies in the following chapters.

¹¹ Leo Tolstoy, *Anna Karenina* (Modern Library, 1949).192

1. How Has Military Technology Strategy Been Described?

Descriptions of technology strategy are variable and incomplete but have evolved to recognize the importance of approaching technological acquisition with purposeful intent. One of the earliest descriptions, held a deterministic view of technology. In their 1970 book, *The Strategy of Technology*, Stefan Possony and J.E. Pournelle examine the technological pursuits of the U.S. military at the beginning of the Cold War. Their definition of technology strategy is the strategy that is used to win the technological war. A war caused by “technology [that] flows on without regard for human intentions, and each technological breakthrough offers the possibility for decisive advantages to the side that first exploits it.”¹² Possony and Pournelle’s view aligns with technological determinism theory—the “belief that changes in technology exert a greater influence on societies and the processes than any other factor.”¹³ The deterministic view of technology strategy is problematic in military history, as it assumes clear primacy of the role of technology in the outcomes of military strategy. Recalling the cited authors in the introduction of this work, such a narrow view is out of line with significant portions of the literature concerning the role of technology and war. However, their works’ views on technology strategy as a race, highlights the close relationship of technology with the arms-race phenomena. A phenomenon that is introduced in this chapter and serves as the central topic of Chapter III.

More recent authors such as John Arquilla and Keith Carter, describe technology strategy as a process of decision making. Keith Carter states that techno-strategic integration is a “process through which militaries integrate technological advances into a strategy that maximizes their advantages.”¹⁴ Carter’s viewpoint highlights the importance of the strategic utilization of technology but does little to help the reader understand the structure of the process itself.

¹² Stefan T. Possony and J.E. Pournelle, *The Strategy of Technology* (Cambridge, Mass.: University Press of Cambridge, 1970), 2.

¹³ Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, Mass: MIT Press, 1994), 2.

¹⁴ Keith L Carter, “Technology Strategy Integration” (Master’s thesis, Naval Postgraduate School, 2012), v, https://calhoun.nps.edu/bitstream/handle/10945/7317/12Jun_Carter.pdf?sequence=1&isAllowed=y.

John Arquilla's examination of German Admiral Alfred von Tirpitz's technological decisions leading up to WWI, suggests more nuance inside technology strategy. In his study, Arquilla identified the principal question in technology strategy as "Which technologies to emphasize [and] which to relegate to realms of lesser importance."¹⁵ Arquilla hints at a prioritization process far evolved from the binary process described in other works. One of the more unique aspects of Arquilla's work is the identification of the doctrinal and organizational design implications of chosen technological pursuits.¹⁶ His observation supports this chapter's later decision to observe doctrine and organizational connections to technological decision-making in the following case studies. However, while Arquilla's observation brings more details to the puzzle, the expert literature still lacks a study compiling all the pieces—leaving this concept in need of further exploration.

The most recent explanations of military technology strategy continue to carry forward the process approach but are limited in their explanation of the process and purpose. The Center for a New American Security (CNAS) defines technology strategy very simply as a "systematic approach for how to prioritize [military] technology investments."¹⁷ The authors argue technology strategy is necessary because, "technology has always been an integral part of achieving military superiority ... nor [sic] does the U.S. military have sufficient resources to invest in every conceivable technology, even with a \$700 billion-plus defense budget."¹⁸ CNAS's explanation shows a more robust appreciation of technology strategy identifying it as a process that sets priorities and recognizes limitations. But their research, while useful, remains too broad, suggesting a top-level approach to choosing technology that they call "prioritize, invest, and hedge." Their work is very much grounded in the same approach to technology strategy as this study; however, its lack of a functional framework leaves their approach difficult to apply

¹⁵ Arquilla, "A Study in Technology Strategy," 143.

¹⁶ Arquilla, 149.

¹⁷ Paul Scharre and Ainikki Riikonen, *Defense Technology Strategy* (Washington, D.C.: Center for a New American Security, 2020), 9, <https://www.cnas.org/publications/reports/defense-technology-strategy>.

¹⁸ Scharre and Riikonen, 4.

in a typical ends, ways, means format—leaving the framework for technology strategy needing further exploration.¹⁹

2. Technology Development Strategy vs. Technology Strategy

In the U.S. Department of Defense (DOD) acquisition system, or more specifically DOD Instruction 5000.02, there is a term and process referred to as Technology Development Strategy (TDS). The DOD use of the TDS terminology is significantly different than the concept referred to in this study.

Unlike technology strategy, TDS is well defined and meant to govern and regulate the on-time delivery of a chosen technology. Specifically, the TDS inside the DOD acquisition system refers to

an overall program technology strategy to address technology maturation in terms of cost, schedule, and performance. The TDS should contain a preliminary description of how the potential acquisition program will be divided into increments based on mature technologies.²⁰

The critical difference between this work and the TDS in the DOD acquisition system is that this work explores the concept behind the *art of selecting technologies based on their contribution to the desired strategic effect*. Which is quite different from a TDS which focuses on the *production of a chosen technology*. In a TDS, the development of the technology becomes the strategic ends. In technology strategy the strategic ends are the achievement of a military ends state, not the production of the technology. In other words, technology is the means in technology strategy and the ends in a TDS.

Therefore, the use of the term TDS (sometimes shortened to technology strategy) in the DOD acquisition system is separate from the concept in this study. Although there is certainly overlap and coordination between the two functions—selection and emphasis of a technology versus the on-time production of a chosen technology—a technology strategy is the work of a technology-minded military strategist whereas the construction of

¹⁹ Scharre and Riikonen, 4.

²⁰ “Technology Development Strategy (TDS),” AcqNotes, accessed April 18, 2022, <https://acqnotes.com/acqnote/tasks/technology-development-strategytech-dev>.

a TDS is the work of a military-minded technologist. With this delineation set, this review turns deducing a working description of technology strategy by first understanding its components.

3. What Is Technology?

There are multiple definitions of technology with some disagreement. To aid in further exploration, this section derives a working definition from expert literature—ultimately defining technology as *applied human knowledge*.

The common definition of technology is “the practical application of knowledge [or] a capability given by the practical application of knowledge.”²¹ Stefan Possony and J.E. Pournelle defined technology more simply, referring to it as a way of increasing capability and military power.²² Similarly, military historian Martin van Creveld wrote in his book *Technology and War* that “behind military hardware there is hardware in general, and behind that again there is technology as a certain kind of know-how, as a way of looking at the world coping and with its problems.”²³ Whether using Possony and Pournelle’s definition of capability or van Creveld’s “kind of know-how” there is agreement on technology, as an application of human knowledge to solve problems.

The *application of human knowledge* theme is echoed outside of military literature by several authors, including Herbert Simon, who concluded that “science and technology are not things, like automobiles and powerplants, but are the knowledge and computation power that allow us to create such things.”²⁴ Combining these observations brings two conclusions: technology is an applied representation of knowledge; and technology is human-centered and designed to accomplish specific tasks.

²¹ “Definition of Technology,” Merriam-Webster, accessed August 15, 2021, <https://www.merriam-webster.com/dictionary/technology>.

²² Possony and Pournelle, *The Strategy of Technology*, 5.

²³ Martin van Creveld, *Technology and War: From 2000 B.C. to the Present*, 1st ed. (New York, NY: Free Press, 1991), 1.

²⁴ Herbert A. Simon, *Reason in Human Affairs*, 1st edition (Stanford, Calif: Stanford University Press, 1990), 70. Lewis Mumford’s work on technics makes similar points. See; Lewis Mumford, *The Myth of the Machine* (San Diego, CA: Harcourt Brace Jovanovich, 1967).

However, there is disagreement among the definitions and a decision must be made. While van Creveld and Simon seem to define technology as the know-how behind the physical representation, many authors suggest a physical representation for technology. In their study on the effects of military technology on the arms-race, B.T. Feld et al. defined technology stating, “military technology is concerned ... with trucks, tanks, and ships, with guns, bombs, and explosives, with rockets, and airplanes, with surveillance and communication.”²⁵ Similarly, J.F.C. Fuller referred to military technology quite simply as “weapons or tools.”²⁶ While the physical representation of technology certainly cannot exist without the underlying know-how, the know-how is difficult to observe and must be proven through application. Therefore, this study, refers to technology or the pursuit of technology in an applied sense (i.e., trucks, bombs, bullets, computers, ships).

4. What Does It Mean to Act Strategically?

The logical starting place for defining a strategic act is by analyzing the standing definitions of strategy. Analyzation of various expert military authors allows a derivation of common themes. The common themes of a desired end-state, deliberate effort, and continuing intervention lead to the conclusion that acting strategically means participating in a continual decision-making process designed to achieve a premeditated goal that would not otherwise be reached without intervention. Leading to the intuitive, but meaningful, conclusion that technology strategy’s strategic goal is to utilize technology to aid in solving a defined problem.

In military literature, definitions of strategy are numerous. Clausewitz defined strategy as “the use of engagements to attain the object of war.”²⁷ Colin Gray defined strategy as “the direction and use made of force and the threat of force for the purposes of

²⁵ Bernard Taub Feld and American Academy of Arts and Sciences, eds., *Impact of New Technologies on the Arms Race*, A Pugwash Monograph (Pugwash Symposium, Cambridge, Mass: MIT Press, 1971), 278.

²⁶ Fuller, *Armament and History*, 37.

²⁷ Carl von Clausewitz, Michael Howard, and Peter Paret, *On War* (Princeton, N.J: Princeton University Press, 1976).177

policy as decided by politics.”²⁸ Differing slightly, B.H. Liddell Hart defined strategy as “the art of distributing and applying military means to fulfill the ends of policy.”²⁹ Liddell Hart’s version appears to have greatly influenced the modern U.S. military, which currently defines strategy as “the creation, employment, and articulation of the military instrument of national power to achieve policy objectives.”³⁰ The U.S. military further identifies that the “ultimate goal of strategy is to achieve policy objectives by maintaining or modifying elements of the strategic environment to serve [national] interests.” The congruity among the definitions identifies what it means to act strategically.

Three congruent elements are present in the definitions. The first is the presence of a desired end-state. Therefore, to act strategically there must be a goal in mind. The second is the use of a tool, instrument, or force to aid in the achievement of the goal. The use of force or tools implies that the goal would not be achieved without a deliberate effort. A strategic act is therefore a deliberate and premeditated decision to act against the natural or default course of events. The third and final congruency is the implication of an ongoing level of involvement toward the established goal. Strategy is more than a single decision or actions, it is a process of achieving a goal.

Summarizing, acting strategically is a continual decision-making process designed to achieve a premeditated goal that would not otherwise be reached without intervention. Considering that technology is for “coping with the world’s problems” and strategy is goal oriented, an intuitive conclusion is that *technology strategy’s strategic goal is to utilize technology to aid in solving a defined problem*.³¹

5. Deconstructing the Technology Decision

The existing literature suggests technology strategy consists minimally of a choice of technological emphasis (or focal point) and an approach to choosing and integrating the

²⁸ Colin S. Gray, *The Strategy Bridge: Theory for Practice*, 1st ed. (New York, NY: Oxford University Press, 2011), 262.

²⁹ B. H. Liddell Hart, *Strategy*, 2nd Revised (New York, N.Y., U.S.A: Plume, 1991), 335.

³⁰ *Joint Doctrine Note 2–19: Strategy* (Washington, D.C.: Joint Chiefs of Staff, 2019), II–1, https://www.jcs.mil/Portals/36/Documents/Doctrine/jdn_jg/jdn2_19.pdf.

³¹ van Creveld, *Technology and War*, 1.

technology into the military system. While the approach to choosing and the integration method are two separate decisions, they are closely related, and can be categorized utilizing the same terminology. This section discusses why an emphasis must be chosen and clarifies the choosing versus integrating language by providing definitions and examples for the three approaches which are imitative, developmental, and monitoring.

Numerous authors in the standing literature on technology and war highlight the need to choose a technological emphasis. Martin van Creveld's observes that "war is permeated by technology to the point that every single element is either governed by or at least linked to it."³² His observation recognizes that, because there is always a limitation of focus and resources, a strategy for every conceivable piece of technology, even if directly related to war, is unrealistic. Similarly, in a seminal work on how to form a military technology strategy, authors' Possony and Pournelle, express worry about overly broad technology strategies. They state, "a technological 'center of gravity' must be chosen ... research in unrelated fields is good insurance ... but no one spends the major part of his budget on insurance to the detriment of his own plans."³³ In a similar vein, John Arquilla also notes the critical importance of "picking the right tool and linking them to appropriate practices [and organizational design]," going as far as to say "surely the advantage will go to the side that marries good technology strategy with the right doctrine."³⁴

Therefore, an emphasis should be chosen, but the ways in which it is chosen and executed still require identification. In his work, *The Diffusion of Military Power*, Horowitz describes ways militaries often choose to respond to a perceived need to increase force capability. Acknowledging that another military may already have created the new capability, Horowitz states that the military may choose to adopt the other's innovations, develop an entirely new method, or the military may choose to avoid internal changes and respond utilizing other means such as alliances or neutrality.³⁵ While Horowitz's

³² van Creveld, *Technology and War*, 312.

³³ Possony and Pournelle, *The Strategy of Technology*, 66.

³⁴ Arquilla, "A Study in Technology Strategy," 150.

³⁵ Michael Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, N.J: Princeton University Press, 2010), 25–27.

examination is focused on the diffusion of major military innovations, his work suggests militaries have options for achieving their desired capabilities. Directly, the options are: 1) the military can choose to imitate another state's technology and practices through purchase or internally building copies, 2) it can choose to develop novel technologies and accompanying practices, or 3) it can maintain use and improvement of its current technologies and practices.

Therefore, inside technology strategy there are at least three approaches to technological emphasis and technology acquisition: the imitative approach, the developmental approach and the monitoring approach. Notably, most strategies will contain multiple technologies supporting a primary or group of primary technologies. The approaches for the supporting technologies may also be classified as imitative, developmental, or monitoring; however, when classifying the technology strategy, the emphasized technology(s) are the primary concern.³⁶ Notably, these approaches can also apply to labeling organizational design and doctrinal application.

a. The Imitative Approach

The *imitative approach* can be used as a description of an acquisition approach and technological emphasis. In general, imitative acquisition approaches focus on copying technology already in use by another nation. When the copied technology is the primary technology in the technology strategy then imitative also describes the approach to technological emphasis. Although some other approaches may be present for acquiring supporting technologies. In other words, a state is pursuing an imitative technology strategy when its emphasized technology is generally similar to those currently or previously emphasized by another military.

Peter the Great's technology strategy in the naval campaigns of the early 18th century is an example of an imitative approach. Faced with a superior Swedish navy in the Baltics, Peter imitated the Venetian naval technology strategy to achieve a unique advantage against the larger ships-of-the-line employed by the Swedish navy. Because

³⁶ The initial inspiration for these three types of approaches to technology strategy acquisition was provided by Dr. John Arquilla. John Arquilla, Discussion on Acquisition Types, October 19, 2021.

Peter's strategic goal was to conquer Finland—a nation with notoriously rocky coasts—he realized that he could achieve a technological advantage by building ships with a shallower draft. Peter learned how the Venetian navy successfully employed oar-driven shallow-draft galleys to “fight the Turks in the confined waters of the Aegean and Adriatic.” To capture this skill, “Peter sent numerous young Russians [to Venice] to learn the art of galley building.”³⁷ As Robert Massie puts it, Peter's well-chosen technology strategy was able to

neutralize the Swedish fleet simply by conceding to it the open water while his more maneuverable shallow-draft galleys moved in the shallow coastal waters that the larger Swedish ships would not dare enter ... Thus it was the Swedish admiral and captains could only watch helplessly from their larger ships outside as Peter's oar-driven, shallow-draft galley flotillas moved inshore along the coastline, swiftly and efficiently conquering the coast of Finland.³⁸

While Peter's technology strategy was largely imitative of the Venetian Navy, it is notable that utilizing it to bypass a larger navy was a new (developmental) doctrinal form for an old technology. Suggesting that when a technology strategy is imitative it may be partnered with a different approach to doctrine or organizational design, creating a wholly new capability.

b. The Developmental Approach

Similar to the imitative approach, the *developmental approach* can describe the inspiration for the choice of technological emphasis and the acquisition approach. In general, developmental acquisition approaches focus on the invention of new technologies, exploitation of emerging technologies, and/or the reimagining of established technologies. These approaches require creativity to envision and if successful can be game-changing.

The German Blitzkrieg is an example of a developmental approach because the Germans were the first military to emphasize the tank, aircraft, and radio combination as their primary technology. The Germans changed from the WWI emphasis on artillery and riflemen to using existing, but still evolving, technologies in new configurations and with

³⁷ Robert K. Massie, *Peter the Great: His Life and World*, 1st ed (New York, NY: Knopf, 1980), 584–85.

³⁸ Massie, 585.

new methods. In this sense it was a developmental technology strategy, developmental doctrinal approach, and developmental organization design.³⁹ A trifecta of development—providing impressive results. Notably, in this case, the technologies were already existing although they were rapidly evolving.

A developmental acquisition approach can also mean and will frequently involve the new use and/or combination of new and emerging technologies. Examples of the developmental approach and its successes are often associated with paradigm-changing events such as the U.S. development and use of the nuclear weapons in WWII, code named The Manhattan Project. As with all the approaches, when the approach is used for the primary technology, the developmental approach describes the strategies primary inspiration and the strategy itself.

c. The Monitoring Approach

The *monitoring approach* assumes that the military has at least some means and reason to pursue technological change but has chosen to continue typical upgrading along present lines. It is important to note that the monitoring approach is an intentional strategic choice and not a default strategy due to lack of resources, capability, or ignorance of technology availability. Inside the monitoring strategy, there is continuing technological progress along present lines of emphasis (i.e., more tanks are purchased) and some minor incremental change (i.e., software is updated, engines are upgraded). The monitoring label simply states that there is not an intent to create a major change in technological emphasis or practice at the present time.

Defining three approaches to technology acquisition and selection of the technological emphasis provides another indicator of decision making in technological pursuits. While the inspired approach for the emphasized technology is likely to be the greatest interest to this study, it is also logical to assume that any technology strategy will include non-emphasized technologies that employ multiple if not all of the deduced

³⁹ Carter, “Techno-Strategic Integration,” 133–40. Saying a technology is “old” is probably worthy of explanation beyond the scope of this paper. For our purposes, old simply means it had been employed for military purposes prior although in other ways and in other forms.

approaches. Thus, the identification of acquisition approaches also represents the first observed structural element of technology strategy. Where these decisions lie in the architecture of technology strategy is to be discovered in the coming chapters and discussed in the concluding chapter.

6. What Technologies Are Important to This Exploration?

Considering the definitions above, the technologies of concern in a military technology strategy are technologies requiring dedicated intervention to acquire and align them towards a defined strategic goal. In most cases, this definition will likely mean acquiring and adopting technology not currently owned or operated by the military; however, cases exist (such as Blitzkrieg) where the new emphasis on currently owned but non-emphasized technology qualify as technology strategy under this definition. These cases specifically, highlight how previously owned technologies can be grouped and emphasized (along with appropriate doctrinal and organizational adaptation) to create significant technological change. The interplay of technologies suggests that any examination of technological decision making could benefit from a simple categorization of military technology. Since technology shaped to military purpose is the primary concern, the theories on war by authors such as Carl von Clausewitz, Baron Antoine-Henry De Jomini, J.F.C. Fuller, and Trevor Dupuy inspire three basic categories: weapons, transportation/delivery systems, and information systems. These categories can serve to organize the examination of intricate technology strategies where technologies are emphasized as groups such as Blitzkrieg (tanks, aircraft, radios) or in 1950s U.S. Cold War case study in Chapter III.⁴⁰

a. Weapons

Clausewitz defined war as “an act of force [sometimes translated as violence] to compel our enemy to do our will.” Since war is the application of force, many tools in war are agents of violence. Thus, the *first category of technology is weapons*. Weapons are any tools designed with the primary purpose of killing or disabling personnel or destroying

⁴⁰ see Carter, 131.

property.⁴¹ Examples of weapons include the obvious firearms and explosive devices, but in the modern age, cyber weapons, capable of holding property hostage or causing destruction or disruption through electronic means, are weapons in this analysis.

b. Transportation and Delivery Systems

Multiple authors, including Clausewitz, Fuller, Jomini and Dupuy have noted the importance of mobility in war.⁴² Mobility enables militaries to take the offensive, to synchronize effects, and maneuver against an enemy. Technology, from as early as the bridle to today's high-speed aircraft and submarines, enable rapid movement and troop concentration, fast delivery of firepower and supplies, and long-range delivery of military effects. Technologies that enable these capabilities as their primary function are classified as transportation and delivery systems. These systems are often part of a merger of technologies such as tanks and aircraft. Although pure transportation or delivery technologies such as a cargo aircraft and ships are abundant as well.

c. Information Systems

Clausewitz noted that surprise is both the “means to gain superiority” and an “independent element.”⁴³ Similarly, Jomini noted that Security and surprise are “principles of war” or elements that if “violated in the presence of a skillful enemy” may lead to defeat.⁴⁴ These elements are often enabled by information technologies. Military information technologies are technologies that enable military operations through the collection, storage, distribution, or conversion of information. Examples include the obvious sensors and computer systems but can also include technologies more typically associated with communications, such as radios and data link systems. Similar to the

⁴¹ Trevor Dupuy dedicates a significant portion of his study to the identification of the common characteristic of weapons—lethality. See Dupuy, *The Evolution of Weapons and Warfare*, 286.

⁴² Clausewitz, Howard, and Paret, *On War*; Dupuy, *The Evolution of Weapons and Warfare*; Fuller, *Armament and History*; Baron Antoine-Henri De Jomini, *The Art of War: De Jomini, Baron Antoine-Henri* (Saint Paul, MN: Wilder Publications), accessed May 10, 2022, <https://www.amazon.com/Art-War-Baron-Antoine-Henri-Jomini/dp/160459358X>.

⁴³ Clausewitz, Howard, and Paret, *On War*, 198.

⁴⁴ Antoine Henri baron de Jomini and Charles Messenger, *The Art of War* (Greenhill Books, 1996), 17.

merger of weapon and delivery technologies, information technologies are increasingly becoming part of the mosaic of military technologies. While the Cold War case study in Chapter III is able to examine information technologies in a clear, delineated manner, future examinations will find that the information content of weapons and delivery systems may blur the distinction between these categories.

7. Technology Strategy: A Working Description

Compiling the above delineations, in future chapters technology strategy is identified by *the decision-making process surrounding the emphasis and/or acquisition of particular weapons, transportation/delivery, and information systems and their accompanying practices in order to enable the military to meet a desired strategic intent*. The provided description will serve as an indicator and separator of technology strategy from other forms of strategy and decision making in exploration.

B. STRUCTURE OF CASE STUDY EXPLORATION AND ANALYSIS

This final section outlines the structure of the forthcoming exploration and details the technology strategy characteristics of interest. The first part defines how the arms-race phenomenon and offense-defense theory is used as a lens for technology strategy observation. The final sections detail the characteristics of interest which are the relationships of technology strategy to the military system, its common strategic forms, and executional pitfalls.

1. Observational Lenses

Because any strategy's purpose is to create and/or control the cause-and-effect relationship between the decisions in the strategy and the external environment, the relationship between the strategy and environment is the ideal place to stand-and-observe. The next two chapters observe technology strategy through the arms-race phenomenon and the state of the offense-defense balance. In an arms-race, technological decision making is observed as an independent variable by focusing on how the technology strategist's decisions affect the strategic environment. Alternatively, in offense-defense theory the state of technological development worldwide can increase or decrease the technology

strategist's perception of the state's technological capability. By observing technological decisions through the offense-defense theory lens, technology strategy becomes the dependent variable. Observing technology strategy through the two separate lenses provides more objectivity to the analysis and may increase universality to the observed characteristics.

2. Relationships

Of the three principal characteristics pursued in this study, the relationship characteristics most explicitly define technology strategy's connection with the military system. Surveying the current literature shows that military doctrine and organizational design are the most interrelated to technological decision making.

Three authors suggest the importance of observing doctrine and organizational design in conjunction with an exploration of technology strategy. As noted earlier, van Creveld specifically highlights the systematic relationship of technology in the military system, stating technology is so permeated in the military that "every single element is either governed by or at least linked to it."⁴⁵ Likewise, as discussed earlier, Arquilla frequently notes the organizational and doctrinal implications of technological decisions.⁴⁶

Alan Beyerchen's work provides even more granularity to the systematic relationship between technology, doctrine, and organization. Beyerchen defines three hierarchical yet overlapping distinctions of the systematic change caused by technology in the military system. Technical change—which Beyerchen associates mostly with tactics—is the initial introduction of a new device and how the soldier wields or employs it. This step occurs frequently before the device is efficiently employed, such as the early use of tanks at Cambrai.⁴⁷ Operational change is demonstrated when the technology is used in conjunction with other tools to accomplish "new functions" and coupled with new or

⁴⁵ van Creveld, *Technology and War*, 312.

⁴⁶ Arquilla, "A Study in Technology Strategy," 149–50.

⁴⁷ see Fuller, *Armament and History*, 138.

modified “procedures for their collective employment.”⁴⁸ The German incorporation of radios into tanks in the late 1930s to enable communication and coordinate fire (prior to the full development and use of Blitzkrieg) is an example of operational change. Notably at the operational level there is doctrinal change, as the soldier still wields the technology (directly or indirectly) but under different guidance or in a new combination of tactics. Beyerchen’s final level, Technological change—likened to strategy—is resultant of the interplay of operational and technical change and its effect on the “context of combat.”⁴⁹ Blitzkrieg was a technological change created by the interaction of the operational changes of radios and close air support doctrine interplaying with the technical changes in tanks and aircraft technology as well as the organization of panzer and Luftwaffe units. Distinctly at this stage, Beyerchen’s work may imply that organizational, technological, and doctrinal changes are all working in tandem to achieve strategic goals. As the technology strategy concept under observation in this study is based on the technological decisions designed to create strategic effects, the observations of van Creveld, Arquilla, and Beyerchen compel this exploration to note doctrinal and organization design elements in tandem to ensure a more complete understanding of the subject.

3. Forms

While technology strategy, as defined in this exploration, has yet to have dedicated study, nations have been incorporating technology into strategic-decision making for centuries. As such, just as in other strategies, various forms or templates can be deduced through observation. Common examples of these strategic forms in infantry strategies are *shock and awe*, *defeat in detail*, or the *Fabian* strategy. To aid in future study, guide strategists, and provide for added vocabulary in the discipline, this study will attempt to discern and name technology strategy forms through observation.

⁴⁸ Beyerchen, Alan, “From Radio to RADAR,” in *Military Innovation in the Interwar Period*, ed. Williamson Murray and Allan R. Millett (New York, NY: Cambridge University Press, 1996), 266–68. The listed page ranges outlines Beyerchen’s entire description of the levels of technology integration. The exact quote is on page 267.

⁴⁹ Beyerchen, Alan, 267.

4. Pitfalls and Stratagems

Any discipline is wise to capture its mistakes, learn from them, and develop best practices for future operations. Throughout the forthcoming exploration, pitfalls (mistakes) are noted and analyzed to suggest stratagems (best practices or tools-of-the-trade) in the formulation and execution of technology strategy. Identification of pitfalls and stratagems also provides an epistemological component to accompany the largely structural observations and may aid in providing a more complete understanding of the subject. With a working description of technology strategy, a structured approach, and a detailed list of desired characteristics, this work now turns to observing technology strategy through the arms-race phenomenon.

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III. ARMS RACING: TECHNOLOGY STRATEGY AS THE INDEPENDENT VARIABLE

World War I broke out largely because of an arms race, and World War II because of the lack of an arms race.

—Herman Kahn ⁵⁰

The initiation and response dynamics of arms-races provide an observational lens for observing the way technological decisions contribute to changes in the strategic environment. This chapter begins with an explanation of the arms-race phenomenon and its connection to technology strategy decisions. Then, analysis of two case studies explore how the technology strategists' acquisition of particular technologies influenced an arms-race. The case studies are the beginning of the Anglo-German naval arms-race at the turn of the 20th century and the beginning of U.S.–Soviet Nuclear arms-race in the 1940s into 1950s. Both studies suggest that technology strategy decisions can heavily contribute to the dynamics of an arms-race and the overall strategic environment. Connecting the contributions of the technological decisions to their outcomes identifies structural relationships, forms, and pitfalls of technology strategy.

A. THE ARMS RACE PHENOMENON

When choosing what technologies form the basis of a technology strategy, strategists frequently consider how international actors may perceive their acquisition and development of new military technologies and capabilities. Often referred to as the security dilemma, the acquisition of more or newer technologies, although intended to increase one's own security, can also decrease the perceived security of other players in the international community.⁵¹ The security dilemma occurs because of a change in the quantity or quality of a nation's technology—for example, acquiring ten more battleships or more powerful bombs can increase perceived strength. Reciprocally, any neighboring nation that had previously

⁵⁰ Herman Kahn, "Twelve Nonissues and Twelve Almost Nonissues," Hudson Institute, accessed December 10, 2021, <http://www.hudson.org/research/2213-twelve-nonissues-and-twelve-almost-nonissues>.

⁵¹ Robert Jervis, "Cooperation Under the Security Dilemma," *World Politics* 30, no. 2 (1978): 170, <https://doi.org/10.2307/2009958>.

possessed equal or superior strength, as perceived by technological quantity or quality, may perceive a relative diminution of its strength and hence security. If the diminishing power interprets the growing state's actions as hostile, it may respond by increasing or upgrading its own battleships and bombs to maintain the desired level of security. The resultant increase reduces the net gains of the original actor. Seeing their net gain reduced, the originator may respond by adding more battleships and bombs, or developing new weapons, thus restarting the cycle. The action-reaction spiral of competition, commonly called an arms race, can therefore result in the originating state never achieving the desired advantage in military power and security it originally desired.⁵²

Therefore, the spark igniting an arms-race is often a change in the perception of the quantitative and/or qualitative ratio between two or more states that are comparing their capabilities to one another through a measure of some distance from or parity (i.e., equal capability).⁵³ The conditions are set when one party pursues a change in its capability, and the arms-race spiral begins when another party measures the change relative to its own capability and attempts to stop the change. It is ultimately perception of the opponent's increased capability and intentions that causes an arms-race. Therefore, for an arms race to occur, actual military capability (ultimately measured in action) does not need to increase, only the perception of capability. Power perception is often simply one's view of the tangible elements of an opponent's military. These tangible elements are most frequently expressed by the number and quality of technologies—i.e., bombs, tanks, ships, etc. Recall that Chapter II stated that

Technology strategy is identified by searching for the decision-making process surrounding the emphasis and/or acquisition of particular weapons, transportation, and information systems and their accompanying practices in order to enable the military to meet a desired strategic intent.

Based on the derived description of technology strategy, internal decisions of technology strategists have a strong connection to arms-race initiation and dynamics. By

⁵² Jervis, "Cooperation Under the Security Dilemma."

⁵³ Colin S. Gray, "The Arms Race Phenomenon," *World Politics* 24, no. 1 (1971): 41, <https://doi.org/10.2307/2009706>.

observing the decisions and outcomes, one observes technology strategy and can therefore note unique characteristics. The following case studies highlight the connection between technology strategy and arms-race dynamics by analyzing the technological choices of the actors.

B. CASE STUDY ONE: THE ANGLO-GERMAN NAVAL ARMS-RACE

Case Study One observes a strategist whose technological decisions significantly contributed to the initiation of a naval arms-race despite including specific strategy elements to avoid arms-race provocation. Admiral Alfred von Tirpitz hoped that by increasing naval power with a battleship-centric navy, Germany would gain a measure of political and military leverage against Britain.⁵⁴ Despite staying intentionally inferior in battleship numbers to Britain, the Tirpitz Plan resulted in the Anglo-German arms-race. The arms-race failed to meet Tirpitz's strategic objectives, financially draining Germany and contributing to the hostilities precipitating a world war. Analysis following the vignette, examines Tirpitz's technological emphasis options and suggests that a different technology strategy may have still met the strategic intent and avoided the arms-race. Tirpitz's choices suggest 1) a relationship between technology, doctrine, and organization, 2) two possible forms of technology strategy called the Inferior Ratio and Quality-at-the-Margins, and 3) the presence of a unique pitfall and stratagem that this study calls the Comparison Trap.

1. Vignette

In the late 19th century Britain and France possessed vast empires across great oceans and Kaiser Wilhelm II watched with envy. Despite the growing wealth and industrialization of the newly unified Germany, it lacked a world-class navy. Well known for the prestige of its army, the Kaiser felt that building a strong navy was the natural next step to move Germany from a "meager colonial empire [with] a collection of unwanted African real estate and far-flung Pacific islands," to a vast empire and its rightful "place in the sun."⁵⁵ Wilhelm

⁵⁴ Jonathan Steinberg, *Yesterday's Deterrent: Tirpitz and the Birth of the German Battle Fleet*, 1st ed. (New York, NY: The Macmillan Company, 1965), 18.

⁵⁵ Holger H. Herwig, *"Luxury" Fleet: The Imperial German Navy, 1888–1918*, Rev. ed (London ; Atlantic Highlands, NJ: Ashfield Press, 1987), 19, 36.

believed that several other colonial powers, specifically “Spain Portugal, Denmark, and the Netherlands” were in decline and their colonies would soon be ripe for the taking.⁵⁶ As such, Germany should be in a place to take possession of the lost colonies. In an address at the turn of the century, Kaiser made his intentions clear:

as my grandfather [did] for the Army, so I will, for My Navy, carry on unerringly and in similar manner the work of reorganization so that it may also stand on an equal footing with my armed forces on land so that through it the German Empire may also be in a position abroad to attain that place which it has not yet reached.⁵⁷

If Wilhelm was correct and the colonies of Spain, Portugal, Denmark, and The Netherlands were soon to be available, Germany would have competition in acquiring them. Therefore, from the onset Germany’s navy had to consider its capability against the other major naval powers. Most notably France, Russia, and the British Royal Navy. For Germany to expand, it would need to deter the other naval powers from intervening. Early discussions within the German Admiralty focused on the Russian Navy as Germany’s closest rival on the Baltic.⁵⁸ But the British Royal Navy remained the worldwide master of the sea and a navy capable of deterring Russia may still be insufficient in deterring Britain.

To help accomplish his dream, the Kaiser appointed Rear Admiral Alfred von Tirpitz as the German State Secretary of the Naval Office. Soon after his appointment, Tirpitz made it clear that the German Navy would be built as a “a measure of naval power” against Britain.⁵⁹ In June 1897 he wrote:

In the distinctions between one class of ship and another, and in the choice among ship designs within the various classes, the most difficult situation in war into which our fleet can come must be used as a basis. For that constitution of our naval force which meets the most difficult situation will be seen to be sufficient for all other situations. The limits of our resources prevent any attempt to meet every conceivable eventuality on its own in an ideal manner ... For Germany the most dangerous naval enemy at present time is England. It is also the enemy against which we most urgent require a

⁵⁶ Herwig, 19.

⁵⁷ Herwig, 17.

⁵⁸ Steinberg, *Yesterday’s Deterrent*, 121.

⁵⁹ Steinberg, 18.

certain measure of naval force as a political power factor ... A fleet must be so constructed that it can unfold its greatest military potential between Heligoland and the Thames [North Sea] ... A fleet constructed on this basis corresponds so well to our requirements both against France ... and against Russia that for the moment we need to not pay particular attention to those enemies in determination of our ship classes and in the selection of designs.⁶⁰

Detering the Royal Navy was no easy task. Britain had recently displayed its overwhelming naval supremacy to celebrate Queen Victoria's Diamond Jubilee. In the parade, the Royal Navy showcased 165 warships in six columns stretching five miles.⁶¹ An impressive display. But Tirpitz had a plan to challenge Britain without having to match the full strength of the Royal Navy. Germany would construct and sustain a fleet near the British homeland in the North Sea. Due to the vastness of the British empire, the Royal Navy would be unable to concentrate in home waters and the German Navy would have a fleet-in-being effect that would deter Britain from interfering in Germany's continental acquisitions. Such a fleet should also be powerful enough that, if attacked, it could sufficiently damage the Royal fleet. The damaged fleet would then be vulnerable to other naval powers and thereby risk the British empire's continuing naval supremacy. Earning Tirpitz's operating concept the nickname "risk theory" (the fleet itself is also referred to as *Risikoflotte* [Risk Fleet]).⁶² Figure 1 is an image of Europe in the early 1900s; the North Sea, the operating area of Tirpitz Risk Fleet, is depicted in the center-left of the image.

⁶⁰ Steinberg, 209. From Steinberg's translation of Tirpitz Memorandum of June 1897 which was titled General Considerations on the Constitution of our Fleet according to Ship Classes and Designs.

⁶¹ Herwig, "Luxury" Fleet, 1.

⁶² Steinberg, *Yesterday's Deterrent*, 20 and John Arquilla, "A Study in Technology Strategy: The Curious Case of Alfred von Tirpitz," *Comparative Strategy* 36, no. 2 (March 15, 2017): 148, <https://doi.org/10.1080/01495933.2017.1317540>.



Figure 1. Early 1900s Europe Depicting the North Sea⁶³

The Kaiser's unwavering support and a series of naval laws allowed Tirpitz to build the German Navy. The first naval law in 1898 called for the construction of seven battleships, two large cruisers, and 30 light cruisers. Added to the current fleet, the first naval law increased the German fleet to 19 battleships, 8 armored cruisers, 12 large cruisers, and 30 light cruisers over the next six years. In 1900, Tirpitz passed his second law, effectively doubling the German navy to 38 battleships, 20 armored cruiser, and 28 light cruisers. Except for four battleships held in reserve, every battleship and armored cruiser was slated to join the Risk Fleet in the North Sea. A small fleet of three large cruisers and four light cruisers were allocated for overseas use.⁶⁴ Germany's naval capability was growing, but Britain was starting to take notice.

By 1906, Britain was increasingly aware of Germany's naval growth and strategy. Admiral Sir John Fisher, the First Sea Lord of Britain, declared, "our only probable enemy is German. Germany keeps her whole fleet always concentrated within a few hours of Britain.

⁶³ Editors of the Encyclopedia Britannica, "German Empire - Tirpitz and the German Navy," Britannica, accessed May 21, 2022, <https://www.britannica.com/place/German-Empire/Tirpitz-and-the-German-navy>.

⁶⁴ Herwig, "Luxury" Fleet, 42.

We must therefore keep a fleet twice as powerful concentrated within a few hours of Germany.”⁶⁵ Admiral Fisher also instituted sweeping reforms in training, recruiting practices, equipment quality, organization, and leadership.⁶⁶ The most impactful of these, he displayed in 1906 with the unveiling of the *H.M.S Dreadnought*—an all-big-gun battleship that possessed the firing power of two pre-dreadnought ships in broadside and three in firing ahead.⁶⁷ Figure 2 is an early picture of the British *Dreadnought*.



Figure 2. The British Battleship *H.M.S Dreadnought*⁶⁸

By 1908, Britain was upsetting Tirpitz’s entire strategy. Britain’s shipyards continued building dreadnought-class ships, and under even greater secrecy, Britain changed the cruiser paradigm by introducing a heavily armed big-gun class of battlecruisers. The *Invincible* (Figure 3) was the first of this new battlecruiser class and it revolutionized cruisers the way that the *Dreadnought* changed battleships. Although these new battlecruisers would later show questionable capability in actual battle—several were destroyed at the Battle of Jutland

⁶⁵ Herwig, 50.

⁶⁶ Herwig, 48.

⁶⁷ Herwig, 56.

⁶⁸ Editors of Encyclopedia Britannica, “Dreadnought: Description & Facts,” Britannica, accessed May 21, 2022, <https://www.britannica.com/topic/Dreadnought-British-battleship>.

in WWI—they added a considerable increase in perceived capability.⁶⁹ From Tirpitz’s point of view, if Britain continued to build ships of the dreadnought paradigm, his newest ships would be inferior to Britain’s newest. If Germany was to continue its path to achieve a measure of naval leverage against Britain, it would need to respond.

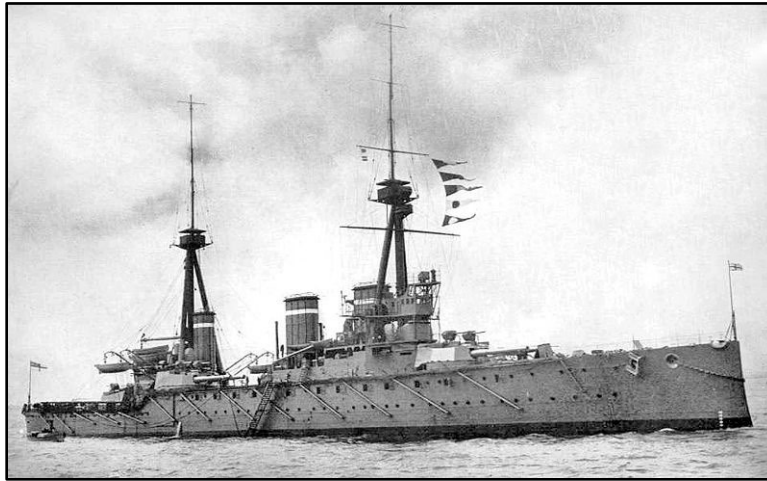


Figure 3. The British Battlecruiser *H.M.S. Invincible*⁷⁰

The Anglo-German Naval Arms-Race and the failure of Tirpitz’s strategic intent soon followed. Tirpitz responded to the new British *Dreadnought* and *Invincible* by unveiling the 1906 and 1908 Naval Law amendments. The amendments changed the plans of the German ships under construction transforming the ships into *Dreadnought*-like battleships and battlecruisers.⁷¹ Britain in turn responded with more ship contracts and the Anglo-German Naval Arms Race became a spectacle of the world—each country responding to the other’s increases in power in a dangerous action-reaction spiral. In the end, considering that neither country had any dreadnought-class battleships in 1905, Britain clearly outpaced Germany. By 1914, Britain managed to build 34 dreadnoughts to Germany’s 22. In addition,

⁶⁹ Arquilla, “A Study in Technology Strategy,” 147.

⁷⁰ David Bocquelet, “Invincible Class Battlecruisers (1907),” Naval Encyclopedia, accessed May 22, 2022, <https://naval-encyclopedia.com>.

⁷¹ All ships imitating the *Dreadnought* style are later simply referred to as the dreadnought-class of battleship and battlecruisers.

Germany's preoccupation with the buildup never allowed it to significantly increase colonial holdings. In all the Tirpitz plan failed to avoid an arms-race, failed to allow an increase in Germany's colonies, and the hostilities it caused may have contributed to the outbreak of a world war.

2. Tirpitz's Technology Strategy

From the beginning Tirpitz wanted to shape the strategic environment with his technology strategy. Although the results did not match his intent, his strategy intended to build a deterrent fleet while avoiding both an arms-race and a preventive attack.⁷² To do so, Tirpitz chose a naval technology strategy based on inferior quantity but superior quality. Tirpitz felt that by building a Risk Fleet of fewer battleships with high quality weapons, armor, and optics, and placing it in the North Sea he would be able to deter Britain; thereby shaping the strategic environment and providing Germany the political leverage and naval deterrent it needed to build its empire.

Tirpitz likely knew Germany would lose a naval arms race if he pursued battleship parity. Besides having a much larger standing fleet, Britain also possessed the majority of the world's shipping building facilities and expertise. In 1896, British shipyards produced an average of 78% of the world's ships.⁷³ A direct attempt to imitate and achieve parity with Britain would certainly spark a naval arms-race with Britain. Given the conditions at the time, Germany would start the race in a severe deficit and most certainly lose. Tirpitz also frequently remarked that he feared an arms-race might convince the Royal Navy to attack the German fleet in port before it reached sufficient strength to defend itself—an action dubbed a “Copenhagen” moment after the 1807 British Naval operation that captured the Danish fleet preventing it from joining France.⁷⁴ Tirpitz thus knew from the beginning that his technology strategy would have effects on the strategic environment and he formed his strategy to minimize and shape these effects.

⁷² Herwig, “*Luxury*” *Fleet*, 37.

⁷³ Sidney Pollard, “British and World Shipbuilding, 1890–1914: A Study in Comparative Costs,” *The Journal of Economic History* 17, no. 3 (1957): 427.

⁷⁴ Herwig, 37.

To avoid provocation, Tirpitz built a numerically inferior fleet but chose the ratio of numerical inferiority carefully to ensure he still possessed a chance of victory. Under the Admiral's direction, the German Naval Office calculated in 1899 that with a ratio of 2:3 battleships (German to British), Germany would be able to meet Tirpitz's Risk Fleet strategy and still stand a chance of victory in battle.⁷⁵ The one third gap, they thought, could be covered, and victory attained due to Germany's "higher quality of ships" as well as "superior tactics, better-trained officers, [and] first rate leadership."⁷⁶

To achieve the quality edge, Tirpitz needed to capitalize on new technologies. Large guns and heavy armor were increasingly necessary as naval battles evolved into long-range shoot-outs on water in the same way land-based artillery was evolving on land in the Russo-Japanese War (1904-1905). Emphasizing battleships allowed Tirpitz a fleet that could take advantage of the latest advances in weaponry, armor, and German optics allowing it an offensive edge against the standing battleships of the British Navy. Tirpitz decided to build a fleet with weapons utilizing the latest plunging artillery and "big-gun" technologies paired with superior German optics.⁷⁷ Battleships under Tirpitz also added increased armor above and below the water, as well as deck plating to protect against plunging fire, underwater torpedo tubes, and rapid firing guns.⁷⁸

The decision to use an acquisition approach that imitated the British's technological emphasis may have significantly contributed to the start of the arms-race. The choice of battleships reduced Germany's plausible deniability. Battleships had difficulty supporting colonial disputes in shallow waters and as such Germany would be unable to hide their actual intent, which increased the likelihood of a Britain taking early notice. In fact, battleships were the Britian's gauge of naval power. The British 1889 Naval Defense Bill officially declared that the Royal Navy would ensure its continued maritime supremacy by sustaining

⁷⁵ Herwig, 36.

⁷⁶ Herwig, 36.

⁷⁷ Arquilla, "A Study in Technology Strategy," 147.

⁷⁸ Herwig, *"Luxury" Fleet*.

as many battleships as any two other naval powers combined.⁷⁹ Therefore, Tirpitz chose to emphasize the exact technology that Britain was using to gauge a country's naval power. So, the increase in German battleships meant that at some point an unacceptable ratio would be reached between German ships and another power, over which Germany had no control, and an arm-race with Britain would ensue. In essence, the battleship made it easy for Britain to gauge parity and left little deniability in Germany's growth in relative capability. Ideal conditions for a security dilemma and an arms-race.

3. Other Technology Strategy Options

To successfully conclude that the technology strategy is indeed strategic and the observations valid, it is necessary to suggest that alternate technological choices may have altered the strategic environment in the desired way. If one accepts the assumption that an arms-race was, at least partially, contributed to by Tirpitz's technological decisions, and that the arms-race was undesirable, then it is applicable to examine the Tirpitz case to see if a different technology strategy could have still met the Kaiser's intent and avoided an arms-race.

Tirpitz had other options for technological emphasis. Considering the Kaiser's desire for Germany to become a major naval power, and Tirpitz's strategy to deter the British Royal Navy, there were three options for technological emphasis: battleships, cruisers, and submarines.⁸⁰ Analysis of one of the choices not taken sheds light on characteristics and the strategic effects of technology strategies.

⁷⁹ "How Serious Was the German Naval Threat to Great Britain before 1914?," Churchill Archives Centre, accessed April 27, 2022, <https://archives.chu.cam.ac.uk/education/churchill-era/exercises/german-naval-threat-pre1947/>.

⁸⁰ Another option would have been to emphasize torpedo and gun boats, which Tirpitz did build in large quantities. The French were experimenting at the time with this style of Navy under the Jeune École doctrine, so it would have represented another imitative route for Tirpitz. However, its ability to meet the Kaiser's intent may have been limited. Building a navy around these smaller boats was more akin to a coast guard style navy with limited expeditionary capability and would have difficulty supporting global colonization.

a. *What if Germany Had Chosen a Submarine-Centric Navy?*

An alternate naval technological emphasis for the Germans was the submarine. Unlike a battleship technology strategy, which was an imitative acquisition approach, a submarine-centric naval technology strategy would have been taking a developmental acquisition approach and would have hidden from Britain's two-power rule. A German navy consisting primarily of submarines with battleships, cruisers, and other smaller ships in a secondary role may have been able to provide Germany a measure of naval power against Britain with less threat of an arms-race or international instability.

In the mid-to-late 19th century, multiple countries were developing operational submarines, but none had chosen to make undersea warfare a technological emphasis. In the U.S. Civil War (1861–1865), the Confederate Navy had developed and employed a human-powered submarine named the *CSS H. L. Hunley*. Due to gross human error and lack of experience, crews were frequently injured or killed (22 in this case). In response the Confederacy established the world's first submarine school just outside of Charleston SC in 1863.⁸¹ Advanced tactics and training were, for the first time, formally developed. Later that year the Hunley became the first submarine to sink an enemy warship. Unfortunately, the Hunley was lost at sea after the attack and the Confederates destroyed much of their naval records at the end of the war.⁸² The concept was proved, although no nation as of 1900 had built a technology strategy emphasizing the acquisition and development of submarines.

The lack of dedicated attention worldwide to submarines may have allowed Germany an edge. Germans were not ignorant in submarine construction. Referred to in German as an *Unterseeboot* [under-sea-boat] and shortened to U-boat, the Germans built an experimental submarine in 1850. The early submarine sank and did not at least initially inspire confidence in the technology. However, it did manage to create interest when it was found and recovered later in 1871.⁸³ The recovery inspired many German private inventors. On average from

⁸¹ Raimondo Luraghi, *A History of the Confederate Navy* (Annapolis, MD: Naval Institute Press, 1996), 256.

⁸² Luraghi, xi.

⁸³ Jak P. Mallmann Showell, *The U-Boat Century: German Submarine Warfare 1906–2006* (London: Chatham, 2006), 201.

1871 until the turn of the century the Naval Office in Berlin was receiving “five serious submarine designs per year.”⁸⁴

Germany was also keenly interested in the submarines primary weapon, torpedoes. Earlier in their development, they purchased several of the first self-guided torpedoes, later either copying or creating their own design.⁸⁵ When Tirpitz was building his technology strategy in the 1890s, torpedoes had yet to be proven, but technology strategy decisions are often about analyzing technological trends and assessing future potential, not present results. The trend was soon highlighted.

The first significant demonstration of torpedo capability happened at Port Arthur in 1904 when a group of small Japanese torpedo boats snuck into the port at night and, using torpedoes, sank or damaged a large portion of the Russian Pacific Fleet.⁸⁶ Greatly depleting Russia’s naval capability in the Russo-Japanese War (1904-1905). Later naval actions in WWI showed torpedoes to be particularly effective. In particular one German Submarine, the U-9, sank three British cruisers in one afternoon in the fall of 1914.⁸⁷ A German technological emphasis early on, or even as late as 1905, may have rapidly developed torpedo technology for submarines and enabled the German Navy to have an offensive edge.

But could a submarine-centric navy still meet Tirpitz’s desire for a political lever? It is certainly possible. The Royal Navy’s largest fear from the German Imperial Fleet was a “bolt from the blue”—a sudden attack on the British fleet using torpedo boats or submarines.⁸⁸ Long after the start of the arms race, British planners began to realize the danger and tried to plan against it. But at the time information technologies lacked the ability to detect underwater craft and the British knew such an attack would have a high probability

⁸⁴ Showell, 23.

⁸⁵ Antony Preston, *The Royal Navy Submarine Service: A Centennial History* (London: Conway Maritime, 2001); This refers to the Schwarzkopf torpedo design. Some sources claim it was a copy of the Whitehead design, other claim it was similar due to typical technological clustering of invention see also Herwig, “*Luxury*” *Fleet*.

⁸⁶ Showell, *The U-Boat Century*, 25.

⁸⁷ Colin Fraser, “The Dawn of the Submarine: U-9 Sank Three British Cruisers in 90 Minutes,” War History Online, October 9, 2017, <https://www.warhistoryonline.com/world-war-i/three-cruisers-livebait-squadron-sunk-german-u-9-m.html>.

⁸⁸ Showell, *The U-Boat Century*, 24.

of success.⁸⁹ With enough U-Boats, Germany could have applied significant leverage. U-boats may also have attracted a lot less British attention than a battleship fleet—possibly avoiding an arms-race and still achieving the Kaiser’s and Tirpitz’s strategic goals.

4. Analysis: What Does the Anglo-German Arms Race Teach about Technology Strategy?

The following analysis deduces characteristics of technology strategy from the observed and suggested alternative strategies in the German case study. The sections below organize the characteristics into relationships, strategic forms, and pitfalls. Key highlights are the tightly coupled doctrinal, organizational, and technological relationships, the presence of a Quality-at-the-Margins strategic form, and the presence of a Comparison Trap pitfall and stratagem—all of which may serve to guide future technology strategists in studying, formulating, and executing technology strategy.

a. Observed Technology Strategy Structural Relationships

The exploration of Tirpitz’s strategy highlighted two system-level relationships. As predicted by the Beyerchen model explained in Chapter II the way the navy chose to wage war and its organizational design were tightly linked. These elements of doctrine and organization both affected, and were affected by, technology decisions.

(1) German Naval Doctrine

Tirpitz’s choice of battleships as a deterrent seemed to be significantly influenced by the recent (1890) publishing of Alfred T. Mahan’s book, *The Influence of Sea Power Upon History*. Mahan’s study of naval history concluded that the growth of the British empire was due to its ability to use battleships in decisive battles to gain “command of the sea.”⁹⁰ In her remarkable study of the conditions leading up to WWI, Barbara W. Tuchman’s remarks that Mahan’s book was a favorite of the Kaiser, who ordered a copy to be placed on every ship

⁸⁹ Showell, 24.

⁹⁰ A. T. Mahan, *The Influence of Sea Power upon History, 1660–1783* (Boston: Little, Brown and Company, 1898), 539, <https://catalog.hathitrust.org/Record/000482399>.

in the German Navy.⁹¹ The Mahanian doctrine likely influenced Tirpitz and many of the naval decision makers at the time.

Mahan's arguments may have very well been the basis of Tirpitz selection of battleships over the alternative cruiser-centric warfare favored by his predecessor. Mahan argued that four points vehemently: "[1] concentration of naval force in battlefleets decided control of vital sea lanes; [2] that large-scale blockades and not cruiser warfare were decisive; [3] that overseas colonies were vital to a nation's prosperity; [and 4] that naval bases were more valuable than control of large land areas."⁹² These four points are clearly seen in the Kaiser's and Tirpitz's aspirations and naval strategy—suggesting a strong influence by the Mahanian doctrine. Indeed, nearly every source reviewed remarks on the devotion of Tirpitz to Mahanian principles. Reaffirming a connection between technology strategy and doctrinal adoption or development in this case.⁹³

(2) German Naval Organization

Similarly to the doctrinal observations, it is notable that Tirpitz Risk Fleet concept also required organizational changes inside the Navy. At the highest level he divided the Navy into two fleets. Each fleet uniquely specified a technological emphasis under which it was organized. The first he designated as the *Home Fleet* intended to be used in the North Sea or in reserve. The Home Fleet emphasized the battleship and was intended to meet Tirpitz's *Risk Fleet* concept. The second fleet he designated as the *Overseas Fleet*. Tirpitz envisioned the cruiser's capabilities as better suiting the needs of colonial defense and thus the Overseas Fleet emphasized the cruiser under an employment concept based on a form of raiding (a concept later referred to as *Kreuzerkrieg* [cruiser war]).⁹⁴ However, Tirpitz felt that the cruiser, and later the battlecruiser, with its big guns, could also supplement the Risk

⁹¹Barbara W. Tuchman, *The Proud Tower: A Portrait of the World before the War, 1890–1914*, Barbara W. Tuchman's Great War Series (New York, NY: Random House Trade Paperbacks, 2014), 147.

⁹² Herwig, "*Luxury*" Fleet, 15.

⁹³ see Arquilla, "A Study in Technology Strategy," 146 and; Bernard Brodie, *Sea Power in the Machine Age*, 1st ed. (Princeton, N.J: Princeton University Press, 1941), 292 and; Steinberg, *Yesterday's Deterrent*, 142–43.

⁹⁴ see Edwin Palmer Hoyt, *Kreuzerkrieg: The Gripping Story of the German East Asia Cruiser Squadron in World War I*, 1st edition (New York, NY: World Publishing Company, 1968).

Fleet and this secondary mission should be the priority in design. He stated that “vessels provided for overseas service must be constructed according to the design specifications of the home fleet.”⁹⁵ Thus the Overseas Fleet and Home Fleet each had separate organizational and technological requirements that were linked and prioritized.

There also appeared to be an evolving organizational growth from Tirpitz’s choice to emphasis battleships. Battleships were expensive, significantly slower, and meant for deep water battles. Their large size and slower speed meant that they also required a fleet of other ships for scouting, supplementing, and providing protection from torpedo boats (a technology that terrified turn of the century sailors). Therefore, a *support fleet* of additional ships were designed and built to protect and aid the primary battleships. Resulting in the organization around the battleship that included not just cruisers, but an additional fleet of scouts, submarines, torpedo boats, naval airships, and the new class of torpedo boat hunters called destroyers. As Tirpitz’s technology strategy was executing, his organizational structure was changing with it.

Thus, the chosen technology influenced the way the German Navy was organized and, reciprocally, the way the fleet was organized influenced the chosen technology. Just as in the German doctrine, there is a tight connection between technology and organizational change. While the technology decisions remain the larger focal point of this analysis, all three of the elements appear to be moving or changing as a result of one another.

b. Observed Technology Strategy Forms

Tirpitz’s technology strategy took on a unique form based on his strategic intent. Because Tirpitz was building an imitative fleet of battleships but wanted to avoid provoking Britain into a preventative attack, he intentionally chose to maintain an inferior number of ships. This *Inferior Ratio* strategic form was an intentional decision meant to create the strategic effect of reducing his posture from an offensive one to a deterrent one. However, Tirpitz also wanted to ensure, if the Navy was engaged, that it stood a significant chance of victory despite its numerical inferiority. To this end, Tirpitz sought to build an imitative navy

⁹⁵ Steinberg, *Yesterday’s Deterrent*, 217.

of inferior quantity but higher quality in weapons, armor, and optics. Thus, Tirpitz merged an Inferior Ratio strategic form with an emphasis on quality to create a *Quality-at-the-Margins* strategic form. Tirpitz's Quality-at-the-Margins strategic form was a direct use of technological decision making to attempt to achieve strategic objectives and as such was an ideal example of this work's ideation of technology strategy. The form's failure to reach its intended end however, suggests that the future use of it may require substantial modification or a different end-state match.

c. Suggested Technology Strategy Pitfalls and Stratagems

Considering why Tirpitz may have chosen an imitative battleship strategy as well as why he may have ignored the alternative developmental submarine strategy, leads to the suggestion of the *Comparison Trap pitfall*. Tirpitz need to ensure that Britain knew (or at least suspected) that Germany possessed a capable navy. Deterrence was Tirpitz's principal goal, but deterrence requires an enemy to have some gauge of your capability and thus an imitative approach seems appropriate. By modeling his navy after Britain, Tirpitz could ensure his enemy knew he was of sufficient power to give him a deterrent capability, but he could also intentionally appear numerically inferior as to not provoke a preventative attack. Unfortunately, Tirpitz miscalculated and when WWI started, Germany was left with a navy of inferior size that it was hesitant to engage directly in a naval war with Britain. As a result, the High Seas fleet contributed little to Germany's war effort in WWI. This may have been due to a poor adherence to the "doctrinal implications" of Tirpitz technological decisions or because Tirpitz never expected to go to war with his deterrent fleet and was therefore unsure of its capability.⁹⁶

However, during WWI, Britain underestimated Germany's small and underdeveloped submarine fleet, who according to some scholars "nearly won the war" for Germany.⁹⁷ Thus, while Tirpitz may have assumed it necessary to imitate the power he

⁹⁶ John Arquilla makes a strong argument that if Tirpitz had sent his fleet against Britain early in the war they would have had a strong chance of strategically decisive naval victory. See Arquilla, "A Study in Technology Strategy."

⁹⁷ Arquilla, 149.

wished to deter, such an action may not have the desired result depending on strategic intent. Resulting in the *Comparison Trap stratagem*:

If you model yourself after your opponent, they are aware of your capability, and your deterrent threats may have more legitimacy. But beware, deterrence can fail, and you will be playing by the rules the opponent knows well. However, if you model yourself in a new or different pattern than your opponent, they may underestimate you.

The Comparison Trap stratagem above, alludes to the natural tendency to mirror another's military when attempting to deter them, especially when that military is the leading power in their domain. However, deterrence has a shaky history in military studies and very often mirror imaging turns to arms-racing.

5. Case Study Conclusion

Analysis of the Tirpitz case suggests that the choice of battleships contributed to the arms-race more greatly than a navy built around another technology such as submarines. Ironically, Tirpitz's technology strategy was specifically designed to avoid an arms-race. Unfortunately, the Inferior Ratio strategic form still provoked the Royal Navy into reacting and failed to deter Britain from joining the war against Germany. Contributing to the strategic failure was that the battleship was the Royal Navy's gauge of power and placing battleships in the North Sea clouded Germany's claim that its navy was simply for colonial aspirations.

Why then choose battleships? It is possible that Tirpitz's belief in the Mahanian doctrine is what caused such a dedication. It is also possible that an arms-race was simply unavoidable, and Britain would have eventually responded to any German increase in naval power. However, it seems much less likely for the Royal Navy to respond if it was permitted to bask in its own magnificent dreadnought-battleships while the German Navy pursued an offsetting advantage that would not be known until it was needed. The continual adherence could also be due to a Comparison Trap—the allure to mimic an opponent to ease comparison—because relative power was the primary concern. Tirpitz could have leaned toward an imitative technology strategy of his opponent because it allowed him to easily keep track of the difference in parity. In a submarine-centric navy, Tirpitz may have had as

much difficulty gauging his naval power as his rival did—a very uncomfortable position in a deterrent-based strategy.

While Tirpitz looks unfavorable throughout most of this study, it is notable that his fleet did perform well at the one and only large-scale sea battle in WWI. Despite being outnumbered in dreadnoughts class battleships at Jutland, the German fleet sunk three battlecruisers, three heavy cruisers, and eight destroyers—while losing significantly less German ships and sailors.⁹⁸ The German Quality-at-the-Margins strategic form, did, at least at Jutland, contribute to closing the parity gap due to the quantity disparity. The Risk Fleet may not have survived a long war with high attrition but its technological advantages in superior deck plating and gunnery may have provided it advantage in the short term. Unfortunately, Jutland did not change the strategic balance or break the blockade. Yet, what if the High Sea Fleet had gone into battle in 1914 and prevented the British Expeditionary Force from getting to and reinforcing France? The Schlieffen Plan may have succeeded. Thus, the true error may have been to fail to use the battle fleet in 1914. By 1916, a tactical victory could not have a true strategic effect.⁹⁹ Since the Risk Fleet was designed to create high attrition in a decisive battle to weaken the British and not to fight a continual sea war, Jutland could be used as proof that it served its purpose, but it was just used too late. Hence the numerically inferior but superior Quality-at-the-Margins strategic form may serve future technology strategists well if the purpose of the strategy is well defined and executed.

While the goal of this case study is simply to observe technology strategy's characteristics, this example does suggest technology strategy formulation should closely consider the implications of an arms-race. The Anglo-German naval arms-race was expensive for Germany and was a major contributor to the outbreak of WWI. While it is dangerous and irresponsible to attribute anything as dynamic or politically involved as an arms-race to a singular cause, this analysis certainly suggests a strong link between technology strategy choices made and either the avoidance or the initiation of an arms-race.

⁹⁸ Geoffrey Bennet, *The Battle of Jutland* (London: Batsford, 1964), 155.

⁹⁹ see Arquilla, "A Study in Technology Strategy."

C. CASE STUDY TWO: U.S. TECHNOLOGY STRATEGY—THE BEGINNING OF THE NUCLEAR ARMS-RACE

Case Study Two explores the United States' emphasis of nuclear weapons and its relationship to the nuclear arms race. While the U.S. was the first nuclear power, the original aim was to prevent others' acquisition of nukes, not to deliberately start an arms race. However, after the United States' use of nuclear weapons in WWII the Soviet Union quickly pursued a nuclear program of its own. While they may not have been able to prevent the arms-race, the United States' continual emphasis of nuclear weapons and long-range delivery capability intensified the race. Just as in Case Study One, the outcome suggests a close tie between technological choices and the strategic environment. By examining the U.S. technological choices and their outcomes, this study discovers further characteristics of technology strategy and lends further strength to the importance of technology strategy.

1. Vignette

The atmosphere inside the Truman Whitehouse at the end of the 1940s was tense. Truman had two significant challenges—nuclear proliferation and communism. The President had helped to end the largest war in human history by authorizing the use of a new weapon based on cutting-edge science with devastating effects on the Japanese cities of Hiroshima and Nagasaki. But the explosions of Fat Man and Little boy simultaneously ended one conflict and started another. The U.S. now had to contend with others who wished to possess the new weapon and had to contend with the growing threat from the spread of communism.

Even before the end of the war, the Soviet Union and the spread of communism had concerned the West. During and shortly after WWII, the Soviet Union had annexed much of Central Europe to include the Baltic states of Estonia, Latvia, Lithuania, and Eastern Germany. In these states, the Soviet Union began an aggressive transformation of economic and political processes known as Sovietization which resulted in increased political influence and wealth for the Soviet Union.¹⁰⁰

¹⁰⁰ Alvin Z. Rubinstein, "The Sovietization of Eastern Europe," *Social Science* 30, no. 2 (1955): 99–104.

The Chinese revolution also marked a significant growth in communist influence. Supported by the Soviet Union, Mao Zedong led a Chinese peasant revolution to overthrow the Nationalist army, establishing the communist based People's Republic of China in October of 1949. To the Truman administration it seemed as if all of Asia, might follow Central Europe into communism.

Truman felt the Soviet Union's support to the spread of communism was a threat to Western ideals. But stopping the spread meant foreign engagement. In a speech before Congress in March of 1947 Truman stated:

The seeds of totalitarian regimes are nurtured by misery and want. They spread and grow in the evil soil of poverty and strife. They reach their full growth when the hope of a people for a better life has died. We must keep that hope alive.¹⁰¹

Early tests of intervention under the titled *Truman Doctrine* showed promise.¹⁰² The U.S. was able to successfully support the Monarchy in Greece by supplying weapons and support, enabling the defeat of the communist insurgency. But witnessed by Stalin's blatant blockade of Western Germany in June of 1948, stopping communism necessitated active deterrence of the Soviet Union and its massive conventional military.

The U.S., however, would have a significant problem matching the Soviets' military power. By all conventional measures the Soviet Union was superior; attaining conventional parity would be difficult. Following WWII, the U.S. had rapidly and according to some, "wastefully" downsized its military forces in an effort to "bring the boys home" and back to work.¹⁰³ Due to public outcry, and even some internal demonstrations, the Army instituted a rapid demobilization following the war. From August of 1945 till 1947 the Army, which still included the Army Air Corps, reduced from a peak in '45 of 8,000,000 troops down to

¹⁰¹ "Recommendation for Assistance to Greece and Turkey, Truman Address to Congress 12 March 1947," National Archives, February 1, 2012, <https://www.archives.gov/global-pages/larger-image.html>.

¹⁰² Truman's foreign policy was guided by George F. Kennan's Containment Strategy see "The Truman Doctrine," Department of State: Office of the Historian, accessed May 10, 2022, <https://history.state.gov/milestones/1945-1952/truman-doctrine>; "Kennan and Containment: 1947," and Department of State: Office of the Historian, accessed May 10, 2022, <https://history.state.gov/milestones/1945-1952/kennan>.

¹⁰³ Maxwell D. Taylor, *The Uncertain Trumpet* (Harper and Row, 1960), 12–13.

an effective strength of only ~900,000.¹⁰⁴ The loss of personnel not only reduced the quantity of the army but also its quality. The well-functioning military machine now had significant gaps between the gears, and by some estimates it would take years and significant funding to reorganize to meet the expected combat effectiveness for its size.

Truman needed a way to counter Soviet aggression and the spread of communism at a low cost and with a smaller army. He turned to nuclear weapons. Later falling under the banner of atomic-diplomacy Truman periodically would place nuclear weapons or deliver platforms in key locations in order to deter Soviet or communism actions. This policy frequently included forward staging in Britain and Berlin with limited deterrent success. In 1950, Truman's atomic-diplomacy showed its real failure when North Korea, aided by China and the Soviet Union, crossed the 38th Parallel. The U.S. was either unwilling to use or unsure of the effectiveness of atomic weapons in such a war. As a result, the Korean war looked very much like a conventional military response under the guise of police action. Maxwell Taylor, a strong opponent of primary reliance on nuclear weapons, would later write:

An outstanding impression from the operations in Korea has been the ineffectiveness or inapplicability of many of our modern weapons to the requirement of the Korean type of limited war ... we denied ourselves the use of special weapons [i.e. atomic weapons] for a variety of reasons, some military, some political ... the fact that we deliberately abstained from using them is a reminder that we may do so again in future situations.¹⁰⁵

But Truman's atomic-diplomacy was also facing additional opposition—the Soviet Union soon developed its own nuclear weapons. The successful development and use of the atomic bomb by the U.S. during WWII, surprised the world. But its development was far from secret. Many analysts would later conclude that Stalin was aware the United States' possession of the new capability long before its initial use. In fact, when President Truman alluded to its use at the 1945 Potsdam conference, stating that “the U.S. possessed a ‘new

¹⁰⁴ John C Sparrow, *History of Personnel Demobilization in the United States Army*, DA Pamphlet 20-210 (Washington, D.C.: Department of the Army, 1952), 265, https://history.army.mil/html/books/104/104-8/CMH_Pub_104-8.pdf.

¹⁰⁵ Taylor, *The Uncertain Trumpet*, 16–17. A book that is sharply critical of the New Look

weapon of unusual destructive force.’ Stalin showed little interest, replying only that he hoped the United States would make ‘good use of it against the Japanese.’”¹⁰⁶ Some analysts feel that his indifference stands as proof of his deep knowledge and possible espionage of the program.¹⁰⁷ Early knowledge notwithstanding, the Soviet Union joined the “nuclear club” in August of 1949—testing their own atomic bomb and challenging U.S. nuclear supremacy.¹⁰⁸ Truman’s atomic diplomacy was failing. The Soviets had acquired the bomb and communism was spreading. The U.S. needed a new strategy.

2. U.S. Technology Strategy: Same Strategy, Same Result, New Name

The incoming Eisenhower administration’s new strategy was not very new; it is better described as a clearer articulation of the previous emphasis on nuclear weapons. The administration campaigned on, and later enacted policy, based on fiscal conservation and responsible use of military forces. To downsize the military and still possess the ability to *rollback* communism, the administration continued the deterrent based foreign policy built on the threat of nuclear punishment. After a speech by Secretary of State Dulles, the policy was dubbed the doctrine of *Massive Retaliation* and was very much a rehashing of many of Truman’s policies. To accompany the rehashed doctrine, Eisenhower also created *The New Look* plan for the armed forces. The plan included changes to organizational structure and technological emphasis that refined the services to the nearly singular purpose of nuclear deterrence. Under Eisenhower, technology strategy, organizational design, and doctrine were addressed with a reasonably clear, although misguided, direction. As Thomas C. Schelling would later note, utilizing nuclear punishment as a form of deterrence against anything but “all-out, indiscriminate, society destroying, war...was in decline almost from its enunciation in 1954.”¹⁰⁹ Massive Retaliation thusly proved to be as ineffective as Truman’s Atomic

¹⁰⁶ U.S. Department of Energy, “Potsdam and the Final Decision to Use the Bomb,” The Manhattan Project, 2013, https://www.osti.gov/opennet/manhattan-project-history/Events/1945/potsdam_decision.htm.

¹⁰⁷ David Holloway, *Stalin and the Bomb* (New Haven, CT: Yale University Press, 1996), 116–17.

¹⁰⁸ William Burr, “Detection of the First Soviet Nuclear Test, September 1949,” *National Security Archive*, Arms Control and Disarmament Cold War - General, no. 684 (September 2019), <https://nsarchive.gwu.edu/briefing-book/nuclear-vault/2019-09-09/detection-first-soviet-nuclear-test-september-1949>.

¹⁰⁹ Thomas C. Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 1976), 190.

Diplomacy. However, a recounting of the technological decision-making, and connection of doctrine and organizational design are very useful to this study.

The technological emphasis of *Massive Retaliation* and *The New Look* plan were formally outlined in National Security Council (NSC) report 162/2. The report created a national-level emphasis on the development and use of nuclear weapons. Nuclear deterrence would be used to meet strategic objectives that included, rolling back communism, deterring Soviet attempts to spread into Europe and reducing spending.¹¹⁰ In this sense, NSC 162/2 represented the first formally codified U.S. national technology strategy and defined the principal objective of the U.S. military forces to “deter and, if necessary, to counter Soviet military aggression ... based on massive atomic capability.”¹¹¹

When Dwight D Eisenhower became the 34th President of the United States in 1953, he wanted to be tougher on communism than Truman. Key to his presidential campaign was shifting from Truman’s containment strategy to a rollback strategy. But under the Truman administration, partially a result of the Korean War, defense spending had grown, and the U.S. was accumulating debt. Eisenhower’s campaign also vowed to reduce this debt and decrease military spending. After commissioning a secret meeting of experts in the solarium of the White House, Eisenhower had his answer to reducing overall spending, stopping communism, and deterring soviet aggression: “A strong military posture, with emphasis on the capability of inflicting massive retaliatory damage by offensive striking power.”¹¹²

Eisenhower’s *New Look* strategy intended to reduce cost and deter Soviet actions by fully leveraging the United States’ nuclear supremacy. Supporters of the New Look felt that the nuclear deterrent had failed under Truman and in Korea because the U.S. was capable of

¹¹⁰ Because the nuclear emphasis intended to “offset” the Soviet’s greater conventional capabilities, it later earned nicknames such as the Nuclear Offset Strategy or the First Offset Strategy see Peter Grier, “The First Offset,” *Air Force Magazine*, 2016, <https://www.airforcemag.com/PDF/MagazineArchive/Magazine%20Documents/2016/June%202016/0616offset.pdf>.

¹¹¹ James S. Lay Jr., “A Report to the National Security Council” (Washington, D.C., October 30, 1953), 19, <https://irp.fas.org/offdocs/nsc-hst/nsc-162-2.pdf>.

¹¹² Lay Jr., 5.

fighting without the use of nuclear weapons and thusly avoided making use of them.¹¹³ They felt that maintaining a military capable of conventional and nuclear responses was both expensive and unnecessary. To ensure the U.S. would not make this mistake again, the New Look intentionally shifted and limited the capability of the military to emphasize nuclear armament instead of conventional capabilities.¹¹⁴ To this end, the plan called for the reduction and reallocation of the military budget with most of the funding going toward support of the Air Force's nuclear bombing capability. In contrast, the New Look plan regarded the U.S. Army as a less useful asset, resulting in large reductions in the Army's budget and manning levels.¹¹⁵ To further strengthen the United States' intent to lead with nuclear weapons in response to communist actions, the New Look also included a new foreign policy based on nuclear deterrence. Secretary of State Dulles announced what became known as the policy of *Massive Retaliation*:

It is not sound to become permanently committed to military expenditures so vast that they lead to practical bankruptcy ... But there is no local defense which alone will contain the mighty land power of the Communist world. Local defenses must be reinforced by the further deterrent of massive retaliatory power.¹¹⁶

The U.S. emphasis on nuclear weapons resulted in development of thermonuclear weapons and intensified the arms-race. To summarize Bernard Brodie, it was not that the new technologies were more revolutionary than the first atomic weapons, it was that they “force [sic] home some conclusions that were insufficiently absorbed before.”¹¹⁷ The 1954 test of the United States' first thermonuclear weapon in the South Pacific yielded a blast of 15 megatons—1,000 times greater than either bomb dropped on Japan. Codenamed the

¹¹³ A. J. Bacevich, *The Pentomic Era: The U.S. Army Between Korea and Vietnam* (CreateSpace Independent Publishing Platform, 2012), 11.

¹¹⁴ Taylor, *The Uncertain Trumpet*, 18.

¹¹⁵ Taylor, 51–52.

¹¹⁶ quoted in Meena Bose, *Shaping and Signaling Presidential Policy: The National Security Decision Making of Eisenhower and Kennedy* (College Station, TX: Texas A&M University Press, 1998), 90–91, <http://ebookcentral.proquest.com/lib/ebook-nps/detail.action?docID=3037708>. For original text of speech see “Text of an Address by Admiral Radford on the Defense Plans of the Nation,” *New York Times*, Dec. 15, 1953, 31.

¹¹⁷ Bernard Brodie and Fawn McKay Brodie, *From Crossbow to H-Bomb*, Rev. and enl. ed, A Midland Book, MB 161 (Bloomington: Indiana University Press, 1973), 264.

Bravo Test, the explosion produced a fireball over 4 miles in diameter, and lethal radioactive effects much further—even killing a Japanese fisherman through radiation poisoning more than 80 miles away.¹¹⁸ Figure 4 is a photograph of the mushroom cloud produced during the Bravo Test.



Figure 4. The United States' Thermonuclear Bravo Test at Bikini Atoll¹¹⁹

At nearly the same time as the Bravo Test, the U.S. introduced the high-altitude B-52 Stratofortress bomber. The B-52 was capable of flying above most defense systems and ranging to distances greater than 12,000 miles.¹²⁰ The new bomber capability meant that, theoretically, the U.S. possessed the ability to take off from inside the U.S., bomb any city

¹¹⁸ Audra J. Wolfe, *Competing with the Soviets: Science, Technology, and the State in Cold War America*, Johns Hopkins Introductory Studies in the History of Science (Baltimore, Md: Johns Hopkins University Press, 2013), 20–21.

¹¹⁹ “Castle Bravo,” Atomic Heritage Foundation, accessed May 22, 2022, <https://www.atomicheritage.org/history/castle-bravo>.

¹²⁰ “Historical Snapshot,” Boeing, accessed January 6, 2022, <https://www.boeing.com/history/products/b-52-stratofortress.page> The B-52 could fly up to 50,000 feet well above the anti-aircraft guns available in the early 1950s. However, the Soviet Union was working on early versions of surface to air missiles. Most notably they would introduce the SA-1 and SA-2 in 1955 and 1957 respectively. These high altitude air defense systems would continue to challenge the U.S. ability to deliver nuclear weapons. See; “S-25 SA-1 Guild,” GlobalSecurity.org, accessed January 9, 2022, <https://www.globalsecurity.org/military/world/russia/s-25.htm> and; “V-75 SA-2 Guideline,” GlobalSecurity.org, accessed January 9, 2022, <https://www.globalsecurity.org/military/world/russia/v-75.htm>.

in the Soviet Union and then land again in the U.S. These new capabilities, combined with the extremely difficult defense of large immovable population centers, left the United States' enemies extremely vulnerable.¹²¹ It seems, the U.S. development of thermonuclear bombs and advanced delivery systems, combined with the Massive Retaliation policy was intentionally intensifying the nuclear arms-race.

It did not take long for the thermonuclear weapons debut to be answered. The Soviet Union began closing the quality gap in the arms-race quickly. The Soviets' first thermonuclear weapon test, although extremely inferior to the Bravo, had occurred seven months prior to the United States' Bravo Test and by 1955 the Soviets possessed a thermonuclear bomb comparable to the US.¹²² During this time, the Soviet Union also made strides in weapons delivery technology. Working off the basis of the German V-2 rockets, the Soviets began a secret program in 1946 to further develop long-range ballistic missiles.¹²³ The Soviets' research progressed quickly, eventually catching the U.S. by surprise with the launch of Sputnik One (Figure 5).

¹²¹ Brodie and Brodie, *From Crossbow to H-Bomb*, 267.

¹²² Wolfe, *Competing with the Soviets*, 20.

¹²³ Gary Goldberg, trans., *Decree of the USSR Council of Ministers" Questions of Reactive Weaponry* (Wilson Center Digital Archive, 1946), <https://digitalarchive.wilsoncenter.org/document/121064.pdf?v=d7572510b75e6d1c15b5172ecd1be022>.

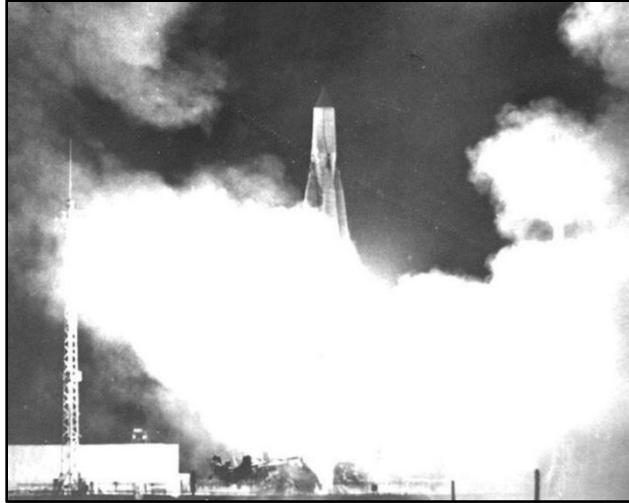


Figure 5. The Launch of Sputnik One¹²⁴

The Soviet launch of Sputnik, the world's first satellite, in October of 1957 sent the U.S. into a frenzy. Many feared that the Sputnik rocket was far more advanced than U.S. rockets and suggested that if the Soviets could rocket a satellite into space, they must also possess an intercontinental ballistic missile (ICBM) that could deliver a nuclear weapon into the US.¹²⁵ The U.S. quickly began pouring more funding and research into rocketry to close a presumed *missile-gap*.¹²⁶ In all areas, the U.S. seemed to be having difficulty maintaining superiority and the arms-race was intensifying.

As weapon delivery system advances increased the threat of a surprise first strike, preservation of a retaliatory capability extended the arms-race to information system technologies. Most notably, the U.S. expanded research into detection technologies with the hope that a Soviet attack could be detected prior to impact allowing for the U.S. to launch bombers and missiles prior to destruction. Using newly developed computing, networking and RADAR technology, in 1958 the U.S. created the Ballistic Missile Early

¹²⁴ "Sputnik: 60 Years of the Space Age," The European Space Agency, accessed May 22, 2022, https://www.esa.int/About_Us/ESA_history/Sputnik_60_years_of_the_space_age.

¹²⁵ Roy E. Licklider, "The Missile Gap Controversy," *Political Science Quarterly* 85, no. 4 (1970): 603, <https://doi.org/10.2307/2147598>.

¹²⁶ Later analysts note that there was never a significant missile gap as the U.S. was firmly ahead of the Soviet Union in missile technology and this is better stated as a *missile gap scare* see Licklider, "The Missile Gap Controversy."

Warning System (BMEWS) as a network of three different RADAR stations in Greenland, Alaska, and the United Kingdom.¹²⁷ Additionally, the U.S. worked with Canadian scientists to develop experimental low-frequency long-range RADAR technology to detect Soviet bombers attempting to fly across the arctic circle.¹²⁸ The need to manage the information gathered by the new RADARs led to many of the early developments in computer technologies. For example, in 1958, the U.S. installed the highly advanced CG-25 computer in the BMEWS to monitor ICBM launches, calculate trajectories, and predict impact points, providing decision makers with rapid data.¹²⁹ The CG-25 was also the first solid state computer and represented the rapid development of computer technology which had relied on mechanical relays only a few years prior.¹³⁰ The nuclear arms-race was clearly growing beyond just weapons technology.

But the expansion into all the new technologies in order to maintain an edge over the Soviet Union was expensive. In 1960, U.S. expenditures on defense had grown to \$47 billion, an almost 28 percent increase from the \$34 billion budget Eisenhower had hoped for under the New Look.¹³¹ The growing cost was, at least partially, due to the constant expansion into additional supporting technologies that were unpredicted. Crash programs in response to the Sputnik scare resulted in increases of funding, as well as the continual buildup of more bombers and nuclear weapons.

By the end of the 1950s the failure of nuclear weapons to deter conflict was long past evident. Proxy wars and conflicts such as Vietnam (1945-1975), the First Taiwan Strait Crisis (1954-1955), the Algerian War (1954-1962), the Congo Crisis (1960-1965), and several others, represented undeterred limited wars between the U.S. and Soviet Union. Highlighting the fallacy of this approach, General Maxwell Taylor wrote that continuation

¹²⁷ Melvin L. Stone and Gerald P. Banner, "Radars for the Detection and Tracking of Ballistic Missiles, Satellites, and Planets," *Lincoln Laboratory Journal* 12, no. 2 (May 12, 2013): 220.

¹²⁸ Directorate of Command History, 23.

¹²⁹ Melvin L. Stone and Gerald P. Banner, "Radars for the Detection and Tracking of Ballistic Missiles, Satellites, and Planets," 224.

¹³⁰ "Timeline of Computer History," Computer History Museum, accessed January 8, 2022, <https://www.computerhistory.org/timeline/computers/>.

¹³¹ Taylor, *The Uncertain Trumpet*, 21.

of a nuclear emphasis, “ ... prepares for one improbable type of war, while leaving the United States weak in its ability to meet the most probable type of threat. It fixes the form of possible military reaction, with a resultant loss of flexibility and adaptability for the political and military policy of the United States.”¹³² Taylor’s argument stood on strong ground.¹³³ The United States’ lead in nuclear arms had not prevented Korea and the numerous proxy wars throughout the 1950s into the 1960s, further leading to Vietnam and many high casualty conflicts. The New Look and Massive Retaliation doctrine may have only contributed to a change in a way the countries fought, instead of deterring all conflict. Taylor would later lead a shift in U.S. strategy. In contrast to an overwhelming focus on nuclear weapons, Taylor’s *Flexible Response* strategy called for a more balanced approach and would later be adopted by the Kennedy administration. Despite the failure, there is still a great deal to be learned from the U.S.’s deliberate choice of a technological emphasis to achieve a strategic affect.

3. Analysis: What Does the Start of the Nuclear Arms-Race Teach about Technology Strategy?

The following analysis deduces characteristics of technology strategy from the U.S. case study. The U.S. case suggests the presence of two unique strategic forms: Big Bet and Technology-in-Being. The case also suggests two technology strategy pitfalls: Iceberg and Opportunity Cost. Just as in the previous case, the provided analysis and vocabulary may serve to guide future technology strategists in studying, formulating, and executing technology strategy.

a. Observed Technology Strategy Forms

The early U.S.–Soviet nuclear arms-race highlighted two forms of technology strategy. The first form described the national-level strategy of the U.S. that took a big bet

¹³² Taylor, 40–41.

¹³³ General Taylor was not the only author to push for a adaptable approach. In his work, Robert Osgood also stated, “The...experience of the last decade indicate that America’s over-all strategy should be the containments of the Communist sphere of control by our readiness to oppose aggression with a variety of means under a variety of circumstances.” see Robert E. Osgood, *Limited War: The Challenge to American Strategy*, 5th ed. edition (Chicago: Univ of Chicago Pr, 1957), 235.

on nuclear weapons to achieve the desired strategic effects. The second form describes how the U.S. Air Force combined nuclear weapons, delivery capability, and an alert status to create a technology-in-being effect. The *Big Bet* and *Technology-in-Being* strategic forms are discussed below.

(1) Big Bet

The New Look's nuclear-focused strategy took on an almost singular capability and type of response. As General Taylor later noted, the singular focus was betting that all future wars would be nuclear and the threat of all out nuclear war would deter all lesser conflict.¹³⁴ While the doctrinal and multiple associated technological bets (nuclear weapons, long bombers, ICBMS, etc.) failed to deter lesser conflicts, it should not be ignored that unlimited war between the U.S. and Soviet Union did not occur, and the nuclear emphasis may have led to increased awareness and even some cooperation between the U.S. and Soviet Union. Thusly, the U.S.'s chosen *Big Bet* strategic form may provide a template for future strategists given an appropriately aligned strategic intent.

(2) Technology-in-Being

The U.S. technology strategy's form created a dominant weapon capability that was able to exert a technology-in-being effect on the Soviet Union. Just having a larger nuclear arsenal would not provide the U.S. the deterrence it required. They also needed to be able to deliver the nuclear weapons to target with high confidence. Thus, the U.S. sought to maintain a clear superiority in nuclear delivery capability compared to the Soviet Union. To support the overall Big Bet strategy on nuclear weapons, the Air Force built a bomber force of greater quantity and quality than the Soviet Union. Doctrinally, the U.S. Air Force also developed an alert posture "with the goal of having 30 percent (later 50 percent) of its aircraft able to launch within 30 minutes of notification, which [later] dropped to 15

¹³⁴ Taylor, *The Uncertain Trumpet*, 40–41.

minutes with the introduction of Soviet ballistic missiles.”¹³⁵ Combining long-range delivery with massive firepower and an alert status gave the U.S. nuclear-centric bomber fleet a technology-in-being affect.¹³⁶ The technology-in-being affect created by the technological decisions in meeting the desired deep strike capability, meant that a constant threat loomed over every Soviet city. Guarding against the U.S. meant building the capability to destroy the looming threat, a feat that naturally led to imitating the technology that created it and further intensifying the arms-race.

It is worth noting that the partnering of delivery and firepower capability that dominated the nuclear arms-race is similar to what J.F.C. Fuller called the dominant weapon. Fuller defined a dominant weapon as “the weapon which, on account of its superior range, can be brought into action first, and under the protective cover of which all other weapons, according to their respective powers and limitations can be brought into play ... the higher its striking power, accuracy of aim, volume of fire and portability, the more dominant [it] will be.”¹³⁷ The United States’ technology strategy focused on bringing delivery and firepower capabilities together in a way that created a dominant weapon. This observation suggests that if a strategist is attempting to achieve a technology-in-being affect, (i.e., a strategic intent of changing the enemy’s calculus just by the possession or placement of the technology) it may be desirable to emphasize a dominate weapon in their technology strategy. Such as pursuit may be called a *Technology-in-Being* strategic form.

b. Suggested Technology Strategy Pitfalls and Stratagems

The launch of Sputnik by the USSR suggested a highly advanced ICBM capability without having to actually launch an ICBM. The Soviet launch of Sputnik showed an impressive civilian capability, but also suggested the existence of a hidden, but incredibly advanced, military rocket technology. The missile scare effect of the Sputnik launch

¹³⁵ Robert S. Hopkins, III, Bruce Blair, and William Burr, eds., “How the Strategic Air Command Would Go to Nuclear War,” *National Security Archive*, Cold War: General Nuclear Strategy and Weapons, 2019, <https://nsarchive.gwu.edu/briefing-book/nuclear-vault/2019-02-25/how-strategic-air-command-would-go-nuclear-war>.

¹³⁶ This approach’s namesake is from the naval strategy known as a fleet-in-being where, a naval fleet stays in port but, because of its continual existence, forces the opponent to fear and guard against it.

¹³⁷ Fuller, *Armament and History*, 21.

suggests the possibility of an *Iceberg pitfall*. Similar to an iceberg where the greatest mass remains unseen, the Soviets launch of Sputnik created a U.S. perception (at least among the U.S. populace) of a technological gap that could have led to an attack with capabilities not anticipated. The U.S. response was to increase resources toward missile and rocket technologies as well as the creation of several agencies devoted to the prevention of technological surprise, such as DARPA.¹³⁸ The U.S. fear of technological surprise, created by the way the Soviets displayed their rocket capabilities, intensified and expanded the arms-race. For a technology strategist, such a technique may be useful in intentionally intensifying an arms-race or increasing strategic deterrence. Suggesting the *Iceberg* stratagem:

Let your opponent see your technological progress in peaceful pursuits and they may assume equal or greater progress in military arenas. The adversary fears what they do not know but can see reflected in your overt actions. Peaceful progress, especially with an implied dual-use, may equal greater deterrence.

4. Case Study Conclusion

Analysis of the U.S. case study indicates a strong correlation between technological decisions and the dynamics of an arms-race. The United States' nuclear weapons centric technology strategy greatly intensified the Soviet Union's desire for nuclear weaponry and failed to meet the U.S. strategic goal of deterring limited wars. A failed technology strategy. However, beyond several notable characteristics of technology strategy, this case study also teaches that the least expensive or most powerful technology may not end up being the most effective. Nuance and problem matching are key in technological choices. Parity may be important in one arena but completely ineffectual in another. Furthermore, parity itself appears to be a constant guessing game. The adversary's technological development and chosen directions of their delivery and information technologies may quickly change the measurement of parity, thus a technology strategist may be wise to

¹³⁸ DARPA, "Advancing National Security Through Fundamental Research," DARPA, accessed January 9, 2022, <https://www.darpa.mil/about-us/advancing-national-security-through-fundamental-research>.

avoid mirror imaging and assumptions of continued supremacy. Technology strategy is, indeed, a complex endeavor.

D. CONCLUSION

The very essence of this work's concept of technology strategy is the connection between the chosen technology and the strategic environment. When choosing technologies, this connection should not be overlooked. In both the Anglo-German naval and U.S.–Soviet nuclear arms-race, decision-makers failed to fully consider the techno-strategic link contributing to undesired consequences both starting and intensifying undesirable arm-races. Perhaps more devotion to and study of the characteristics of technology strategy, such as those presented in this chapter and the next, may prevent a future technology strategist from repeating the same mistakes.

IV. OFFENSE-DEFENSE THEORY: TECHNOLOGY STRATEGY AS THE DEPENDENT VARIABLE

Man's Increasing Power of Destruction, Unchecked, Will Overwhelm
Hope, Beauty and Freedom in the World.

—H.G. Wells¹³⁹

As a prominent element of international relations theory, Offense-Defense Theory (ODT) possesses a rich literature exploring technological decision-making. Additionally, ODT provides an excellent lens through which to observe a case study of a nation's perception of the offense-defense (OD) balance and its effect on technology strategy. As such, this chapter proceeds in three parts. The first examines the literature on ODT and postulates what a technology strategist may learn and apply from the theory. The second presents a vignette highlighting France's interwar (1919-1939) perception of the OD balance and its relationship to technological decisions. The third section examines ODT and the French vignette to identify characteristics of technology strategy.

A. OFFENSE-DEFENSE THEORY

The following exploration suggests that ODT may allow a technology strategist to estimate the comparative cost of a given strategy relative to an opponent and can highlight the critical differences in the way technologies influence the levels of war. The theory may also provide insight into how the character of conflict may change as a result of the evolution of technology. Overall, the exploration finds the tenets of ODT useful in examination of technology strategy characteristics and suggests that consideration of the OD balance is critical in technology strategy formulation.

ODT postulates military technology advancements affect the relative costs of offensive and defensive strategies.¹⁴⁰ The cost fluctuates due to advancements in technology

¹³⁹ H. G. Wells, "Civilization at the Breaking Point," *The New York Times*, May 27, 1915, sec. Archives, <https://www.nytimes.com/1915/05/27/archives/civilization-at-the-breaking-point-mans-increasing-power-of.html>.

¹⁴⁰ Charles L. Glaser and Chaim Kaufmann, "What Is the Offense-Defense Balance and Can We Measure It?," *International Security* 22, no. 4 (1998): 50, <https://doi.org/10.2307/2539240>.

and may do so unevenly, thereby more greatly favoring either defensive or offensive pursuits.¹⁴¹ These changes in the relative efficiency of one strategy compared to the other can have a stabilizing or destabilizing effect on the international security environment.¹⁴² ODT uses two key variables to make stability predictions. While ODT is one of many theories in international relations and far from a perfect model, the variables and their predictions may serve a technology strategist well.

1. The Variables

ODT proposes two variables to describe the relationship between offensive (advancing) forces and defensive (non-advancing) forces. As defined by Robert Jervis in 1978, the “two key variables in ODT are (1) the offense-defense balance ... whether it is ‘easier’ to take territory or to defend it, and (2) offense-defense distinguishability ... whether the forces that support offensive missions are different from those that support defensive missions.”¹⁴³ Interplay of these two variables predicts the stability of the international security environment.

a. The Offense-Defense Balance

The *OD balance* (often referred to as *the balance*) is the ratio of the efficiency of using a technology offensively versus defensively.¹⁴⁴ Said another way, “the balance is ... the amount of resources that a state must invest in offense (or defense) to offset an adversary’s investment in defense (or offense).”¹⁴⁵ For instance, if technological innovations are more cost-effective to use in defensive strategies, they favor defensive actions. As an example, early fighter aircraft typically required refueling to support combat actions if they

¹⁴¹ In two important works on ODT, George H. Quester and Robert Jervis identify both technology and geography as the principal elements. For our purposes, geography is understated but no less important. George H. Quester, *Offense and Defense in the International System* (New York, NY: John Wiley and Sons Inc., 1977), 4 and; Jervis, “Cooperation Under the Security Dilemma.”

¹⁴² Jervis, “Cooperation Under the Security Dilemma,” 194.

¹⁴³ Glaser and Kaufmann, “What Is the Offense-Defense Balance and Can We Measure It?,” 47 see also; Jervis, “Cooperation Under the Security Dilemma.”

¹⁴⁴ Glaser and Kaufmann, “What Is the Offense-Defense Balance and Can We Measure It?,” 55.

¹⁴⁵ Sean M. Lynn-Jones, “Offense-Defense Theory and Its Critics,” *Security Studies* 4, no. 4 (June 1995): 674, <https://doi.org/10.1080/09636419509347600>.

were a great distance from their starting base. Their lack of long-range mobility without the additional cost and risk of forward bases made them more efficient in strategic defense operations.¹⁴⁶ Conversely, technological progress that removed this restriction shifted the balance. For instance, the addition of drop tanks in WWII gave the P-51 significantly improved range and the capability to support a daylight strategic bombing campaign without the increased cost or risk of forward bases—a movement toward the strategic offense.¹⁴⁷ Similarly, the dawn of nuclear-powered ships and submarines removed the need to refuel at sea or maintain as many ports—in the submarine case also decreased the need to surface—vastly increasing the ships offensive efficiency. Analyzing these developments as a whole and across the major players in the international environment gives a picture of the balance of the system.

The way technologies interact to create greater efficiency in strategies complicates ODT because many technologies can aid both offensive and defensive pursuits. However, ODT maintains that there are principal characteristics of technologies that align them to support either offense or defensive strategies more efficiently. The identifying of offensive (or defensive) technological characteristics is among the most critical and controversial components of ODT.

(1) Offensive Technology Characteristics

The principal strength of the offense lies in its ownership of the initiative. The initiative allows the offense to determine the time and place of the fight. In contrast, the defense is, by nature, reactive to the actions of the offense.¹⁴⁸ Exploiting the initiative is thus a key capability created by offensive leaning technologies. Advances in technologies that enable rapid movement and/or preserve capability with fewer logistical requirements, greatly

¹⁴⁶ However, they may still be offensively dominate at the tactical or operational level. See later discussion on the OD balance at the different levels of war.

¹⁴⁷ Karen Daneu, “The P-51 Mustang as an Escort Fighter: Development Beyond Drop Tanks to an Independent Air Force” (Fort Belvoir, VA: Defense Technical Information Center, April 1, 1996), vi, <https://doi.org/10.21236/ADA330888>.

¹⁴⁸ Clausewitz, Howard, and Paret, *On War*, 357.

favor offensive strategies.¹⁴⁹ In warfare, these traits are often associated with mobility. Thus, a primary characteristic of offense-leaning technologies is the ability to enhance mobility in a particular context and level of war.

Exploitation of the initiative requires the offense to concentrate forces effectively where the defense is weak. Because the defense is almost always reactive, the movement of the defense trails the offense. The defense recognizes this delayed movement and often must disperse its forces or estimate where the offense is likely to attack to ensure sufficient counter-forces are positioned. Therefore, assuming that the defense has not correctly estimated the offense's movements, the offense will be able to concentrate and attack before the defense can concentrate its forces. Assuming both sides are using the same technology, to stay balanced the defense must have a greater amount of the same technology.

As a tactical example, assume two sides are equipped with only a single tank. The tank brings a high degree of mobility, enabling it to stand as a defensive guard along an entire front (i.e., patrolling). However, while its mobility enables it to patrol the front, because the defensive does not own the initiative, there is no guarantee that the tank will be at the location at which the offense chooses to battle. Alternatively, because the offense determines the place of battle, it can assure itself that its tank will be at the battle. Thus, a highly mobile asset can benefit both sides, but in a symmetrical match the defense requires more of the asset due to the efficiency loss in distribution.¹⁵⁰

A real world parallel to the tank example also demonstrates the contextual and level of war impacts of ODT. In the spring of 1944, the Germans suspected a pending Allied landing in Western Europe but were unaware of the exact location. The Germans possessed more divisions (59) but had to spread them out widely because the Allies had the option of landing at a number of places. Conversely, due to the mobile nature of the Allies' amphibious

¹⁴⁹ George H. Quester, *Offense and Defense in the International System* (New York, NY: John Wiley and Sons Inc., 1977), 3.

¹⁵⁰ Note that this example is used under the "all other things considered equal" assumption. The interplay of technologies and van Creveld's "solids and gaps" observation alters this pure example and will be discussed later. It is also worth noting with the provided example that the use of the tank and aircraft to enable the highly effective Blitzkrieg tactics throughout WWII is often cited by ODT proponents as proof that mobility technologies tipped the OD balance toward the offense.

landing capability, they could choose their location and achieve local superiority with smaller overall numbers. In the end, the Allies mobility allowed them to exploit the initiative, land at Normandy, and secure the beach head with six amphibious divisions (plus 3 highly mobile airborne divisions), marking a significant turning point in WWII.¹⁵¹

(2) Defensive Technology Characteristics

The principal strength of the defense lies in its goal of preservation and denial. Whereas an offensive action must achieve an objective, such as seizure of land or destruction of a key element, the reciprocating defensive action is to prevent the attacker from achieving their objective—what Clausewitz referred to simply as “preservation” and “denial.”¹⁵² Technologies that increase military capability against a concentrated and/or maneuvering opponent are defensive-leaning technologies. Increased capability against concentrated or maneuvering forces requires increased range, accuracy, rate of fire, targets per strike, and/or probability of kill. Collectively, these elements are referred to as firepower.¹⁵³

Technologies that increase range and accuracy reduce the offensive space for maneuver by increasing capability across a large front. Long-range weapons also reduce the benefits of increased offensive speed by increasing the distance that the offensive must endure an attack before reaching their objective. Similarly, weapons with high rates of fire or large kill radii increase the vulnerability of concentrated offensive forces. The offensive must disperse to reduce risk thereby inducing a burden on the offense’s command and control mechanisms.¹⁵⁴

Examples include the introduction and widespread use of machine guns and artillery in WWI. By increasing the range of artillery and machine gun fire, gaps between the fronts

¹⁵¹ “Fact Sheet: Normandy Landings,” Whitehouse.gov, June 6, 2014, <https://obamawhitehouse.archives.gov/the-press-office/2014/06/06/fact-sheet-normandy-landings>.

¹⁵² Clausewitz, Howard, and Paret, *On War*, 357.

¹⁵³ Glaser and Kaufmann, “What Is the Offense-Defense Balance and Can We Measure It?,” 64 and; Keir A Lieber, *War and the Engineers: The Primacy of Politics over Technology* (Ithaca, NY: Cornell University Press, 2018), 43, <https://doi.org/10.7591/9781501724466>.

¹⁵⁴ Dupuy, *The Evolution of Weapons and Warfare*, 309–10 and; van Creveld, *Technology and War*, 174.

(no-man's land) increased and an offensive charge was much more costly for the offense than the defense. Overcoming such a barrage required dispersion of troops and distribution of attacks, such as the German *sturmtruppen* [stormtrooper] tactics or a combination of technological progress (the tank) and tactics such as the Allied strategy used by Ferdinand Foch in 1918. Interestingly, while the *sturmtruppen* tactics would later evolve to form the basis for Blitzkrieg, both approaches to overcome the superiority of the defensive balance still did not yet have the technological support to significantly shift the balance. Even aided by the quickly-evolving technologies such as the tank and aircraft, Foch's 100-day offensive struggled to overcome the strength of the defensive. The impending result was staggering with "the Allies [losing] close to 1,070,000 casualties, and the Germans [losing] 1,172,075."¹⁵⁵ A far from decisive result on numbers alone. Therefore, although advances in firepower are generally seen as antithetical to mobility and assumed to favor defensive strategies. Note that the disparity in the balance may not be large—especially if the balance is beginning to shift from one extreme (defensive) as it was at the end of WWI.¹⁵⁶

(3) The Balance and the Level of War

As alluded to earlier, the balance may fluctuate significantly depending on the level of war and the specific context of a given conflict. ODT theory essentially allows for three levels of balance calculation: the strategic, operational, and tactical levels. While technology contributes heavily to the balance, the organizational and doctrinal uses of technology, at any particular level of war, also play a significant role in determining fluctuation in the balance. A technology strategist must consider the whole picture and the level of war when evaluating the balance.

At the *strategic* level, offensive technologies enable the delivery of forces, weapons, or information from the "homeland to a theater of operations or between theaters" more

¹⁵⁵ "The Hundred Days Offensive," National WWI Museum and Memorial, accessed April 21, 2022, <https://www.theworldwar.org/learn/about-wwi/hundred-days-offensive>.

¹⁵⁶ The advances in heavy artillery and the cumbersome but high fire rate of the Maxim machine gun used throughout WWI are frequently used as examples to illustrate the defensive nature of that war.

efficiently than they prevent a defending force from denying these operations.¹⁵⁷ Long-range nuclear naval ships are examples of technologies that are offensively aligned at the strategic level. Reciprocally, the high training and procurement cost of these technologies makes them less efficient for typical defensive uses where the need for remote refueling depots is reduced.

Notably, the organizational and doctrinal uses must also embrace the offensive capability. For instance, the U.S. carrier strike group, a strategic-offensive tool is both organized and doctrinally aligned around the nuclear-powered carrier. Other countries possessing aircraft carriers, such as Japan, have not embraced nuclear energy as the source of propulsion and tend to utilize their carriers in more defensive postures. Thus, technologies that support delivery of military capability from the homeland to the target zone are strategically offensive, but their absolute nature may take further analyzation of the country's developmental decisions and alignment with doctrinal and organizational choices.

At the *operational* level technological advances enabling the movement, sustainment, and positioning of forces, weapons, or information prior to battle, benefit the offensive. Conversely, technologies that enable the "detection of action, assessment of the threat, decision on response and instruction dissemination" benefit the defense.¹⁵⁸ The exceptional mobility of tank and aircraft operations of the German Blitzkrieg is an example of operationally offensive technology advances. Just as in the strategic level, the doctrinal and organizational decisions also supported the offensive capabilities in two specific ways. First, strike and movement operations were coordinated through radios inside the tank and aircraft enabling flexibility, rapid force concentration, and close air support.¹⁵⁹ Second, the Germans specifically created and organized Panzer Divisions and Luftwaffe *Geschwader* [equivalent to USAF Wing] to support rapid penetration and encirclement doctrine.¹⁶⁰

¹⁵⁷ Lieber, *War and the Engineers*, 40 and; Glaser and Kaufmann, "What Is the Offense-Defense Balance and Can We Measure It?," 61–62.

¹⁵⁸ Glaser and Kaufmann, "What Is the Offense-Defense Balance and Can We Measure It?," 62.

¹⁵⁹ Carter, "Techno-Strategic Integration."131

¹⁶⁰ Ernest R May, *Strange Victory: Hitler's Conquest of France* (New York: Hill and Wang, 2001), 87–88.

Alternatively, technologies enabling the “detection of action, assessment of the threat, decision on response and instruction dissemination” benefit the defense.¹⁶¹ An outstanding example of these technologies, combined with organizational innovation and doctrinal refinement, is the early warning system that helped save Britain during *The Blitz* (1940). By linking smaller chain home RADARs and observational posts utilizing a centralized control system, Britain was able to identify incoming German aircraft efficiently and effectively.¹⁶² The true benefit of this defensive operation was defense aircraft to the threat instead of pursuing costly and inefficient aircraft patrols. “In other words, [they] regarded the main contribution of radar as a means of economizing in fighters, one of [their] most precious commodities.”¹⁶³ At the operational level, integrating RADAR and observers with the appropriate organizational design and doctrine increased defensive efficiency.

The *tactical*-level deals with exploitation of battlefield advantages. Tactical offensive-favoring technologies increase the ability to move under fire and survive, whereas tactical defensive technologies slow mobility and deny territory. The design and uses of the first tanks at the Somme and Cambrai in WWI fit the tactical offense definition. These early tanks served as large moving walls of steel for infantry troops to shoot from and shelter behind when advancing on the enemy line. However, unlike the later Blitzkrieg operations, the WWI use of tanks received little doctrinal development or organizational support and these technologies maintained only their tactical level influence.

Tactical-level defensive technologies are designed to slow mobility or deny territory. Often these technologies are designed for low cost and minimal maintenance, such as barbed wire and landmines. In the case of WWI, these mobility-slowing defensive technologies were part of the reason tanks were developed. The heavy armor and metal tracked propulsion of tanks negated the mobility slowing effects and helped restore movement to the battlefield.

¹⁶¹ Glaser and Kaufmann, “What Is the Offense-Defense Balance and Can We Measure It?,” 62.

¹⁶² Williamson Murray and Allan R. Millett, eds., *Military Innovation in the Interwar Period* (Cambridge, UK: Cambridge University Press, 1996), 286.

¹⁶³ R. V. Jones, *The Wizard War: British Scientific Intelligence 1939–1945* (Brattleboro, VT: Echo Point Books & Media, 2017), 199 see also; Murray and Millett, *Military Innovation in the Interwar Period*, 285–86.

Therefore, it is necessary to evaluate the OD balance at each level of war and optimize technological decisions based on the technology's intended use and within their expected context. Often, the same technology contributes to the balance in different ways depending on the level of analysis. In the P-51 drop-fuel-tank example above, the increased cost of using aircraft over long ranges made them more efficient in a strategic defensive; however, at the tactical level, fighter-type aircraft employed in close air support missions served as highly maneuverable fires platforms that were difficult to defend against with common ground forces. Thus, at the tactical and even operational level, fighter aircraft tend to be offensively more efficient and at the strategic level defensively more efficient.¹⁶⁴ Additionally, notice that tanks were used in both the tactical and operational levels above. The chief difference between the two cases is the organizational and doctrinal integration of the tank. This type of switching in the balance from strategic to tactical is common, may be dependent on organizational or doctrinal choices, and should be considered when building a technology strategy.

b. Distinguishability

In addition to the balance, ODT's other variable is the ability to distinguish between offensive and defensive postures, also referred to as *distinguishability*. As alluded to in Chapter III, an arms-race or other hostile actions are often the result of fear of an opponent's increased capability and/or unknown intentions. A country building numerous fortifications and fixed artillery sites along its border is less likely to alarm its neighbor than a country that sends several tank battalions to patrol its border. While in both cases the state may have defensive intentions, the use of tanks in a defensive posture is not as easily distinguishable due to the mobile nature of tank technology. Many common technologies in use today similarly suffer from this lack of distinguishability, including aircraft and naval vessels. The firepower of these air and naval technologies gives them strong defensive characteristics, while their maneuverability grants them strong offensive characteristics. Whether they are

¹⁶⁴ It is worth noting that the effect of the aircraft on the OD balance at the operational level may simply be a matter of design choices or even commanders' payload specifications. Aircraft operating in a defensive posture are likely to choose external fuel tanks for increased loiter time instead of extra bombs and missiles, whereas a fighter on a tasked strike or air interdiction mission is likely to favor more bombs and missiles.

more efficient at one or the other may be discernable only through in-depth, often classified, knowledge of the technology. Along these same lines, technologies that are either inherently or designed to be neutral will place similarly increased emphasis on how they are employed. Neutral technologies are likely to become increasingly prevalent, and distinguishability of posture more important, as weapons, delivery, and information technologies begin to merge. (i.e., smart weapons and autonomous drones)

A technology strategist would be wise to consider the apparent offensive or defensive nature of a chosen technology and how it may affect international stability. In the next section, the Tirpitz case study from Chapter III illustrates ODT. As the section explores the predictive tenets of ODT, consider that the German battleships' deep-water capabilities and position in the North Sea gave the Tirpitz strategy unmistakable offensive characteristics, sparking not only an arms race but contributing to a war—despite Tirpitz's stated intent to create a naval fleet to deter war.

2. The Prediction

Proponents of ODT claim that the two variables mentioned above—offense-defense balance and the distinguishability of offensive or defensive posturing—predict the stability of the international environment by estimating the value actors place on attacking or waiting to be attacked. In “Cooperation Under the Security Dilemma,” Robert Jervis offers the matrix shown in Figure 6.

	OFFENSE HAS THE ADVANTAGE	DEFENSE HAS THE ADVANTAGE
OFFENSIVE POSTURE NOT DISTINGUISHABLE FROM DEFENSIVE ONE	1 Doubly dangerous	2 Security dilemma, but security requirements may be compatible.
OFFENSIVE POSTURE DISTINGUISHABLE FROM DEFENSIVE ONE	3 No security dilemma, but aggression possible. Status-quo states can follow different policy than aggressors. Warning given.	4 Doubly stable

Figure 6. Robert Jervis's Four Worlds Matrix¹⁶⁵

Jervis's diagram approximates four states of varying stability in the international system based on cross referencing the OD balance and the distinguishability of the technology's posture. At the top of Jervis's matrix are the two states of the OD balance—offense advantage and defense advantage. On the left-hand side of Jervis's matrix are the two states of distinguishability—distinguishable and indistinguishable. Notably, the most stable condition is when the OD balance favors the defense and postures are distinguishable. Inversely, the most unstable environments are characterized by poor distinguishability and an offensive advantage. Applying Jervis's chart to the Anglo-German arms-race, one observes that although Tirpitz's navy never intended to attack Britain, the offensive characteristics of the battleship and its offensive posture in the North Sea created a highly unstable environment. Britain's response was therefore both unsurprising and predictable utilizing ODT. Tirpitz should have chosen his technology more wisely. ODT, as a prediction tool, certainly has some historical validity and applicability when choosing technology.

3. Limitations and Difficulties of ODT

The critics of ODT raise several arguments of relevance to a strategist building a technology strategy. While many critics of ODT accept the premise of an OD balance, they

¹⁶⁵ Source: Jervis, "Cooperation Under the Security Dilemma," 211.

argue that it is 1) difficult to draw a clear distinction between offensive and defensive weapons; 2) states and actors often struggle to correctly evaluate the balance and 3) that the OD balance and distinguishability variables are far less important variables in predicting international stability compared to other elements, such as politics and economics.¹⁶⁶ To this list, this research paper adds that 4) ODT also suffers from an underdeveloped understanding of the role of information systems in the OD balance and 5) lacks a significant examination of the relationship between the OD balance and the character of conflict. Examination of the proposed counterarguments provides useful knowledge for a technology strategist.

a. Distinction between Offense and Defense Technologies

The difficulty of classifying weapons as offensively or defensively dominant is among the most controversial of the theory's components. Some technologies are clearly polarized by their nature to one end of the scale. Such as the clearly immobile and firepower laden Maginot Line (defensive). However, most technologies can exist on a spectrum that, while initially on one end of the scale, can be affected by tradeoff decisions in development and how the technology is utilized. Indeed, most of the distinction arguments against the applicability of ODT contend that the application of a technology, as opposed to its characteristics, primarily determines its offensive or defensive nature.¹⁶⁷

Application is certainly important. Even supporters of ODT such as Jervis state "that whether a weapon is offensive or defensive often depends on the particular situation ... and the way in which the weapon is used."¹⁶⁸ Yet it is also easy to conclude that some technologies are clearly meant to favor mobility or firepower, such as the firepower focused battleship or the mobility focused tank. But, tradeoff decisions during technology development can affect the traits of a technology in ways that reduce its effectiveness in the opposing strategy, sliding it one direction or the other along the spectrum. Aligning the technology use, its basic technological traits, its trade off decisions, with its intended use, will likely produce the best results.

¹⁶⁶ Lynn-Jones, "Offense-Defense Theory and Its Critics," 671–72.

¹⁶⁷ Lynn-Jones, 672–673.

¹⁶⁸ Jervis, "Cooperation Under the Security Dilemma," 202.

For instance, the French conceived of tanks as a defensive weapon designed to protect the infantry. As such, they favored firepower and thick armor in development at the expense of speed (see Figure 12). Due to the favoring of armor, many of the French tanks suffered from poor visibility, which limited their ability to operate alone.¹⁶⁹ The French also did not significantly develop tank-on-tank battle or tank and air integration doctrine, instead viewing artillery as the preferable approach to countering enemy tanks.¹⁷⁰ Alternatively, the Germans built fast-moving tanks designed to pierce fronts but they were vulnerable to more munitions than French tanks due to decreased armor. They also envisioned tanks operating independently which inspired the technological decision to incorporate radios.¹⁷¹ Although an evolutionary process, by April of 1940 German tacticians also learned to integrate tank assaults with highly mobile attack aircraft.¹⁷² The two countries developed the same technology differently based on their preference for mobility or firepower.

These two different approaches to tank development met in May of 1940 around the Belgian city of Hannut—with the French in prepared defensive positions. The battle was the largest armored battle in history at the time and largely ended in a victory for the French although their lack of significantly developed tactics is suggested to have increased their losses even further.¹⁷³ Tank losses on both sides told the same story with the French losing ~105 and the Germans' losing ~160.¹⁷⁴ Later reports from German officers would indicate that they found the French tanks heavy armor and firepower greatly superior to their own stating, "in a simple duel...the best Panzer had almost no chance for success."¹⁷⁵ But the battle represented the German's fighting the battle France prepared to fight—a defensive

¹⁶⁹ Robert A. Doughty, *The Seeds of Disaster: The Development of French Army Doctrine, 1919–39*, Stackpole Military History Series (Stackpole Books, 1985), 151.

¹⁷⁰ As the case study will later note, some visionary French thinkers such as Charles DeGaulle did think through armored maneuver warfare, but their ideas were rejected.

¹⁷¹ Jeffrey A. Gunsburg, "The Battle of the Belgian Plain, 12–14 May 1940: The First Great Tank Battle," *The Journal of Military History* 56, no. 2 (1992): 207–44, <https://doi.org/10.2307/1985797>.

¹⁷² Murray and Millett, *Military Innovation in the Interwar Period*, 42–43. See also Ernest May, *Strange Victory* and Lloyd Clark, *Blitzkrieg*.

¹⁷³ Gunsburg, "The Battle of the Belgian Plain, 12–14 May 1940," 243.

¹⁷⁴ May, *Strange Victory*, 403.

¹⁷⁵ Quoted in. May, 404.

based battle from prepared positions. As witnessed by the rapid movement of the German tanks through Ardennes Forest, when fighting the way the Germans wanted, the fast-moving German tank was more appropriately suited.

The natural and chosen offensive or defensive characteristics of technologies and their envisioned practices clearly matter in technology strategy decisions. Possessing similar base technology does not guarantee an even match; technology must be developed with the correct attention paid to its intended use and balancing of tradeoff priorities. This is the essence of technology strategy.

b. States Frequently Fail to Perceive the OD Balance Correctly

Correctly perceiving the current or future state of the OD balance has historically proved difficult. Jack Snyder's article "The Cult of the Offensive" builds on the work of Barry Posen and Stephen Van Evera to show how militaries continually lean toward offensive strategies even when presented with evidence of a defense dominance.¹⁷⁶ Snyder's analysis shows that military strategists have often routinely dismissed information that did not support the "erroneous belief that a disarming, offensive blow is feasible and necessary to ensure the attacker's security."¹⁷⁷ Such was the state entering into WWI where all actors began and continued with offensive strategies that pitted advanced defense-dominant firepower against underdeveloped Napoleonic-era horse-and-wagon mobility technologies. The failure to perceive the disparity led to Waterloo-like charges across battlefields strewn with barbed wire, blanketed with machinegun fire, filled with poison gases, and cratered by artillery barrages. The over eight million resulting deaths illustrates the difficulty and importance of analyzing the balance.¹⁷⁸

¹⁷⁶ Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars*, Nachdr., Cornell Studies in Security Affairs (Ithaca: Cornell Univ. Press, 1986) and; Stephen Van Evera, *Causes of War: Power and the Roots of Conflict* (Ithaca: Cornell University Press, 2001). For originally coining of the term "Cult of the Offensive" see *War in the Modern World* by Theodore Ropp

¹⁷⁷ Jack Snyder, "Civil-Military Relations and the Cult of the Offensive, 1914 and 1984," *International Security* 9, no. 1 (1984): 112, <https://doi.org/10.2307/2538637>.

¹⁷⁸ One analyst did correctly perceive the imbalance prior to WWI, a leading figure in Russian Finance and Industry named Jean de Bloch. See Michael Howard, "Men against Fire: Expectations of War in 1914," *International Security* 9, no. 1 (1984): 41–57, <https://doi.org/10.2307/2538635>.

Analysts are just as likely to incorrectly perceive a state of defense dominance in an offensively dominant world. While unsupportive of ODT as a conflict prediction tool, the work of Gortzak et al. shows a tendency for strategists' conclusions on the future OD balance to match the balance in recent memory. The vignette later in this chapter explores this fallacy in more depth. Figure 7 shows the work of Gortzak et al. The scale on the left-hand side indicates an increasingly offensive state of the balance as the number increases.

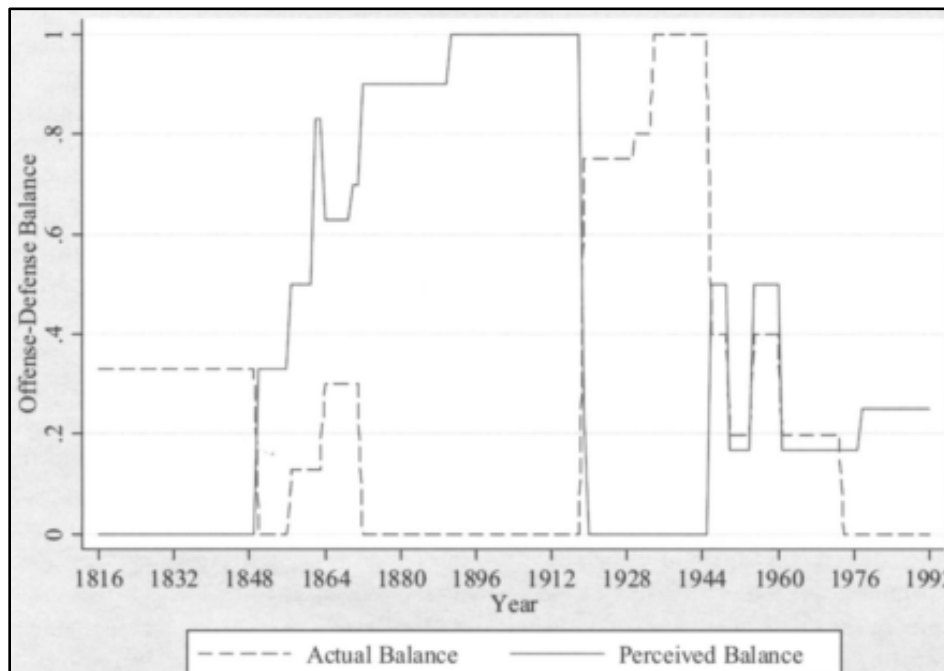


Figure 7. Actual and Perceived Offense-Defense Balance, 1816–1992¹⁷⁹

While the work of Snyder and Gortzak et al. shows that the balance is often perceived incorrectly, their work should not be seen as a dismissal of ODT's usefulness to a technology strategist. Instead, their work highlights the incredible difficulty of evaluating the OD balance and the need to get-it-right or quickly acknowledge an incorrect analysis and adapt.

Adaptation may be a change of strategy or development of technologies to shift the balance. Although developing the technology to shift the balance takes time and even with a

¹⁷⁹Adapted from Yoav Gortzak, Yoram Z. Haftel, and Kevin Sweeney, "Offense-Defense Theory: An Empirical Assessment," *The Journal of Conflict Resolution* 49, no. 1 (2005): 76.

high-level of technological readiness rapid development requires significant support. Such was the case in WWI, where the tank enabled the escape from the trenches, but its development and implementation took over two years when the supporting technologies—the internal combustion engine and caterpillar tracks—were available prior to the war.¹⁸⁰ Indeed, hundreds of thousands of lives were lost in an entire year of trench warfare before the idea was first offered in December of 1915 in a paper written by Colonel Maurice Hankey.¹⁸¹ This observation later prompted Churchill to write:

the suggestion in Colonel Hankey's paper ... ought to have been developed in the long interval that has passed. The problem of crossing two or three hundred yards of open ground and traversing or destroying barbed wire in the face of rifles and machine guns ... ought not to be beyond the range of modern science, if sufficient authority had backed the investigation. The absences of any satisfactory method cannot be supplied by the bare breast of gallant men.¹⁸²

Churchill's lament provides the technology strategist a warning to aggressively seek solutions before and during conflict. While the ideal goal is to correctly predict the current and future OD balance, a technology strategist who quickly acknowledges an incorrect prediction and adapts can save thousands, if not millions, of lives.

Figure 7 also highlights the importance of continually reevaluating an OD balance evaluation. Notice how in key time periods such as the Mexican-American War (1846-1848) and WWI (1914-1918), the perception of the balance and the actual balance were moving steeply in opposite directions. This reciprocating movement suggests a possible *observer's effect* on the OD balance during wartime. As strategists are observing the effect of their technologies, they are often simultaneously developing technologies that disrupt that balance. The resulting oscillation between perception and actual balance shown in Figure 7 is thus

¹⁸⁰ A reference to the Hornsby and Holt caterpillar tracked tractors designed and developed prior to 1910. The modern internal combustion engine was developed and available commercially in the late 1800s. See Etienne Lenoir and Nicolaus Otto.

¹⁸¹ John Simkin, "Maurice Hankey," Spartacus Educational, 2022, <https://spartacus-educational.com/FWWhankey.htm>. See also John Naylor's biography of Hankey.

¹⁸² Winston S. Churchill, *The World Crisis, 1915* (Newburyport, UNITED STATES: Rosetta Books, 2013), 317, <http://ebookcentral.proquest.com/lib/ebook-nps/detail.action?docID=5503197>.

expected and perhaps unavoidable, but the magnitude can be controlled by a strategist who limits the weight of the previous balance in their evaluation of the future balance.

c. The OD Balance Is a Lesser Explanatory Variable Than Others

A common argument against ODT, is that the OD balance is a lesser causal variable in predicting conflict compared to other variables such as political aims. In his book *War and the Engineers*, Keir Lieber concludes that “political and military elites tend not to shape their strategies on the basis of military technology but rather to view the utility of the new technologies through the lens of their current strategies.”¹⁸³ Similarly, Colin Gray states “Governments, not weapons, make war.”¹⁸⁴ Proponents generally acknowledge these arguments and are quick to point out that ODT variables are not causal variables of conflict, they are stability predictors. Any theory attempting to predict the cause of a conflict would certainly need to consider political, domestic, and social variables.¹⁸⁵ ODT predicts stability and likelihood of conflict, not the cause of conflict or if a conflict will occur. To use a simplistic analogy, ODT tells the strategist the amount of dry kindling on the forest floor, not the source of the spark or if an actual fire will occur.

The challenges to ODT’s predictive power do, however, highlight the most important technology strategy takeaway from the theory—a strategist may need to employ a strategy that defies the technological state of play due to any number of political, military, or social factors. Ideally in a defense-dominant system a military would avoid offensive actions. However, due to other causal factors, a military strategist may predict a conflict against the balance in the future. In this instance, the strategist’s ability to show the disproportionate cost of one strategy over the other may enable a more persuasive argument to decision makers,

¹⁸³ Lieber, *War and the Engineers*, 153.

¹⁸⁴ Colin S. Gray, *House of Cards: Why Arms Control Must Fail*, 1st edition (Ithaca: Cornell Univ Pr, 1992), 26, 28.

¹⁸⁵ For an excellent response to this criticism see Lynn-Jones, “Offense-Defense Theory and Its Critics,” 686.

suggest research into balance shifting technology, or at the very least ensure adequate resources are understood and allocated to overcome the starting disadvantage.¹⁸⁶

d. The Role of Information Systems in the OD Balance is Underdeveloped

The continuing growth of information systems poses a challenge for ODT. Information systems are difficult to label as defensive or offensive because the traditional elements of firepower and mobility are rarely apparent in these systems. Even in the pure information domain (i.e., the cyber domain) while operations themselves are often easy to differentiate, the base technologies such as computers and network systems, are difficult to characterize and are very much context dependent.

The incorporation of information systems into weapon systems similarly confuses the distinction of offense and defense characteristics of these technologies. For instance, networked *smart weapons* are now capable of arming, disarming, changing targets, and flight patterns while in flight.¹⁸⁷ This merger of weapons and information systems adds maneuverability to the weapons independent of their delivery systems which traditionally may have limited their mobility. The merger of information systems into other technologies may therefore have significant effects on the OD balance.

Even on their own, the effects of the development of information technologies is undeniable. In WWII, the Allies breaking of the Japanese codes, enabled precise targeting of Japanese submarine and surface ships greatly reducing their offensive advantage without benefiting firepower. Similarly, the development of ULTRA allowed the Allies to decode German messages and greatly increased their information advantage.¹⁸⁸

¹⁸⁶ An excellent example of this situation is the tensions between Taiwan and China from a U.S. perspective. China's development of long-range missile technology and additional A2/AD technologies has shifted the balance strongly in favor of the tactical defensive. U.S. ships coming to the aid of Taiwan would be highly vulnerable to Chinese missile attacks. Yet, China has made numerous statements on its intent to retake Taiwan. Under current conditions U.S. support of Taiwan would be fighting against the OD balance.

¹⁸⁷ Thomas Newdick and Joseph Trevithick, "The Age of Swarming Air-Launched Munitions Has Officially Begun with Air Force Test," *The Warzone*, 2021, <https://www.thedrive.com/the-war-zone/38604/the-age-of-swarming-air-launched-munitions-has-officially-begun-with-air-force-test>.

¹⁸⁸ "War of Secrets: Cryptology in WWII," National Museum of the United States Air Force, accessed April 21, 2022, <https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196193/war-of-secrets-cryptology-in-wwii/>.

More recently, a U.S. war game against an adversarial China showed an undesired effect of information system reliance. When asked how the U.S. information-network-dependent offensive strategy fared, Gen John Hyten stated, “It failed miserably.”¹⁸⁹ The adversary jammed U.S. networks and successfully destroyed many the offensive advantages by reducing the U.S. ability to communicate, coordinate, and concentrate forces. The United States’ over-dependence on networks combined with effective disruption gave a net defensive advantage.

The mixed results suggests that the effect of information systems may be best described as positive and negative exponents, able to increase advantages in one application but decrease them in another depending on their application and the level of reliance placed on them. Much more research and thought are required; however, enough is clear to state that the increasing incorporation and development of information systems will create exponential increases in the capability of offensive and defensive systems. But these advantages may wax and wane with the adaptation of the enemy and there is a distinct possibility that the same information technology that gives an army its advantage also makes it vulnerable.

e. The Relationship Between the Character of Conflict and the OD Balance

Most examinations of the OD balance focus on its ability to predict traditional armed conflict among states. However, this simplistic definition of stability may overlook a strong relationship between the balance and the character of conflict. The word *conflict* is chosen instead of war, because the character of war implies an examination of directly accountable hostilities which are becoming increasingly rare. By contrast, the character of conflict is broader and simply describes the means and ways nations or states use to inflict cost on one another. The character of conflict has changed over time and these changes have often occurred under a strong defensive balance.

The most prominent example of the change in the character of conflict is the effect of nuclear weapons. As noted in the Cold War vignette in Chapter III, while the nuclear arms

¹⁸⁹ Chris Dougherty, “Confronting Chaos: A New Concept for Information Advantage,” *War on the Rocks*, September 9, 2021, <https://warontherocks.com/2021/09/confronting-chaos-a-new-concept-for-information-advantage/>.

race created a strong deterrence between the U.S. and Soviet Union, the two countries continued to inflict pain on each other by funding insurgencies and ideological conflicts in unstable countries as well as other covert espionage acts. For instance, the Soviet Union is estimated to have spent upwards of \$8 billion to support North Vietnamese opposition to the U.S. during the Vietnam War, while avoiding sending large components of its own military.¹⁹⁰ Similarly the U.S. spent ~\$5 billion USD to support the Mujahadeen against the Soviets in the Soviet-Afghan war while avoiding sending U.S. troops.¹⁹¹ While there are certainly a multitude of factors, the strong nuclear defensive balance certainly did not stop conflict from occurring, it just changed the form, or character, of conflict.¹⁹²

It is notable that a similar change is happening presently due to the nuclear defensive stalemate. When Russia invaded Ukraine in February 2022, Western allies, as well as a majority of the world's largest nations, banded together to conduct a quasi-economic-war on Russia. Even nontraditional and non-state actors, such as major corporations like Disney and Apple and the hacker group Anonymous, took action to inflict economic cost on Russia by either curtailing or stopping operations in the country. These measures combined with more traditional measures from state actors, such as the U.S. and Britain supplying advanced munitions.¹⁹³ The West chose this form of response because traditional military responses would have involved a clash of nuclear powers that could escalate into nuclear war.¹⁹⁴ Again, the strong defensive balance of nuclear weapons has created a change in the character of

¹⁹⁰ "Soviet Aid to North Vietnam," GlobalSecurity.org, accessed March 6, 2022, <https://www.globalsecurity.org/military/world/vietnam/hist-2nd-indochina-ussr.htm>.

¹⁹¹ Douglas Martin, "Charlie Wilson, Texas Congressman Linked to Foreign Intrigue, Dies at 76," *The New York Times*, February 11, 2010, sec. U.S., <https://www.nytimes.com/2010/02/11/us/politics/11wilson.html>.

¹⁹² The effect of nuclear stalemate or mutually assured destruction between two large nuclear powers is generally seen as strongly supporting a defensive balance. See Jervis, "Cooperation Under the Security Dilemma," 184.

¹⁹³ Marisa Dellatto, "Netflix, TikTok, Credit Card Companies Suspend Service—Here's The List Of Companies Cutting Ties With Russia Over Invasion," *Forbes*, accessed March 6, 2022, <https://www.forbes.com/sites/marisadellatto/2022/03/06/tiktok-credit-card-companies-suspend-service-heres-the-growing-list-of-companies-cutting-ties-with-russia-over-invasion/>.

¹⁹⁴ "Remarks by President Biden on Russia's Unprovoked and Unjustified Attack on Ukraine," The White House, February 24, 2022, <https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/02/24/remarks-by-president-biden-on-russias-unprovoked-and-unjustified-attack-on-ukraine/>.

conflict. ODT scholars have yet to fully explore this vitally important aspect. For the technology strategist the message is quite simple, a defensive balance does not mean the absence of conflict.

The preceding paragraph and indeed most of the ODT literature focuses on state-on-state conflict. But a strong argument exists that intrastate violence requires a separate evaluation as does conflict between states and nonstate actors. As an example, while ODT notes that nuclear weapons have produced a strongly defensive balance, this balance failed to provide operational or tactical advantages or even sufficiently aid in the analysis of the OD balance in Korea, Vietnam, and the U.S.–Afghanistan conflicts. In fact, despite nearly unanimous agreement among ODT proponents that the world has remained in a state of defense dominance for the last 50 years, intrastate (insurgent) violence has continued to grow globally. ODT theory would suggest that because this type of conflict is more common and growing, it exists in a strategic environment that is likely offensively dominant—a point argued persuasively by Robert Taber in *The War of the Flea*.¹⁹⁵ Figure 8 shows this trend.

¹⁹⁵ Robert Taber, *War of the Flea: The Classic Study of Guerrilla Warfare*, Reprint edition (Washington, DC: Potomac Books, 2002), 10–12. Taber’s perspective is insurgents are strategically offensive and tactically defensive. Inversely the counterinsurgent is strategically defensive and tactically offensive. The technological component is not discussed directly by Taber, but this author’s own experience notes that insurgencies maximize the use of commercial communication and information technologies to fight a narrative warfare and exploit mistakes by the counterinsurgents. A notable example is the use of social media to show dead non-combatants and make claims that the counterinsurgents killed innocents. This had the effect of forcing the counterinsurgents, the U.S. in this case, to utilize lower yield, less effective weapons and take less risks, and therefore less shots, when engaging combatants for fear of collateral damage. In essence, the insurgents exploited information technologies to reduce the effectiveness of the U.S. firepower and technological superiority.

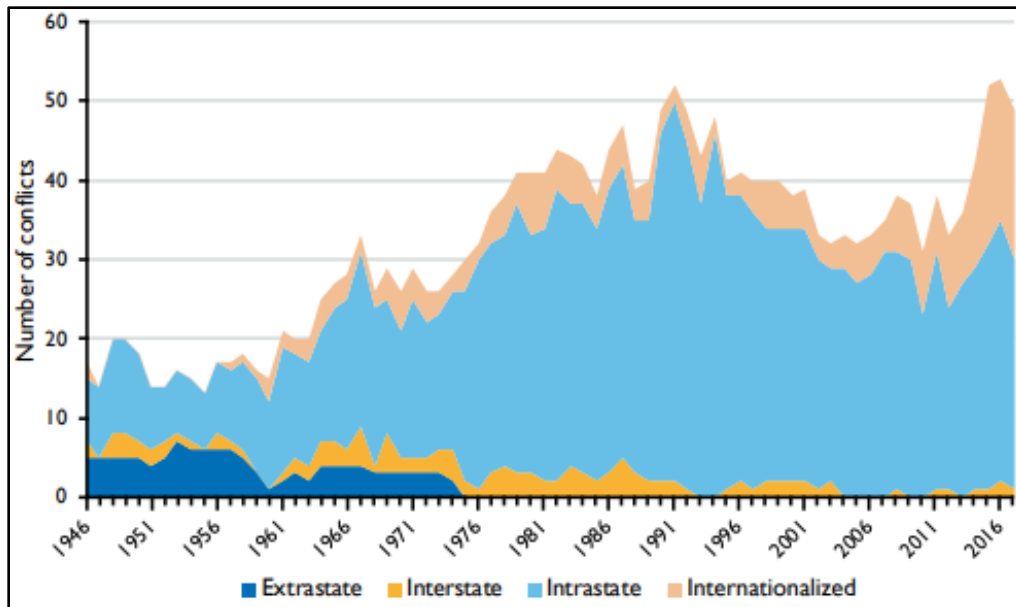


Figure 8. Number of Armed Conflicts by Type of Conflict, 1946–2017 ¹⁹⁶

Because a vast majority of ODT literature is limited to conflicts among states the most common type of conflict in the current age is underdeveloped in the theory. Given the prevalence of state-sponsored insurgencies and proxy wars seen throughout the Cold War and during the Global War on Terror, ODT’s omission of this type of conflict risks the theory’s relevance now and in the future. A more appropriate approach for ODT and for a technology strategist is to examine the balance based on the predicted players and the evolving character of conflict. This approach would place different type of conflicts and players in buckets and examine the players in line with van Creveld’s observation that the best technology strategy is one that “achiev[es] a close fit between one’s own technology and that ... fielded by the enemy.”¹⁹⁷ Each bucket would lead a strategist to ask “what is the balance between country A and B in the conventional realm, the nuclear, insurgency, grey

¹⁹⁶ Source. Kendra Dupuy and Siri Aas Rustad, “Dupuy, Rustad- Trends in Armed Conflict, 1946–2017, Conflict Trends 5–2018.Pdf,” Conflict Trends Project (Peace Research Institute Oslo (PRIO), 2018), 2, <https://reliefweb.int/sites/reliefweb.int/files/resources/Dupuy%20Rustad-%20Trends%20in%20Armed%20Conflict%201946%E2%80%932017%20Conflict%20Trends%205-2018.pdf>.

¹⁹⁷ van Creveld, *Technology and War*, 320.

zone, etc.?” Each inquiry guiding the strategist in choosing a technology emphasis thereby producing a more nuanced, applicable, and adaptable technology strategy.

4. Questions to Guide Technology Strategy Formulation

Distilling the above examination of ODT, two key questions fall out that can aid in building a technology strategy. These questions serve as starting points in defining the structure of a new technology strategy. The first question is: What is the current (or future) balance and who has the cost advantage? The OD balance is a ratio of the cost of defending versus attacking. To employ an offensive strategy in a defensively dominated environment means the attacker will expend more blood and treasure than the defender. Assuming the technology strategist has the ability to choose between an offensive or defensive strategy, aligning with the balance would seem the most appropriate course of action. However, as witnessed, the strategist may have to fight against the balance due to political or other constraints. Understanding the balance and the political context leads the strategist to the second question.

The second question is: Given a known balance, what are the options? From this question, we can intuitively deduce three basic options. 1) The strategist can choose to match the balance (i.e., fight fire with fire), 2) pay the cost of fighting uphill against the balance but utilize technology to attempt to reduce the disadvantages, or 3) provided there is sufficient research and development time, invest in technology specifically designed to shift the balance. Most strategies are likely to incorporate varying degrees of these three options and begin to make technology strategy decisions in concert. Chief among these strategic decisions will be the desired technological emphasis approach (imitate, develop, or monitor) discussed in Chapter II. The chosen approach and the way it answers the proposed OD balance questions will certainly affect the form of the technology strategy. This was the case with the French technology strategy in the interwar period, which is explored in the next section.

The two questions presented, and the following analysis are meant to provide a technology strategist with an increased understanding of the connection between the technological state of international affairs and their individual technology strategy. It is

perhaps easier to focus on the internal desires of a specific nation, service branch, or a smaller entity's desire when making technological decisions. The loss of the connection between the strategic intent and environment is a key purpose of the concept of technology strategy explored in this study. Failure to understand the connection between one's own technology strategy and the state of the strategic environment, of which OD balance is one descriptor, could have disastrous consequences. The French technology strategy explored in the next section perhaps best illustrates this risk.

B. CASE STUDY THREE: INTERWAR FRANCE (1919-1939)

The following vignette explores how the French evaluated the OD balance throughout the 1920s and 30s and how this evaluation affected their military preparations. The examination finds that the French perception of defense dominance had significant effects on their doctrine, organization, and technology decisions. The results of the Battle of France suggests that the French incorrectly evaluated the balance; however, their early preparation and devotion to their perception for almost two decades, provides an excellent case study for technology strategy characteristics.

1. Vignette

The rapid defeat of France in 1940 is a well-studied curiosity in military history. It is indeed perplexing that France and the British Expeditionary Forces (BEF) would lose so quickly. After the Great War, France was the first to turn their attention to preparation and maintained a constant focus on military development while others spent much of the 1920s devoted to economic issues. France, expected a coming war with Germany. As Robert Doughty notes,

After WWI, the French army devoted considerable effort to create the best possible and most modern doctrine ... By 1939 the French army had adopted much new equipment and many new ideas and its doctrine different distinctly from that of 1918. It had conducted extensive tests with new equipment. It had devoted more efforts and resources to analyzing advanced weapons ... than any other army.¹⁹⁸

¹⁹⁸ Doughty, *The Seeds of Disaster: The Development of French Army Doctrine, 1919–39*, 5.

France certainly had a good reason to prepare. In a parliamentary meeting discussing the inadequacies of the Treaty of Versailles, the Heroic Sergeant André Maginot summed up the French spirit directly: “We are always the invaded ... we are always the ones to suffer ... to be sacrificed. Fifteen invasions in less than six centuries gives us the right to demand ... something more realistic than temporary solutions and uncertain hopes.”¹⁹⁹ Similarly, General Ferdinand Foch, the WWI Commander of Allied Armies in 1918, commented that the treaty was closer to a “twenty-year truce” between Germany and France instead of an end to the war. Thus, the French entered the 1920s with a strong drive to prepare for “the German threat.”²⁰⁰

The French spent the next two decades devoting immense resources to building a massive system of fortifications, redesigning their air force, and developing tanks. By 1940, France also managed to gather an allied army of ~3.3 million troops supported by an enormous gathering of artillery. The French were ready to fight a long war using curtains of intense artillery fire and well-armed infantry troops supported by tanks. But this updated version of WWI was precisely the type of war Germany had no interest in fighting.

On 10 May 1940, the Germans employed a new doctrine that brought rapid mobility to the battlefield and displayed a dramatic shift to an offensive balance, contributing to the quick defeat of France and the BEF. Fast-moving German Panzer tanks assisted by tactical aircraft blazed through the under-protected Ardennes Forest on the French northeastern front and crossed the Meuse River at Houx. The French were so surprised they took nearly four days to react.²⁰¹ The German Blitzkrieg tactics brilliantly blended information, delivery, and weapon systems by using on-board radios in tanks and aircraft to coordinate rapid penetration operations that quickly dashed around the surprised French defenses.²⁰² The French and Allied defensive line, despite outnumbering the Germans in artillery (~13k to 7k) and tanks

¹⁹⁹ Vivian Rowe, *The Great Wall of France: The Triumph of the Maginot Line*, 1st ed. (New York, NY: Putnam, 1961), 17.

²⁰⁰ Brent L. Sterling, *Do Good Fences Make Good Neighbors? What History Teaches Us about Strategic Barriers and International Security* (Washington, D.C: Georgetown University Press, 2009), 211.

²⁰¹ May, *Strange Victory*, 452.

²⁰² For an informative summary of the German Blitzkrieg tactics from a techno-strategic integration perspective see Carter, “Techno-Strategic Integration.” 133–144

(3200 to 2500), were quickly surrounded resulting in the capture of over a million troops and the capitulation of France.²⁰³ In a matter of weeks, France went from being the most prepared country, possessing the largest standing army, the most advanced tanks, the greatest artillery, and a modern marvel of defensive fortifications to surrendering to the very country it had been preparing to fight for twenty years.

2. The French Analysis of the OD Balance

How could such a disaster have happened? Timing and luck play into any conflict, and it is certainly possible that the Germans got lucky. The Germans had good fortune to find a location at the town of Houx on the Meuse River that could be crossed without alerting the French and without constructing a bridge.²⁰⁴ The Germans also benefited from the French's slow realization that the main attack was not in Belgium but through the Ardennes—taking days to react. Yet frequently historians who study the conflict conclude that while Germany did experience several lucky breaks, the French were underprepared to deal with the inherent role of chance in war. Despite early and long-standing preparation, the French approach to defense was “too pedantic, too theoretical, and not practical enough” or and they displayed a “lack of imaginativeness.”²⁰⁵

What then caused the French to pursue misdirected defensive preparations? The French devotion to the defense and the superiority of *puissance de feu* (firepower) are often seen as anchors preventing the French from seeing the changing balance over the interwar period. While visionaries like Charles De Gaulle offered a counter view, they were largely ignored and often politically attacked. As the noted historian and French patriot Marc Bloch would later lament, “as a nation we had become content with incomplete knowledge and imperfectly thought-out ideas. Such an attitude is not a good preparation for military success.”²⁰⁶ In the end, the French continued to cling to a belief in the superiority of the

²⁰³ R. H. S. Stolfi, “Equipment for Victory in France in 1940,” *History* 55, no. 183 (1970): 12.

²⁰⁴ May, *Strange Victory*, 408.

²⁰⁵ May, 460 and the second quote is from; Doughty, *The Seeds of Disaster: The Development of French Army Doctrine, 1919–39*, 195.

²⁰⁶ Marc Bloch, *Strange Defeat*, 1st Edition (New York, NY: W. W. Norton & Company, 1999), 143.

defense, a belief that depended on the Germans fighting the war that France wanted to fight—a defensive war in an offensive dominant world.

Analysis of the French doctrinal evolutions from the end of WWI until 1940 shows that the French believed that maintaining superiority in firepower was the key to victory.²⁰⁷ They built their military around a meticulously controlled and robust artillery corps, believing that a nation that could most effectively control and concentrate its firepower would be victorious. In contrast they treated mobility as subordinate to firepower in its ability to create battlefield affects. “The French perceived maneuver, at any stage of a campaign, predominantly in the sense of moving units in order to have them deliver fire or of moving fire without moving units.”²⁰⁸ As Doughty further explains, “Reliance on firepower, according to the French, ruled against subtle maneuvers on the battlefield because of the difficulty in massing and controlling material means ... this limited view of maneuver dominated their doctrine.”²⁰⁹ Even if advances in mobility were to help with massing and controlling material, the French felt that “these extensive maneuvers are as favorable to offensive purposes as to defensive ends.”²¹⁰

The French Army’s writings throughout the interwar period reflected a belief that the OD balance would remain firmly in favor of the defensive. Both their 1921 and 1936 versions of army doctrine show a strong preference for the defense and changed little between the two versions. One document endorsed directly by the French High Command provided a clear summation of the French evaluation of the balance. The 1939 published work of General Narcisse Chauvineau titled, “*Une Invasion Est-elle Encore Possible?*” glorified the defense stating that “in a strongly conducted defense, casualties would be much lower than those suffered in an offensive battle.”²¹¹ Going as far as to provide an numerical estimate of the

²⁰⁷ Doughty, *The Seeds of Disaster: The Development of French Army Doctrine, 1919–39*, 77.

²⁰⁸ Doughty, 97.

²⁰⁹ Doughty, 97.

²¹⁰ B. H. Liddell Hart, “A Study of the French ‘F. S. R.’: Instruction Provisoire Sur L’Emploi Tactique Des Grandes Unités,” *Royal United Services Institution* 667, no. 468 (December 1922): 666, <https://doi.org/10.1080/03071842209420224>.

²¹¹ Doughty translates the title as “Is Invasion [of France] Still Possible?” see Doughty, 77.

balance, Chauvineau stated “to attack a continuous front, the enemy would require three times as many infantry, six times as much artillery, and 15 times as many shells as did the defender.”²¹² Far from being just another opinion in the crowd, Marshal Henri Pétain, the French minister of war and outspoken advocate of the defensive doctrine, penned the preface to Chauvineau’s work thereby giving it the “unmistakable stamp of High Command approval.” It seems strange in hindsight that Chauvineau’s numbers did not lead the French strategists to conclude that an enemy would look for every opportunity to maneuver around such a considerable obstacle. Perhaps, this would have led them to examine the Ardennes gap more closely. It is possible the French simply believed that the OD balance was firmly defensive and no advances in mobility were going to upset the balance.

The counter view focused on offense and armored maneuver warfare and was championed in two writings by Charles De Gaulle. In his writings *Le fil de l’épée* [*Edge of the Sword*] and *Vers l’armée de métier* [*The Army of the Future* or sometimes translated as *Toward the Professional Army*], De Gaulle argued that war should not be interpreted as an application of rules and that an offensive and flexible mindset was key to victory in both the commander and the units they commanded. A significant part of De Gaulle’s flexible mindset was the ability to recognize the changes in warfare created by the evolution in technology and how to apply them. In 1934 he stated, “the last war saw the power of machinery reach an unheard-of degree, but it was brutal and unstable. By adding to it (*sic*) speed, in the hands of a select body of men [professional soldiers], the future will restore to it some of its former character.” Yet leaders such as Marshal Pétain and General Maurice Gustave Gamelin failed to “understand the true potential of armor” and De Gaulle’s ideas were rejected both in the military and in the larger French government.²¹³

²¹² Alvin D. Coox, “General Narcisse Chauvineau: False Apostle of Prewar French Military Doctrine,” *Military Affairs* 37, no. 1 (1973): 16, <https://doi.org/10.2307/1986565>. 16.

²¹³ Robert A. Doughty, “De Gaulle’s Concept of a Mobile, Professional Army: Genesis of French Defeat?,” *The U.S. Army War College Quarterly: Parameters* 4, no. 1 (July 4, 1974): 33, <https://doi.org/10.55540/0031-1723.1064>.

3. The French Doctrine

The dominant French belief in firepower and assumption of a static OD balance supported the development of an innovative, but largely regarded as slow and ineffective, warfighting concept they called “methodical battle.”²¹⁴ They believed that the strength of the army lay in its artillery, which needed precise control. The French continually stressed the importance of applying a curtain of artillery fire in support of infantry and mechanized movements. Interestingly this tied the mobility of the army to how fast its artillery could move. In this sense, “they saw mobility simply in terms of how to apply firepower.”²¹⁵ But synchronizing all these movements was complicated by “their preferences for short-range attacks with numerous phases and bounds, the length time required to displace artillery, [and] the use of standard densities to compute the amount of artillery needed.”²¹⁶ The French concluded that a high degree of control would be needed to methodically coordinate all these elements and this could only be executed from the highest levels. The concept of “methodical battle” was thus a doctrine based on centralized control and execution.

4. The French Technology Strategy

The French focus on firepower, defense, and methodical battle had significant effects on their technological development choices. Among these decisions three areas of pursuit were unique to the French belief. The most prominent example is perhaps the expensive, impressive, but largely ineffectual Maginot Line. The system of fortification absorbed as a majority of French resources but played a limited role WWII. Similarly, the French dedicated much time and effort to the development of tanks and produced nearly the same number of tanks as the Germans. However, the French envisioned an unimaginative use of their tanks and developed them in ways that reduced their capabilities. Finally, the French’s disastrous aircraft development ideas based on building a slow, clunky, and wholly incompetent *multiplace de combat* (multipurpose) aircraft, resulted in years of poor spending and a fleet of aircraft that were obsolete nearly from the moment they were built. Indeed, the French

²¹⁴ Doughty, *The Seeds of Disaster: The Development of French Army Doctrine, 1919–39*, 4.

²¹⁵ Doughty, 116.

²¹⁶ Doughty, 115.

technology strategy suffered greatly from the devotion to an inaccurate view of the state of the balance and internal dogma.

a. The Maginot Line

The idea for the system of fortifications eventually called *The Maginot Line* originated in a paper written by Marshal Henri Pétain. The paper titled “Note au sujet de l’organisation défensive du territoire” [Note on a Defensive Organization of the Country] stated that “Modern defense systems ... can no longer be anything else than battlefields for armies, pre-arranged in times of peace.”²¹⁷ Greatly influenced by his experiences in WWI, Pétain believed that wars would continue to resemble “one continuous frontier battlefield” much as they did in the western fronts of WWI.²¹⁸ Driven by this assumption, and a political desire to maintain a small standing army in peacetime, France decided to rely on technology to build defensive lines they could resist an enemy long enough to gather an army or even deter an enemy from attacking altogether. Debate over funding, locations and dimensions of the fortifications continued, but by 1929 France began construction on the Maginot Line.

The Maginot Line was neither a wall nor even a continuous line. It was a system of fortifications with gaps designed to channel an attacking army. In the gaps between fortifications the French planned to station “interval troops” equipped with heavy firepower to meet any attacking Germans. Figure 9 shows a brief overview of the location of the Maginot wall. Notably, the most robust system of fortifications was along the Franco-German border and referred to as the Maginot Line Proper. The Proper line was still not a continuous line but was much more robust and is shown with a solid line in Figure 9. The dotted lines in Figure 9 represent less robust fortifications and often only consisted of small fortifications commonly called “pill-boxes [or] *maisons fortes* [strong houses]” containing a turret and/or gun position.²¹⁹ As of 1939, the French Army planned to have only five of these fortified positions per mile, although the number was later increased.²²⁰

²¹⁷ Rowe, *The Great Wall of France*, 24.

²¹⁸ Rowe, *The Great Wall of France*, 24.

²¹⁹ May, *Strange Victory*, 390.

²²⁰ Bloch, *Strange Defeat*, 390.

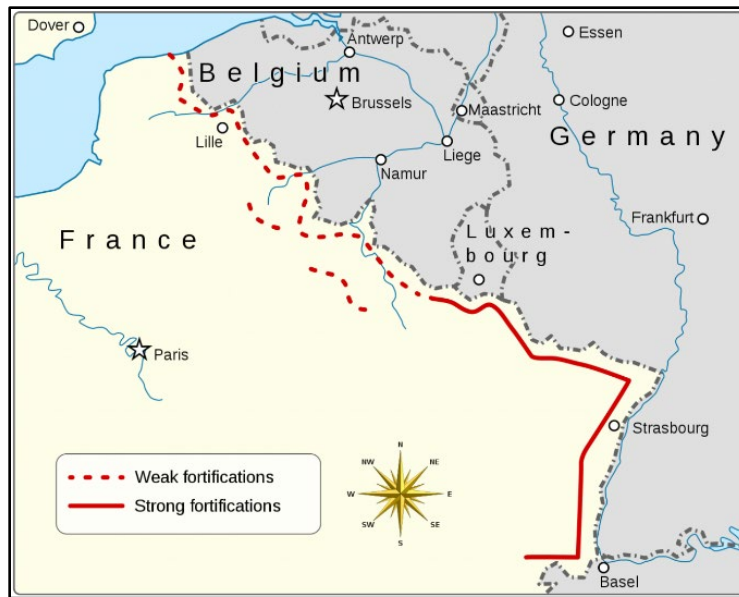


Figure 9. Location of the Maginot Line's Weak and Strong Fortifications.²²¹

The weapons chosen to arm the fortifications is telling of France's preferences for the predominance of fire and dismissive view of mobility. The French planned the average Maginot Line Proper fortification to have four to five 75-mm guns and one to two 135-mm howitzers as well as two 81-mm mortars. Beyond artillery, the Maginot Line fortresses consisted of what one author called "giant armored mushrooms" where machine guns allowed the line defenders to lay down curtains of fire on approaching troops.²²² The fortresses contained housing for troops, ammunition storage, food, water, and filters to avoid poison gases.²²³ They were exactly the tools to emphasize in a defense-dominated war. Figure 10 shows several select images of the Maginot Line's fortification and armament.

²²¹ Michael Peck, "What Your History Teacher Told You about the Maginot Line Is Wrong," The National Interest (The Center for the National Interest, September 3, 2019), <https://nationalinterest.org/blog/buzz/what-your-history-teacher-told-you-about-maginot-line-wrong-77666>.

²²² Joseph Erich Kaufmann and Hanna Wanda Kaufmann, *The Maginot Line: None Shall Pass* (Westport (Conn.) London: Praeger, 1997).

²²³ Kaufmann and Kaufmann.



Figure 10. Select Images of the Maginot Line.²²⁴

However, the Maginot Line Fortification neglected several important requirements. Most notably, none of the main fortifications contained any specifically designed or dedicated anti-aircraft weaponry. The fortresses relied on deep placement underground with narrow turrets reaching the surface for protection. But, while these perhaps provided protection for the occupants, it did not allow the Maginot Line to attack the enemy aircraft.²²⁵ The decision not to equip the fortresses with such an important weapon is strange, since Marshal Pétain frequently stated that the continual development in anti-aircraft ground fire would greatly reduce the effectiveness of attack aircraft—an argument he used frequently to dismiss the necessity of an independent Air Force.²²⁶

Similarly, as German assaults on lesser fortifications to the north would later prove, the fortifications could stop or deter large masses of troops but were highly vulnerable to small teams (a lesson that the Germans perhaps learned or at least confirmed in their assault

²²⁴ Andrei Steven, “16 Interesting Facts about the Maginot Line,” *Historyforce.Com* (blog), October 21, 2021, <https://historyforce.com/16-interesting-facts-about-the-maginot-line/>.

²²⁵ Kaufmann and Kaufmann, *The Maginot Line*, 142.

²²⁶ Greg Baughen, *The Rise and Fall of the French Air Force: French Air Operations and Strategy 1900–1940* (Stroud: Fonthill Media, 2018), 66, 70. Baughen also notes however, that years later when Pétain is brought out of retirement and put in charge of all air defense issues, his views on the utility of air power seemed to change but his opposition to an independent Air Force did not.

on Eben Emael in Belgium).²²⁷ This design flaw left the fortifications vulnerable to small engineer teams capable of jumping from crater to crater and attaching explosives to the turrets. The small team vulnerability fits with the French's own doctrine that disregarded the importance of specialized small teams preferring to focus on large concentrations of infantry.²²⁸ The oversights in the Maginot Line, and the heavy prioritization of artillery is reflective of the French belief in the superiority of a defensive strategy with firepower dominance.

b. Tanks

While the French believed tanks were vital to future warfare, they envisioned the tank as one cog in the methodical battle machine. The 1921 version of the French doctrine placed the employment of tanks under the subject of *Infantry* and regarded the tank as a supporting instrument. In his review of their doctrine in 1921, Captain B.H. Liddell Hart remarked that “this assignment to a purely auxiliary role scarcely seems in accordance with the principle of economic distribution of force, when the speed of the latest types of tanks is (*sic*) taken into consideration.”²²⁹ But the relegation to a support role did not mean the French were not interested in tanks. In fact, they spent a considerable amount of time building and developing tanks and by 1940 had stationed greater numbers of tanks on the northeastern front than Germany.²³⁰ According to one author, the French not only possessed greater numbers but also the “most powerful tank.”²³¹ The Char B1 (Figure 11) was praised as “an element of technical surprise and superiority” based on its combination of heavy armor and dual 47mm and 75mm cannons.²³² The author, like the French, clearly equated being powerful to being well-armed and armored and the Char B1 certainly had both. At the first tank battle at

²²⁷ May, *Strange Victory*, 395–96.

²²⁸ Kaufmann and Kaufmann, *The Maginot Line*, 142.

²²⁹ Liddell Hart, “A Study of the French ‘F. S. R.’: Instruction Provisoire Sur L’Emploi Tactique Des Grandes Unités,” 667.

²³⁰ R. H. S. Stolfi, “Equipment for Victory in France in 1940,” *History* 55, no. 183 (1970): 2.

²³¹ Stolfi, 2.

²³² Stolfi, 2 In his work on the subject, Stolfi describes the Chars B as “best translated as Tank Model B. The implication of the word char is a medium heavy breakthrough vehicle.”

Hannut, the Germans sources would later report that only their 75mm gun equipped Panzer IV was effective against the French armor, leading one analyst to conclude that “fewer than 8 percent of [the German] tanks—50...out of 674—were really effective in tank versus tank combat.”



Figure 11. The French Char B1.²³³

As the Char B1 and other French tanks show, the belief in firepower over mobility and the role of the tank as infantry support was evident in their developmental decisions. Stolfi's work in *Equipment for Victory in 1940*, compares the average capability of the French and German tanks on the northeastern front. Figure 12 is from his work.

²³³ Sebastien Roblin, “France’s Monstrous Char B1 Tank Ate Hitler’s Best Tanks for Breakfast,” The National Interest (The Center for the National Interest, November 20, 2017), <https://nationalinterest.org/blog/the-buzz/frances-monstrous-char-b1-tank-ate-hitlers-best-tanks-23277>.

<i>Average French tank of 3254 in West, May 1940</i>		<i>Average German tank of 2574 in West, May 1940</i>	
Cannon (calibre)	42·4 mm.	Cannon (calibre)	27·3 mm.
Cannon (velocity)	517 m./sec.	Cannon (velocity)	658 m./sec.
Armour (20° slant)	33·2 mm.	Armour (15° slant)	19·9 mm.
Speed (road)	20·1 m.p.h.	Speed (road)	26·5 m.p.h.
Range (road)	89 miles	Range (road)	110 miles

Figure 12. Comparison of French and German Tanks in May of 1940²³⁴

Stolfi's chart serves as a perfect example of the different technological development choices of an offense versus defense leaning nation. France's defense doctrine led to technological emphasis of armor and firepower, while Germany pursued faster speed and range. Resulting in the French having superiority on a fixed front, but only if their armor was close enough to meet the enemy. A point identified by Liddell Hart as early as 1922 in his review of their doctrine when he stated, "The French regulation appears at fault in disregarding the use of tanks and armored cars for the pursuit." As noted earlier in their doctrine, the French preference of defense and use of tanks as support to infantry clearly affected their design decisions.

c. Aircraft

In the French Air Force, the shortage of resources due to heavy spending on the Maginot Line, global depression, and rebuilding efforts led to a technology strategy that suffered from frequent changes in emphasis. The French were constantly searching for the perfect and most efficient use of airpower which resulted in a diverse and wholly inadequate Air Force in the 1940 campaign. As Greg Baughen explains, "the French Air Force failed in 1940, not so much because it was stuck in the past, but because it had been seduced by radical and unproven theories on the way air power would develop in the future."²³⁵ Over-devotion to two theories ultimately spelled disaster for the French Air Force. The first was the belief in the decisive nature of long-range bombing, The second was the misdirected and sustained

²³⁴ Stolfi, "Equipment for Victory in France in 1940," 14.

²³⁵ Baughen, *The Rise and Fall of the French Air Force*, 254.

pursuit of a wholly incapable all-purpose aircraft that the French called the *bombardement, combat and renseignement* design.

The theory that war could be won by long strategic bombing alone was birthed from the writing of *Command of the Air* by Giulio Douhet. His writing increased friction on the proper use of airpower among the French leadership, who were already attempting to settle disputes over the usefulness of an independent air force. Douhet's writing alarmed citizens and politicians on the vulnerability of cities to German long-range bombers. This alarm led to proposals and heavy requirements for fighter type aircraft to protect major cities as well as the development of long-range bombers to threaten German cities as a measure of deterrence. While the Air Ministry tried to develop the new requirements, the Army remained focused on the primacy of the infantry and felt that, while the bombing threat was significant, the primary role of airpower should be to support the infantry in reconnaissance and artillery spotting roles. They continued to battle for their own dedicated aircraft for reconnaissance and artillery support missions, which they felt was the most important role of an air force.²³⁶

The continuing dispute meant that clear priorities were difficult to set. In general, the French army tended to dismiss any notion of an independent role for the air force. Instead, they viewed the aircraft as an extension of the army's mission and therefore felt the army's requirements should be prioritized above all else. General Maurice Gamelin, Chief of the Army Staff, is famously quoted as stating, "There is no such thing as the 'aerial battle' there is only the battle on land."²³⁷

Similarly, and perhaps strangely, despite the WWI lessons on the effectiveness of air support, some top French leaders also did not view the bomber as a battlefield weapon. Even airpower advocates such as Victor Menard, a pursuit plane commander in the French WWI Air Division, maintained that the French air support in the later part of WWI was less effective than demonstrated. He "maintained that German casualties would have been even greater, and French casualties far fewer, if the Air Force had concentrated on supporting the

²³⁶ Baughen, 17.

²³⁷ William L. Shirer, *The Collapse of the Third Republic: An Inquiry into the Fall of France in 1940* (Burlington, VT: Da Capo Press, 1994), 586.

artillery.”²³⁸ These disagreements among priority roles would continue to plague the French and ultimately lead to constant design changes.

In the early 1930s, the French Air Ministry decided to address the disagreements by creating an aircraft that could accomplish all roles. The Air Ministry’s *multiplace de combat* specifications called for a *bombardement, combat and renseignement* (reconnaissance) (BCR) plane that would be “ultra-modern, fast, maneuverable, powerfully armed twin engine [and] ... equally capable of artillery observation, army reconnaissance, tactical bombing, strategic reconnaissance, long-range bombing, escorting, and interception.”²³⁹ The aircraft created under the BCR requirements were best described as airborne “dreadnoughts” with a machine gun covering every approach, medium bomb payload and multiple crew members to manage the workload (Figure 13).²⁴⁰ The desire for efficiency that drove the BCR requirement turned out to be counterproductive. While the French were using the latest in engine advancement to carry their heavy-machine-gun-laden aircraft in the sky, “other nations were exploiting [the much higher power] to achieve speeds undreamed of in France.”²⁴¹ France had again favored firepower over speed, but upon hearing of reports of American and British aircraft flying more than 50km/hr faster than the French BCR aircraft, the Air Ministry concluded that their aircraft would be unable to run down bombers or pursuing fighters. France was going in the wrong direction and needed to shift.

²³⁸ Baughen, *The Rise and Fall of the French Air Force*, 52.

²³⁹ Baughen, 78.

²⁴⁰ Baughen, 69.

²⁴¹ Baughen, 78.



Figure 13. Examples of the Flying BCR Dreadnoughts. Amiot 140 (Top left), The Bloch MB.200 (Top Right), The Breguet 460 (Bottom)²⁴²

Realizing it was building designs that could not keep up with Germany, France shifted its emphasis again. The Air Ministry abandoned the *multiplace de combat* concept and created specifications for specialized aircraft including high-speed bombers, reconnaissance aircraft, and dive bombers.²⁴³ However, this rapid change of emphasis failed to consider the limitations of the nation's industry as "most of the major manufacturers were heavily committed to BCR projects and were loath to abandon the work done and start afresh" on a new bomber. By the end of 1935 they had proposed only a single bomber design.²⁴⁴ However, work on new fighter designs began to quickly emerge and by 1936 aircraft such as the Dewoitine D.501 and the Morane-Saulnier M.S.405 were taking to the air with impressive results. The Dewoitine D.501 in particular was considered the *most heavily armed fighter* in the world—another example of the French's remaining

²⁴² Source. Baughen, 8.

²⁴³ Baughen, 84.

²⁴⁴ Baughen, 85.

desire to maintain firepower superiority.²⁴⁵ Figure 14 shows the characteristically French Dewoitine D.501.



Figure 14. Dewoitine D.501.²⁴⁶

However, despite a concerted effort to catch up in aircraft speed in the late 1930s, the ultimate downfall of the French Air Force technology strategy lay in the delays in dedicated bomber aircraft design, a slow retooling away from BCR aircraft, and the failure to prioritize or truly acknowledge a need for tactical bombing capabilities. In 1938, Air Force General Vuillemin, commander of the French bomber fleet, informed the air minister that due to delays in manufacturing and frequent changes of design “he did not have a single bomber capable of operating by day and his best bomber ... was not even a satisfactory night bomber.”²⁴⁷ Furthermore, Vuillemin felt that “if war should break out in 1938, ... the French Air Force would be wiped out in a week.” The air minister tried desperately to update the bomber fleet and keep up with the continuing advances in fighter aircraft, but the earlier misdirection was impossible to overcome. “In the end, France fell between two stools: it did not have enough combat planes of either the old or the new generation.”²⁴⁸

²⁴⁵ Baughen, 89.

²⁴⁶ Source: “Dewoitine D.501 C.1,” Armedconflicts.com, accessed February 21, 2022, <https://www.armedconflicts.com/Dewoitine-D-501-C-1-t41964>.

²⁴⁷ Baughen, *The Rise and Fall of the French Air Force*, 124.

²⁴⁸ Baughen, 253.

5. What Was the Actual Balance?

Considering the Germany's rapid victory, utilizing an offensive strategy driven by tank and tactical aircraft, one assumes France may have been better served by pursuing an offensive mindset in technological, doctrinal, and organization preparations. By most accounts this assumption holds true. The French Maginot Line, while impressive, was incredibly expensive, costing over 3 billion francs (~\$13 billion U.S. in today's dollars).²⁴⁹ While it is true that purpose of the line was to deter Germany's direct path into France, and that this mission was accomplished, it is irrelevant. The opportunity cost of the immovable fortifications significantly detracted from the resources available to invest in other technologies that may have better supported France's desire to secure its borders. Examining the military expenditures per GDP of France and Germany in Figure 15 paints a similar story.

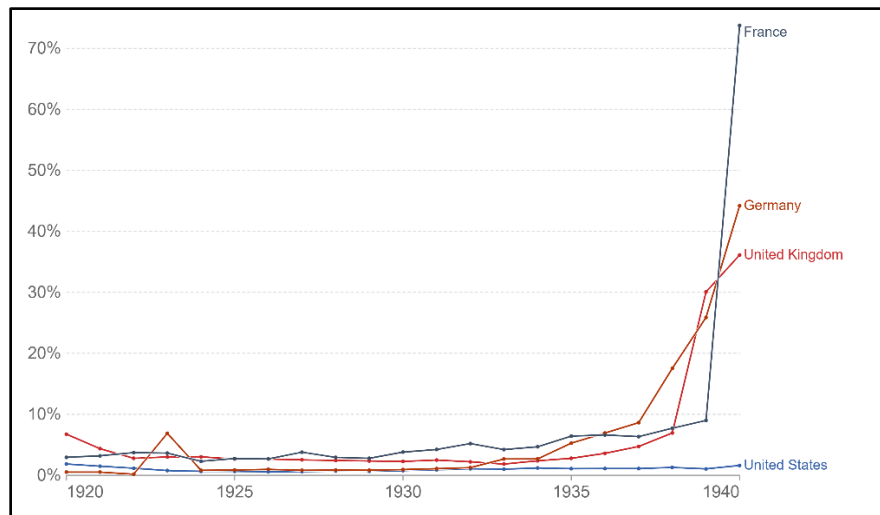


Figure 15. Military Expenditures by Percent of GDP.²⁵⁰

²⁴⁹ Robert Kuttner, "The Economic Maginot Line," *The American Prospect*, August 11, 2011, <https://prospect.org/api/content/1cbcd1aa-b2eb-5855-aa38-61b423041f38/>.

²⁵⁰ Adapted from. Max Roser and Mohamed Nagdy, "Military Spending," *Our World in Data*, August 3, 2013, <https://ourworldindata.org/military-spending>.

Throughout most of the 1920s and 1930s France devoted more of its GDP, (in some cases twice as much) to defense than Germany or any other great power. Such early and consistent expenditures should have led to a France that dominated in tank and aircraft technology, as well as a solid doctrine for utilizing these technologies since their military and government had early on realized the threat of Germany. Unfortunately, France was spending on contextually wrong technologies and/or employing the right technology in the wrong way. The French thinking remained fixed on the balance and ideas of the past. Both the employment of new technologies and their prioritization in development were based on the historical observation that superior artillery firepower would create a static continuous front. But their assumption was incorrect, that balance had shifted from defense to offense.

The advancement of tank and aircraft technologies firmly shifted the balance to offensive and the French defensive mindset in technological development was a poor fit. The creation of a well-armed and continuous front along the entire extent of the eastern border was not fiscally possible nor politically acceptable. Politically, a full extension of the line may have signaled to the Belgians that the French were abandoning them to their fate.²⁵¹ Likewise the cost of the Maginot Line and the additional fortifications were too high to safeguard the entire border. Assumptions had to be made on the most likely course of action of the Germans. Which lead to the conclusion that Germany would attack likely attack through their shared border near the Alsace-Lorraine region (where the Maginot Line was built) or through Belgium as they had in WWI. This large expanse was a great deal of territory to cover under a “pre-arranged” battlefield concept.²⁵²

Perhaps France may have benefited from a highly mobile and agile force that could create a rapid defensive response across a large range of German invasion points—an observation made by Bernard Brodie in *War and Politics*:

...tanks...spearheaded the fateful German thrust through the Ardennes in 1940, but if the French had disposed of a properly concentrated armored reserve, it would have provided the best means for their cutting off the

²⁵¹ Sterling, *Do Good Fences Make Good Neighbors?*, 233–34.

²⁵² Rowe, *The Great Wall of France*;, 24.

penetration and turning into a disaster for the Germans what became instead an overwhelming victory.²⁵³

So, while the French invested in the same potential transformational technologies as the other great powers, they may have failed to fully reap the benefits of these same technologies due to inappropriate specification in the development or misaligned doctrine and organization.

The French believed the balance was defensive and developed their technologies, tanks and aircraft, towards this end. The French attitude towards tanks is best stated by Robert Doughty who concluded, “the French firmly believed that the tank was one of the most important weapons introduced during World War I, but they also believed that the most important function of the tank was to assist the infantry.”²⁵⁴ The French tanks were much slower than their German counterparts and while more powerful, they were employed and developed with the mindset that their primary role was to support infantry movements. In a continuous front war, they assumed the tank would serve the same purpose it had served at Somme and Cambrai and move with or ahead of the infantry under the support of a centrally controlled artillery. Thus, they felt that the tank required only minimal speed and maneuverability to keep up with a soldier on foot—development decisions that shifted the offensively-leaning tank technology toward the defensive.

Similarly, the French Air Force suffered from misdirected priorities. They invested much of their resources into the development of aircraft supporting a mission not aligned with how Germany intended to fight. In the 1940 campaign, Germany virtually ignored French cities and focused its resources on attacking the troops along the front. The French fought hard but were outnumbered in key areas due to over-allocation of French aircraft for protecting cities that were never attacked and piecemealing out to individual army units to act as scouts. The dispersion of aircraft resulted in little air resistance to the German drive through the Ardennes Forest despite scouts detecting the convoys driving with their lights on after

²⁵³ Bernard Brodie, *War and Politics: A Major Statement on the Relations Between Military Affairs and Statecraft* by the Dean of American Civilian Strategists, 1st. edition (New York: Macmillan, 1973), 325.

²⁵⁴ Doughty, *The Seeds of Disaster: The Development of French Army Doctrine, 1919–39*, 141.

dark.²⁵⁵ Furthermore, the dispersion of aircraft certainly contributed to the effectiveness of early German attacks on airfields that were inadequately defended.²⁵⁶

In summary, whereas the Germans were able to concentrate forces with rapidly moving tanks and aircraft, the French organization and doctrine were aligned toward a defensive war based on built up positions on a front and lacked mobility and flexibility. The Germans and French viewed the OD balance antithetically—the Germans offensive, the French defensive—and this heavily contributed to antithetical design choices in their technology, doctrine, and organizational designs.

6. Analysis: What Does the French Example Teach about Technology Strategy?

Exploration of France's technology strategy reinforces previously observed relationships between technology, organization, and doctrine but also notes the existence of a guiding way-of-war paradigm. The case study also highlights new forms of technology strategy and suggests two additional pitfalls and corresponding stratagems. Key highlights include the identification of a triad of strategies necessary for achieving a desired paradigm. Additionally, two forms of technology strategy are identified as well as the crossover-point pitfall. The below sections further explore these observed characteristics.

a. Observed Technology Strategy Relationships

The French case provides further confirmation of the overlapping relationship between doctrine, organization and technology (DOT), but also identifies the presence of a guiding way-of-war ideation or paradigm. The French developed the doctrine of methodical battle due to their belief that technological progress had made firepower the governing principle of war. Their doctrine led to organizational decisions on how and where to place their tanks and aircraft. As the aircraft and tank technologies developed, the French adapted their doctrine and organization although they continued to remain fixed on the primacy of firepower and validity of methodical battle. In this way, technology, doctrine, and

²⁵⁵ Baughen, *The Rise and Fall of the French Air Force*, 190.

²⁵⁶ John Arquilla, *Why the Axis Lost: An Analysis of Strategic Errors*, 2nd ed. (Jefferson, NC: McFarland, 2020), 47.

organizational principles all exerted a continual pushing and blocking effect on one another. The interlocking nature of these three elements agrees with the observations seen in Chapter III and supporting literature and suggests that *technology strategy exists as part of a triad of strategies that includes organizational design and doctrinal development* (sometime referred to as emerging doctrine). The following chapter further explores the DOT relational triad concept.

Notably, the French belief in the superiority of firepower seemed to function as a centralizing way-of-war paradigm in DOT decisions. As the previous analysis shows, the superiority of *puissance de feu* was based on the premise that a future war would be a follow-on version of the Great War. But the validity of paradigm was largely unchallenged, allowing the supremacy of the firepower ideation to become an unchallengeable axiom that continually affected DOT decisions.²⁵⁷ With some exceptions for the few French offense and maneuver advocates such as Ferdinand Foch and Charles de Gaulle, the French analysts viewed technological advances in mobility as always supporting the firepower paradigm. Even when opponents challenged the supremacy of firepower, there was considerable and frequent effort to silence the dissent.²⁵⁸ Suggesting that once an idea, or perhaps better stated as a paradigm, is accepted, it influences DOT decisions and, desired or not, may be difficult to disrupt.

A brief diversion into Germany's approach to war shows similar hints of militaries guiding their DOT decisions based on an internally accepted paradigm on the way war is fought (or will be fought). Following WWI, the reconstituted German General Staff under Chief of Staff Hans von Seeckt established various committees to examine the lessons learned from the war. Among the top questions asked of these committees were "What new guidelines have been developed from the use of new weaponry in the war [and] which new problems put forward by the war have we not yet found solutions."²⁵⁹ Thus the Germans began their analysis of WWI searching for new uses for technology and solutions to previous problems. The perspective of Germany as the conquering force (i.e., to be on the offensive) certainly

²⁵⁷ May, *Strange Victory*, 457.

²⁵⁸ Murray and Millett, *Military Innovation in the Interwar Period*, 33.

²⁵⁹ James S. Corum, *The Roots of Blitzkrieg: Hans von Seeckt and German Military Reform*, 1st ed. (Lawrence, KS: University Press of Kansas, 1992), 37.

influenced these solutions. To the Germans, slow movement and execution of the Schlieffen Plan contributed to their Failure in 1914 to quickly take Paris and capture the French government. New transportation and delivery technologies in WW1, such as the railroad, had enabled France to quickly move forces from its eastern front and confront the German army. The Germans in turn as it was slowed from the North as they moved beyond their own railheads and faced the unexpected effects of the retreating Belgians tearing up their own tracks. Therefore, Germany's failure in 1914, and again in 1918 was due to both insufficient German speed and France's use of technology to rapidly concentrate forces. Through this lens, it is fairly logical to see how Hans von Seeckt's committees developed a theory of victory that stressed fast and rapid movement designed to capture the enemy's key industry and government before they could assemble an army. Thus, one of the primary outcomes of the German reflections on WWI was not how to fight that war better but how to avoid that war—the answer was “*Operation ist Bewegung*” [war is movement].²⁶⁰

Comparatively viewing the French and German doctrine (methodical battle *versus* Blitzkrieg), organization (artillery curtains over infantry *versus* panzer divisions with close air support) and technological tradeoff decisions (armor and firepower *versus* speed and mobility, with two-way radio comms in all tanks) we see antithetic design choices.²⁶¹ Which suggests that how a nation views its way-of-war paradigm and overarching warfighting concept, may be integral to understanding the complex interaction of organization, doctrine, and technology. The following chapter further explores how a paradigm and warfighting concept can shape the relationships in a DOT triad.

b. Observed Technology Strategy Forms

The French technology strategy took on three forms. The first and perhaps most obvious form or descriptor of the way in which their technology strategy manifested was *Defense Dominant*. Heavy investment in the Maginot Line, large artillery, heavily armed tanks, and flying dreadnoughts clearly showed a defensively dominant characteristic. The

²⁶⁰ quoted in Murray and Millett, *Military Innovation in the Interwar Period*, 29 (footnote 120).

²⁶¹ For more on German WWII organization see United States War Department, ed., *Handbook on German Military Forces* (Baton Rouge: Louisiana State University Press, 1990), 102, 595.

tradeoffs made in development of technologies such as armor instead of speed in tanks, and machine guns instead of speed in the BCR aircraft, also gave the technology strategy a defensive characteristic. These observations suggest that both the chosen technology and the strategists' tradeoff decisions dictate the form of the technology strategy, and these can and should be influenced by an evaluation of the OD balance.

The second form seen in the French technology strategy was a *Big Bet* on the Maginot Line. The dense system of fortifications stood as both a deterrent for invasion and a symbol of national pride. Its three billion Franc cost is staggering considering the global economic depression that affected France through much of the interwar period. Many of the early discussions justifying the building of the Maginot Line were based on the limited conscription time of French soldiers, small number of professional soldiers, and the close proximity of the French industrial regions in Alsace-Lorraine to the German border.

Following the Great War, the French people and government were unwilling to maintain a large standing army capable of rapidly meeting a German invasion force. While the French generally acknowledged that a fortification could not hold forever, they felt that a system of fortifications could hold back the Germans while a sufficient conscription army was assembled. Thus, the Maginot Line represented a Big Bet technology strategy with the French investing billions of francs and military resources into a system of fortifications, hoping that the Maginot Line would deter a German invasion, stop an invasion, or at least delay them while a larger army was assembled.

The third form of technology strategy was not observed directly in the French case, but its presence is undeniable as the Germans appeared to intentionally pursue a *balance-shifting* technology strategy. The Germans intentionally invested in highly mobile technologies and developed tactics and doctrine in response to the defense dominance of WWI to overturn the balance.²⁶² They continued these developments into the 1920s and 1930s in preparation for war against France and the rest of Europe. Unlike France who assumed and prepared for a more modern version of WWI, the Germans developed technology with the

²⁶² see Bruce I. Gudmundsson, *Stormtroop Tactics: Innovation in the German Army, 1914–1918* (West Port, Conn.: Praeger, 1995). 171–173

express intent of overcoming the French *puissance de feu*. Guided by their *Operation ist Bewegung* way-of-war ideation, they invested in technology and developed doctrine that brought mobility back to the battlefield in a technology strategy focused on shifting the previous OD balance.²⁶³

c. Suggested Technology Strategy Pitfalls and Stratagems

The French case study suggests two possible pitfalls and corresponding stratagems: *Crossover Point* and *Opportunity Cost*. The mobility-reducing effects of the technical tradeoffs made in the French technology strategy, suggest that there may be a *Crossover Point pitfall* where decisions made in development can shift a technology from offense to defense dominant (and vice versa). As previously stated, many technologies naturally lean toward offensive (i.e., tanks) or defensive (i.e., artillery). However, the dominant features of the technology may be intentionally (or unintentionally) reduced to provide more rounded or even unneeded capabilities.²⁶⁴ An example of which could be reducing artillery caliber and yield in order to reduce weight or handling requirements giving it increased mobility at the cost of reduced firepower. These type of tradeoff decisions in design, shift the technology's natural tendency to support offensive (or defensive) operations toward the opposite strategy.

As explored previously, design tradeoffs are common and, if done correctly in sync, are based on the overall intended use or employment strategy. But it is possible that a strategist setting developmental requirements or choosing designs may convert an inherently offensive technology into a defensive one (or vice versa). Doughty's explanation of France's 1930s

²⁶³ It should be noted that the Germans were not the only ones to invest in this way and even they did not immediately realize the capability of a fully mechanized force. However, their early decision to bring mobility back to war, guided their DOT decisions. See Murray and Millett, *Military Innovation in the Interwar Period*, 34–48.

²⁶⁴ An example of an “unintentional” approach to the Crossover Point is the disastrous Bradley Fighting Vehicle design history portrayed in the humorous movie “The Pentagon Wars” and typically used to illustrate the dangers of scope creep. Originally conceived as a fast scout and troop transporter, numerous individuals and agencies interceded during the design and approval process adding requirements, such as increased armament and ammo stores, that all but eliminated the ability of the vehicle to scout and transport troops. “The Bradley Fighting Vehicle,” A. James Clark School of Engineering, University of Maryland, accessed March 1, 2022, <https://user.eng.umd.edu/~austin/enes489p/lecture-resources/BradleyFightingVehicle-Scenario.pdf>.

discussions on the “proper design of a tank to be used in a defensive role” highlights technological designs hovering around the Crossover Point:

[General] Maurin discussed three major alternatives, the first being what he called the “tank solution,” or using the [already designed and built but slow and lightly armored] B-1 tank. The second, an armored self-propelled cannon that resembled the tank destroyers of World War II, would have a 75mm cannon mounted on the chassis of a D-1 or D-2 tank [another already designed and built light tank]. The modified turret containing the 75mm cannon could be quickly removed and replaced with the standard turret of the D-1 or D-2 tank ... and would supposedly enable the new vehicle to be converted quickly into an offensive weapons system. The final solution ... was a towed turret, mounted on four wheels and carrying a 75mm cannon. The moveable “turrets” could be towed into defensive positions by tractors and moved to other positions once the battle was over. According to Maurin, the best solution was placing a modified turret on the D-1 or D-2 chassis ²⁶⁵

Reading into Maurin’s recommendation, it seems he felt the way to use a tank in a defensive role was to convert it into mobile artillery. Both his preferred second option and the third option contained greatly increased logistical requirements (not to mention a loss of armor and basic features of a tank) that would have significantly reduced mobility but provided increased firepower. One wonders if there were artillery designs already available that could better fill this role instead of converting an offensive technology into a defensive one. Eventually the French did continue to develop tanks along more traditional lines, but the early 1930s discussion illustrates how strategists can quickly find themselves trying to fit a square peg into a round hole. The tank was likely not the appropriate base technology for Maurin’s objective. The presence of an OD Crossover Point pitfall suggests that technological decisions should be approached with a primary (firepower or mobility) characteristic in mind as a starting place for choosing the base technology. Leading to the *Crossover Point stratagem*:

Avoid wasting time and resources trying to convert a piece of equipment into something against its nature. Instead, choose equipment and technology already closely aligned with your primary intended capability and then use tradeoff decisions in development to enable any secondary capabilities.

Another technology strategy pitfall suggested by the French case is the *Opportunity Cost pitfall*. The high cost of the Maginot line drained time, money, and political clout from

²⁶⁵ Doughty, *The Seeds of Disaster: The Development of French Army Doctrine, 1919–39*, 152.

other areas of the French defensive plans. By choosing to build the Maginot Line, the French were simultaneously choosing to withhold investments in other areas, such as a larger and more diverse air force. The Opportunity Cost pitfall reminds the strategist that technological pursuits require definitive direction and guidance. To avoid wasting precious few resources, technological decision making needs to remain strategically, doctrinally, and organizationally aligned. Leading to the intuitive *Opportunity Cost stratagem*:

A technology strategist's constant enemy is scarcity. There will never be enough resources to pursue all possible technological solutions. Thus, each decision to undertake a technological pursuit is also a decision to forgo another.

7. Case Study Conclusion

The OD balance during WWII was offense dominant. The coming of age of tanks and aircraft, combined with the further development of radios led to a rapid increase in battlefield mobility and tipped the OD balance toward the offense. But France wrongly perceived a defensive balance. This incorrect perception affected its technological decisions, doctrine, and the way the military was organized. France had a greater total number of tanks and aircraft, but their decision to develop and employ them in a defensive fashion against the balance meant that greater numbers were not enough. The highly mobile German army could quickly organize and concentrate forces at France's weak points.

Could France's strategy have worked if they had more time? Possibly. When the German units fought the French in Belgium, where France was fighting the way it was designed, France did remarkably well. But Germany was determined to move to France's weakest points and France simply did not have a large enough army or enough fortifications to cover all entry points. Suggesting that to employ under their defensive doctrine and organization against a more mobile enemy in an offense-dominant environment, the French needed more than they had—more tanks, more aircraft, and more fortresses to ensure they could meet any German assault at any location. The economic costs of which would have been astronomical and likely unreachable. Looking forward, it appears more feasible, if not simply more economical, for a technology strategist to focus on correctly predicting the OD balance.

C. CONCLUSION

This chapter explored how offense-defense theory may guide a technology strategist. Standouts among these observations included ODT ability to predict how emerging and standing technologies may affect the economic feasibility of offensive and defensive strategies. While history shows that the OD balance is difficult to predict, a nation that successfully determines the balance and aligns its technological, doctrinal, and organizational elements to the matched strategy, can achieve a certain measure of capability over a comparably equal nation who invests in the opposing strategy.

The French case study explored the connection between a nation's evaluation of the OD balance and its technological decisions. While the French incorrectly evaluated the OD balance, its technology strategy generally aligned with their evaluation of the balance. Their error, while not the only variable in their *Strange Defeat*, certainly hampered the French's ability to adapt to the changing conditions when Germany brought mobility back to the battlefield.²⁶⁶ The lesson stands as a reminder to future technology strategists to expend considerable effort in analyzing the current and future balance.

The exploration of ODT and the French case both served as excellent studies in this work's larger objective of understanding technology strategy. Further strength was found for the interconnected relationship between doctrine, organization and technology, suggesting that technology strategy exists as part of a triad. Also identified were several unique forms of strategy, including, Defense Dominant, Big Bet, and Balance Shifting. Finally, there was the unique Crossover Point and the Opportunity Cost pitfalls that may serve to guide a strategist in technological decision-making. In the following chapter, the observations identified in Chapters II, III, and IV are compiled and analyzed to provide the first formal answer to the question: What is Technology Strategy?

²⁶⁶ an ode to an original work on the subject by the French Patriot Marc Bloch see. *Strange Defeat: A Statement of Evidence Written in 1940* (New York, NY: W. W. Norton & Company, 1999).

V. TECHNOLOGY STRATEGY IS ...

The beginning of wisdom is to call things by their proper name.

—Confucius

In its proper form, military technology strategy is the term applied to a deliberate process connecting technological decision-making to strategic intent. In observing this characterization of technology strategy this study has three key findings. They are: 1) the presence of a paradigm-to-strategy flow that necessitates a close relationship of technology, doctrine, and organizational design (the *DOT triad*), and identifies technology strategy's place in the military system; 2) technology strategy has distinct structural components that can be displayed in a graphical taxonomy (Figure 23) to guide strategy formulation and analysis; and 3) when appropriately defined, technology strategy has an observable history allowing for the compilation of pitfalls and stratagems to guide future application.

This final chapter presents the above findings in four parts by compiling and deriving further observations from the previous chapters' case studies. The first and second sections support key finding one. The first section focuses on the external framework of technology strategy by highlighting the paradigm-to-strategy flow in a recap of the case studies, identifying technology strategy's place in military doctrine, and its match with the U.S. military's force development strategy nomenclature. The second section details the internal structure of technology strategy which are its strategic forms and acquisition approaches. The third section supports key finding two by the compiling characteristics discussed in the previous sections into a taxonomy and a conceptual description of technology strategy. The fourth and final section supports key finding three by highlighting technology strategy pitfalls and stratagems. To aid in succinctly communicating the concepts in this work to its desired audience (i.e., so this chapter alone can serve as a stand-alone summary), this chapter briefly repeats many of the ideas and analysis in previous chapters. As such, in its entirety, this chapter composes an answer for "What is Technology Strategy?"

A. THE EXTERNAL STRUCTURE AND DOCTRINAL FIT OF TECHNOLOGY STRATEGY

The primary purpose of this section is to merge the observations of the previous chapters and U.S. military doctrine to define the external framework of technology strategy (i.e., where it fits in the military system). In observation, technology strategy formulation followed a natural progression. The strategies in the case studies started with an envisioned way-of-war paradigm which informed the creation of a warfighting concept. From the warfighting concept, specific capability requirements were derived (although often with shortcomings), and technological, organizational, and emergent doctrinal strategies were created to realize the required capabilities (not always successfully).²⁶⁷ Similarly, in the pursuit of the derived capabilities there was continual repetition of doctrinal, organizational, and technological (DOT) elements. The repetition suggests that this triad of developmental strategies forms a core component (the *DOT triad*) in the pursuit of capabilities and warfighting concepts. The presence of a *paradigm-to-strategy flow* and *DOT triad* thus suggest that these are key elements in technology strategy's external framework and location in the military system.

In the first section below, the paradigm-to-strategy flow and DOT triad is highlighted in each case study to show the importance of these elements in the structure of technology strategy. The second section explores the U.S. military's force development doctrine and suggests that technology strategy belongs as part of the DOTMLPP-P (Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities, and Policy) considerations step in the joint concept development process. The third section explores the process of deriving capabilities from a warfighting concept and how DOT strategies fit into this process. The fourth section discusses how the time-based force development strategy nomenclature, currently employed by the U.S. military, can categorize technology strategy and address the importance of the time variable.

²⁶⁷ The relationship between an operational concept and required capabilities was identified to me in an email conversation with Mr. Richard Hencke at Headquarters Air Force A-5. It was after this conversation on the current process that I noticed and expanded on a similar relationship in the historical case studies. That expansion I refer to as the paradigm-to-strategy flow. Richard Hencke, "NPS Student Research," July 30, 2021.

1. Paradigm-to-Strategy Flow and DOT Triad in the Case Studies

In the first examined case, the Mahanian *decisive naval battle paradigm* shaped Tirpitz's *Risk Fleet warfighting concept* which centered on positioning a battleship-centric fleet in the North Sea.²⁶⁸ His concept called for a naval force strong enough to draw a substantial number of British ships away from future German colonial conquests, but still inferior enough to avoid sparking a naval arms-race with Britain. Despite intentional inferiority, the Risk Fleet still had to be powerful enough that it would be a risk for Britain to attack for fear of significant losses. To achieve the concept, Tirpitz chose to emphasize battleships and form of technology strategy that balanced overt inferiority in quantity with superior quality armor, weapons, and optics.

The decisive battle paradigm and Risk Fleet operations similarly influenced organizational and doctrinal decisions. Organizationally, Tirpitz built his new navy around the battleship, adopting destroyers and multiple other ship types for protection from torpedo boats and scouting the enemy fleet. He also dictated specific reserve ships for his North Sea fleet and considered his overseas fleet a secondary priority. Doctrinally, the Risk Fleet also showed influence of the Mahanian thesis, developing battleship and large sea battle tactics. In summary, the Mahanian paradigm inspired the Risk Fleet warfighting concept, which led to the identification of a naval capability requirement. The derived requirement then led to the choice of battleship technology, organizational adaptations, and doctrinal changes.²⁶⁹ Thus, the Tirpitz naval development process provided the first view of a pattern that would repeat throughout the entire exploration.

In the second case, the United States' paradigm-to-strategy flow not only influenced national-level technology strategy but also influenced institutional level DOT strategies. The 1950s United States' way-of-war paradigm focused on long-range fiscal

²⁶⁸ Similarly, based on a raiding paradigm, Tirpitz simultaneously developed another warfighting concept (*Kreuzerkrieg*) that emphasized cruisers in an overseas fleet to grow and protect the German colonial empire.

²⁶⁹ Tirpitz's may have failed to fully consider the strategic effects of the chosen technology—a central element of technology strategy. The design and posture of his battleships worked directly against his wish to avoid an arms-race by provoking Britain. Additionally, emphasizing battleships meant significant loss in resource availability for submarine development. An opportunity cost that may have significantly contributed to Germany's loss in WWI.

military efficiency through the use of nuclear weapons as witnessed by the proverbial “more bang for the buck” slogan.²⁷⁰ The *nuclear efficiency paradigm* influenced the creation of the *Massive Retaliation warfighting concept*. In turn, the concept called for capabilities, such as long-range strike, that led the U.S. to emphasize nuclear weapons and specific delivery technologies (i.e., bombers and eventually ICBMs) in its national-level technology strategy.

The national-level nuclear weapons emphasis similarly influenced institutional level DOT decisions for the Air Force, Army, and Navy. Organizationally, the Air Force created Strategic Air Command to manage the requirements of ground alert and eventually air alert nuclear forces. Technologically, the emphasis on nuclear weapons meant that the range and payload of bombers were also developmental priorities. Similarly, in the Navy, the submarines that could carry ballistic missiles received the highest attention, and, in the army, Generals fought desperately for ownership of the ballistic missile and anti-ballistic missile programs to ensure the Army maintained a role in the United States’ new way of war.²⁷¹ Just as in the Tirpitz case, the United States’ technology and accompanying DOT strategies were built to achieve capabilities derived from a warfighting concept which was influenced from a paradigm on the way war should be fought in that context. In other words, DOT strategies were sequential, but always the last step in the process.

The last step observation suggests technology strategy conforms to a preconception but it should be noted that technological feasibility is (or should be) a consideration for decisions-makers at the conception of their warfighting concepts. For instance, Tirpitz would later state that he dismissed submarines because they lacked deep water capability. If truthful, Tirpitz at least considered the technological possibility, although in his case he came to incorrect conclusion and ignored that he could have made deep-water a design requirement, thereby accelerating the pace of U-boat development.²⁷² In this way, DOT decisions were observed as linear, but the feasibility element of DOT influence is constant.

²⁷⁰ Chester J. Pach Jr., “Dwight D. Eisenhower: Foreign Affairs,” Miller Center, October 4, 2016, <https://millercenter.org/president/eisenhower/foreign-affairs>.

²⁷¹ Refers to the navy’s Polaris submarine and the army’s Zeus missile program

²⁷² Arquilla, “A Study in Technology Strategy.”

In the final case, the French conceptual paradigm was the superiority of *puissance de feu* [firepower]. From the *puissance de feu* paradigm the French built the *pre-arranged battlefield warfighting concept*.²⁷³ From the concept, the French derived the need for a prepared line of defense capability which directly influenced DOT strategy requirements such as a meticulously controlled line of artillery fire, fortresses, and tightly coupled infantry and tank movements.

Interestingly, the French case best highlights how a technology strategist should question the guiding paradigm. An inaccurate, or poorly formed paradigm, can lead to a poor warfighting concept and technology strategy decisions. The French formed their firepower paradigm based on an inaccurate view of the future of warfare drawn from the ostensible lessons of WWI instead of analyzing the changing technological environment. As the emerging technology changed the strategic environment, the French failed to alter their paradigm. The stagnant paradigm then led to the creation of an even more divergent warfighting concept that then led the French to pursue capabilities poorly suited to the war that was to come. Although incorrect, the French case further confirmed the paradigm-to-strategy flow structure.

Further, telling of the importance of the paradigm-to-strategy flow, was that the Germans' victory over the French in 1940 was based on an antithesis—maneuver. The German *Operation ist Bewegung* [operation (read as war) is movement] led to the development of Blitzkrieg—a warfighting concept that required rapid force movement and coordination capabilities. The derived capabilities were met technologically through fast-moving tanks, tactical bombing aircraft and radio coordination. Organizationally, the concept's capabilities required armor-based Panzer divisions and a tactical-aircraft-focused Luftwaffe. Doctrinally, the Germans supported their lightning war concept by developing new methods of decentralized execution, increasing their ability to move rapidly and exploit new initiatives. While the outcome was positive in the German case and negative in the French case, the observed and repeated flow from paradigm, to concept, to desired capabilities, to DOT decisions is clearly crucial to the external structure of technology

²⁷³ Rowe, *The Great Wall of France*; 24.

strategy and provides an identifier for where the observations in this paper integrate into the military system.

2. Technology Strategy and the Joint Concept Development Process

The paradigm-to-strategy flow identifies technology strategy as an enabler of a future warfighting concept(s). Military processes focused on enabling future military capabilities are therefore ideal for the placement of the technology strategy concepts identified in this study and are well developed in U.S. military instructions. Therefore, the standing doctrine on the concept development process is the natural entry point for incorporating the observations of this work and future research into technology strategy.²⁷⁴

The U.S. military recognizes the need to prepare for and prevent degradation of military capability due to changing times and contexts. Older technologies and way-of-war paradigms become dated with adaptations of the enemy and the evolution of technology.²⁷⁵ Similarly, superiority in one context does not always mean superiority in other contexts and the context and character of conflict seems to continually change and adapt.²⁷⁶ U.S. planners recognize the time and context-based devaluation and look through multiple time horizons in order to fully estimate the strategic challenges of the future environment.²⁷⁷ Resources are then allocated to the development of specific capabilities supporting new or improved ways of fighting (warfighting concepts) designed to maximize the potential of a military arriving at a particular time and context ready to face the challenges of the environment. The decisions focused on acquiring or developing the required technological capabilities derived from a warfighting concept are key to envisioning the concept of technology strategy. Figure 16 depicts a military concept development process for joint operations. The circled region depicts the suggested starting location of DOT strategy development.

²⁷⁴ For full doctrine see *Guidance for Developing and Implementing Joint Concepts*, CJCSI 3010.02E (Washington, D.C.: Chairman of the Joint Chiefs of Staff), accessed March 8, 2022, https://www.jcs.mil/Portals/36/Documents/Doctrine/concepts/cjcsi_3010_02e.pdf?ver=2018-08-01-134826-593.

²⁷⁵ As seen in this work's French case study and more recently the 1990–1991 US-Iraq Gulf War.

²⁷⁶ As evidenced by the U.S. Cold War case in this thesis and commonly noted in the Vietnam and US-Afghanistan war.

²⁷⁷ Two of the most common methods are STEEP and PMESII-PT

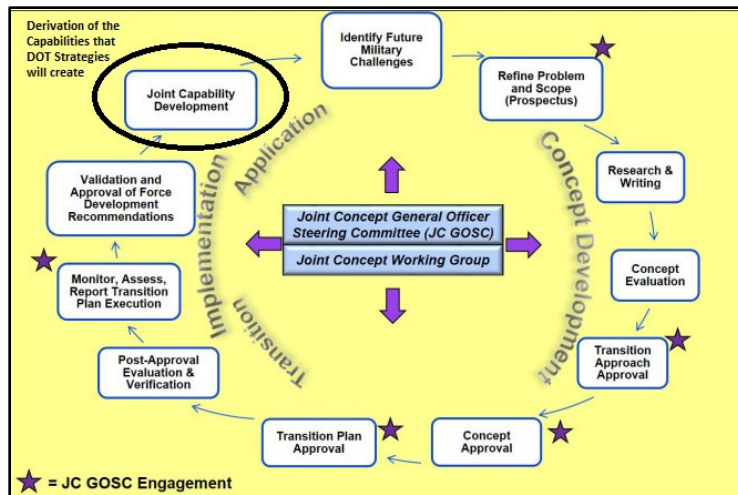


Figure 16. The Joint Concept Development Process²⁷⁸

As a concept transitions through the development process, the development team should derive the necessary capabilities and requirements to achieve them. In the case studies, this step is akin to where Tirpitz derived the North Sea Fleet capability, the U.S. envisioned the long-range strike capability, or the French envisioned a prepared defensive line of firepower. According to Chairman of the Joint Chiefs of Staff Instruction 3010.02E these new or modified capabilities are brought to fruition through changes in components summarized by the DOTMLPF-P acronym.²⁷⁹ The acronym stands for doctrine, organization, training, material, leadership, personnel, facilities, and policy.²⁸⁰ While U.S. Joint doctrine treats all these levers of change relatively equally, the observations in this thesis show a more centralized role of doctrine, technology (a component of material), and organization in how a country achieves a new way of war and suggests they should occupy a more centralized role. Additionally, while the doctrine notes that these items are the instruments of change, it stops short of stating that any component deserves its own strategy. This thesis suggests that all DOT triad components require dedicated and

²⁷⁸ Chairman of the Joint Chiefs of Staff, *Guidance for Developing and Implementing Joint Concepts*, A-6.

²⁷⁹ Chairman of the Joint Chiefs of Staff, 11.

²⁸⁰ The dash annotates that policy is outside of the military domain. Although it is considered because policy restricts concept development/realization or alternatively, concept development/realization may identify gaps in policy

simultaneous strategy development to ensure effective and efficient achievement of the desired warfighting concept. Figure 17 demonstrates the centralized role of the DOT triad in the DOTMLPF-P construct in a capability portfolio (explained in the next section).²⁸¹ Figure 18 shows the connection between concept, capability, and strategies in a slightly different format to help with understanding.

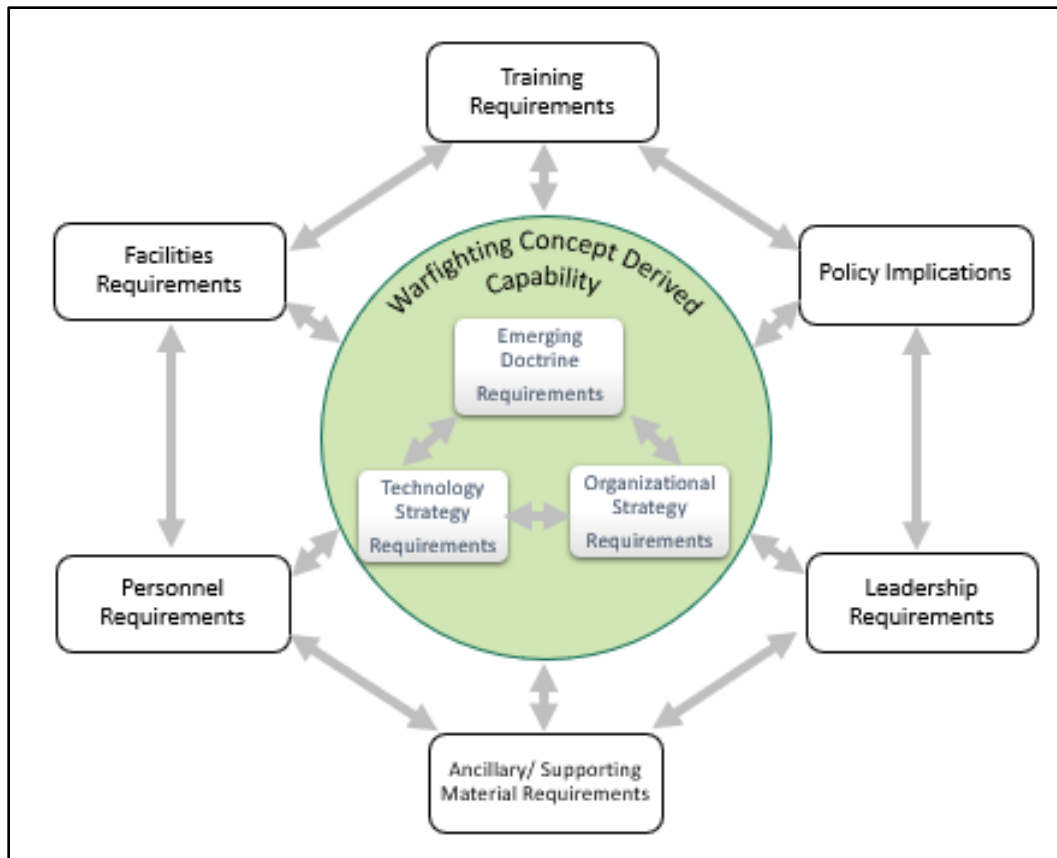


Figure 17. A Capability Portfolio with DOT Strategies as Center of DOTMLPF-P Architecture

²⁸¹ Chairman of the Joint Chiefs of Staff, *Guidance for Developing and Implementing Joint Concepts*, A-3.

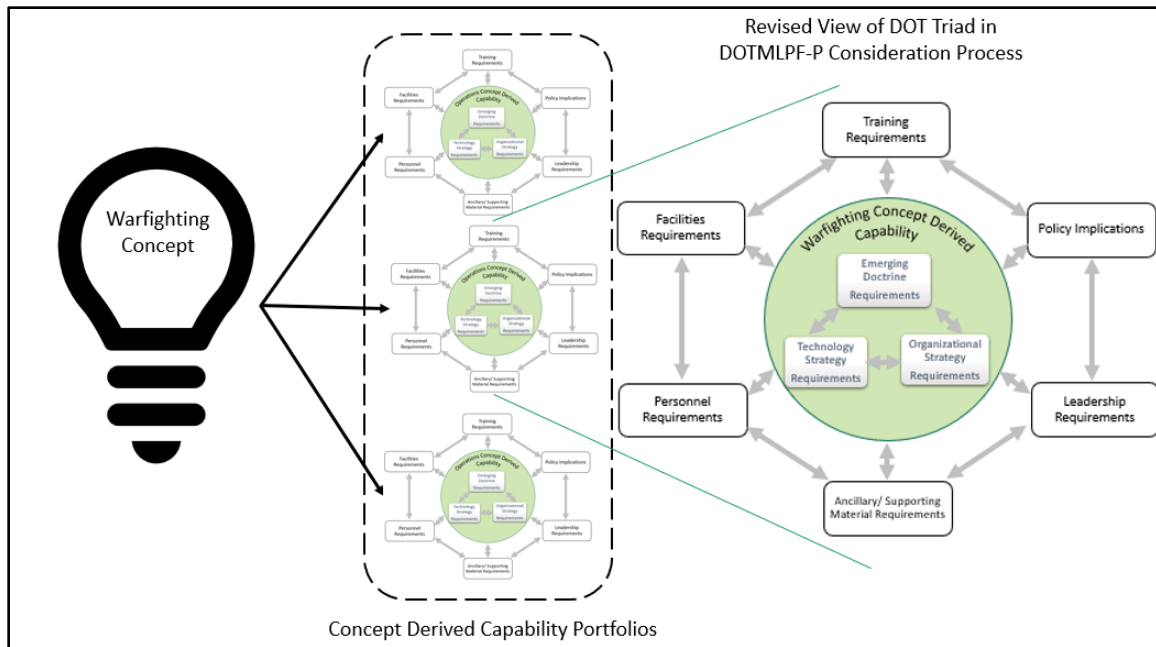


Figure 18. New Envisioning of DOTMLPF-P inside a Warfighting Concept

Checking the proposed doctrinal position of technology strategy with the earlier case studies, one finds agreement. Tirpitz built a technology strategy focused on battleships with high-quality armament and optics to meet his desired North Sea deterrent capability (although it failed to deter). Similarly, the U.S. built a fleet of long-range bombers and eventually ICBM missiles to meet their desired deep strike capability (with deterrence of general war a success but limited war a failure). The French built a system of fortifications to meet their defensive and hoped-for deterrent line capability requirement (though the Maginot Line failed to deter or defend).²⁸² As the need for new capabilities are derived from current and future warfighting concepts, the technology strategist identifies technological possibilities and alternatives to meet the desired capabilities and then builds the desired technology strategy. Creation of a technology strategy and its DOT triad

²⁸² While the examples shown are not all successful in achieving their strategic goal, the intent here is to simply show where they were formulated. Identifying this basic structure (paradigm-to-strategy flow) can help future researcher's better analyze where a breakdown in the strategy may have occurred. For example, Tirpitz's chosen technology strategy (Battleships over Submarines) may have been incorrect to meet the intent, the U.S. may have had right paradigm (efficiency through deterrence) and warfighting concept (Massive Retaliation) but the wrong context by trying to apply it to all forms (general and limited) of war; and the French may have misjudged the OD balance and latched onto the wrong paradigm (superiority of firepower and defense).

components can thus be thought of as a core part of the DOTMLP-FP consideration and implementation step within the larger concept development process.

By positioning DOT strategies in this central location and identifying their connection to the overall strategy, it creates a deliberate point to question DOT decision making against strategic intent. For instance, in Tirpitz's failed technology strategy, it is suggested that the Mahanian influence likely limited Tirpitz's envisioning of any technology other than Battleships that would deter British intervention into German empire building. The influence was likely strong enough that the entire Risk Fleet concept was envisioned with battleships from the beginning. By deliberately adding in the creation of DOT strategies, it gives the strategist pause to focus on the connection between the DOT decision and strategic intent. A pause may have helped Tirpitz realize that submarines or even a more balance fleet may have better achieved his strategic intent.

3. Capability Portfolios and Levels of Technology Strategy

Interestingly, while this work has focused on the primary technology used to meet the required capability, reflection on the observed cases and U.S. doctrine highlights that each warfighting concept derived capability often requires an array of DOT pursuits. The grouping of all DOT triad components and their DOTMLPF-P counterparts needed to achieve a derived capability, can be thought of as a *capability portfolio*. The principal benefit of viewing technology and its accompanying DOT strategies, in this manner, is it keeps the technological decisions linked to strategic purpose and their necessary organizational and doctrinal innovations. Figure 19 demonstrates the capability portfolio concept for the Tirpitz navy case study.

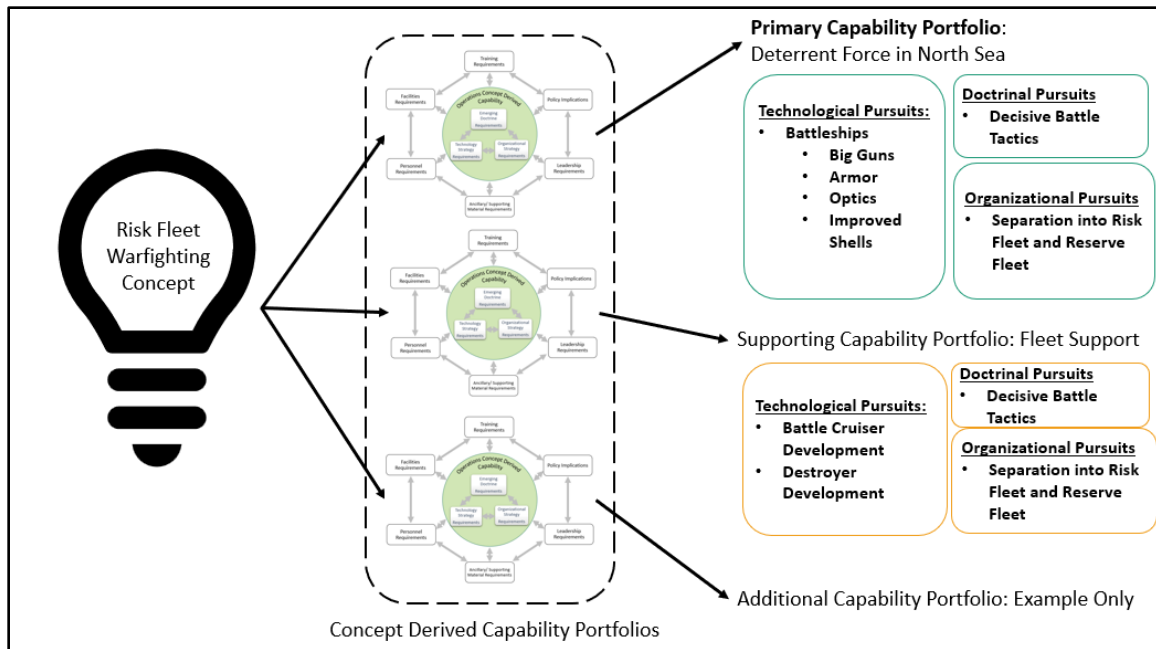


Figure 19. Tirpitz's Risk Fleet Capability Portfolios

Introducing the capability portfolio concept means that a conceptual definition of technology strategy must consider a multiple-level approach. Referencing Figure 19, notice that building from the bottom up, technological, and other DOT pursuits make up capability portfolios and multiple capability portfolios make up warfighting concepts. Intuitively, one can also summarize that militaries may pursue multiple concepts at a time. These observations raise an interesting dilemma in referring to technology strategy.

Does the term “technology strategy” refer to the technological component in the pursuit of a specific capability, all the technological pursuits in a warfighting concept, or all the technological pursuits of a military or institution?

The answer is yes. Just as in any strategy, technology strategy exists at multiple levels and the strategic end and emphasized technology are the characterizing elements at each level. Recall from Chapter II that technology strategy is concerned with the emphasis on acquisition of particular weapons, transportation, and information systems to reach a strategic end state. At the portfolio level, the emphasized technology and strategic ends may be different than at the concept or institutional level.

For instance, in Figure 19 notice that Tirpitz's battleship fleet also required support from cruisers, submarines, naval airships, and destroyers to protect the battleships that comprises the main force. Inside the fleet support capability portfolio, cruisers and destroyers would have been the emphasized technology and their strategic ends was the protection of the battleships. Thus, it would be appropriate to refer these pursuits as the *fleet support technology strategy*. However, stepping back to the Risk Fleet concept level, the main effort or emphasized capability and thus the emphasized technological pursuit was the battleship fleet.²⁸³ The Risk Fleet technology strategy emphasized battleships, although it contained a portfolio that included cruisers, destroyers, submarines, ect. and a subordinate technology strategy with its own form and acquisition approaches.

Stepping back even further, technological emphasis in the dominant warfighting concept defines the highest level of technology strategy. The Cold War case study illustrated a grand level of technology strategy. In the 1950s, the U.S. employed multiple different warfighting concepts to include preventive and/or preemptive nuclear strikes, special operations, peacekeeping operations etc., but its primarily emphasized warfighting concept was Massive Retaliation with nuclear weapons and delivery technology. Thus, the United States' grand technology strategy is best described by its emphasis on nuclear weapons although other concepts and technologies were developed with lesser resource priority. Notice that the focus on emphasized technology is not only useful in understanding the levels of technology strategy but also in understanding how an institution prioritizes its resources toward technological development and acquisition. The key element in the technology strategy concept in this paper is ensuring that the connection between resource priority and strategic intent remains aligned.

4. The U.S. Military's Force Development Strategy Nomenclature: Time and Technology Strategy

In all three observed cases, the technology strategists had to consider the time variable in their strategy to varying degrees. Tirpitz recognized that his battleship navy

²⁸³ A modern example of this is the US's carrier strike groups that contain multiple types of ships, but the carrier is the emphasized technology and capability supported by others.

would need to be built over many years, and he feared that political action would cut his fleet short during the building process. To fight the Reichstag, he advocated for the Naval Laws to lay out the prolonged shipbuilding process and ensure the intent was carried through by legal action. In the third case study, the French Air Force found itself fighting the war in 1940 with aircraft that were known to be inferior in 1933 despite a herculean effort to try and replace the fleet of poorly designed BCR aircraft. Similarly, in the 1950s, there was a perception that the U.S. technology strategists failed to anticipate future developments in rocket design and fell behind in ballistic missile development. While the existence of an actual “missile gap” in the 1950s is still being debated, the current debate over the “hypersonic missile gap” highlights once again the importance of looking forward.²⁸⁴ Any concept of technology strategy must therefore consider time as a primary variable.

U.S. doctrine provides a time structure to force development strategies that can aid in understanding how technology strategy may be applied. U.S. Joint Doctrine Note 2–19 identifies three types of force developing strategies based upon the time that they expect to meet their end state. They are employment, development, and design strategies.²⁸⁵ Each of these strategies focuses on achieving the desired warfighting concept or evolutionary version of the desired concept in a specified time range. *Employment Strategies* focus on achieving the warfighting concept, and the capabilities required to execute it, in the immediate-to-three-year time horizon; *Developmental Strategies* are focused in the two-to-seven-year time horizon; and *Design Strategies* are focused on the five-to-fifteen-year time horizon.²⁸⁶ The doctrinal time-based method of strategy classification can thus be used to better classify technological strategic pursuits.

²⁸⁴ Licklider, “The Missile Gap Controversy,” 600 and ; Stephen Losey, “What Should Be the United States’ Next Move on Hypersonic Tech?,” Defense News, March 14, 2022, <https://www.defensenews.com/air/2022/03/14/what-should-be-the-united-states-next-move-on-hypersonic-tech/>.

²⁸⁵ There is an acknowledged confusion in terminology here. “Force development strategies” can refer to any strategy designed to develop the force in any timeline. But in this specific joint doctrine note, a “Development Strategy” is a strategy designated for a specific time frame. To help with confusion, when I mean the latter, I capitalize both “Development” and “Strategy.”

²⁸⁶ Joint Chiefs of Staff, *Joint Doctrine Note 2–19: Strategy*, III–1, III–2.

It is the responsibility of the technology strategist to ensure technological decisions align with the time horizon designated for the capability and/or warfighting concept. Many concepts and capabilities may take years to develop while some will be realized quite quickly. Most of the case studies explored in this thesis focused on long-term technology development and design strategies, but new warfighting concepts and capabilities can often be achieved with commercially ready products.

In the author's own experience, the United States' desire for more surveillance aircraft in Afghanistan led to the purchase of commercially procured private aircraft. The aircraft were then employed in a surveillance role equipped with commercially purchased domestic traffic cameras.²⁸⁷ By using commercially ready technology in an employment-type technology strategy, the U.S. military was able to achieve new surveillance and intelligence capabilities within a matter of months.²⁸⁸ While Employment Strategies like the surveillance aircraft example, are more likely to require imitative or innovative approaches using available technologies, Developmental or Design Strategies may provide the strategist more options to pursue other approaches and strategic forms. It is the responsibility of the technology strategists to determine how to meet the capability in the timeline desired.

Another recent example highlights the benefits of thinking in time. The U.S. Army's approach to developing the M1 tank involved an incremental advancement process across multiple horizons. The M1 Abrams was designed to be a fast-moving heavily armed tank equipped with a 120mm main cannon. However, the 120mm cannon technology needed further development and budget constraints prevented dual development of both the M1 tank and the 120mm cannon. As a solution the army designed the M1 to accept both the 105mm and 120mm cannon. The 105mm was an existing technology and allowed the tank to reach readiness in a shorter time horizon. In turn, the 120mm cannon was moved to a technology strategy at a further horizon where it was eventually developed and added

²⁸⁷ Often referred to as commercial off-the-shelf (COTS) procurement

²⁸⁸ No intent here to downplay the key role of human intelligence and the hard work of the analyst merging the intelligence. All were important to successes in ISR targeting.

to the M1 tank.²⁸⁹ Classifying strategic pursuits by time to realization has clear benefits in technology strategy construction.

B. THE COMPONENTS OF TECHNOLOGY STRATEGY

The internal components of technology strategy consist of the strategic forms and the technological acquisition approaches. The first section discusses the different forms or templates of technology strategy. The second section recaps the three types of acquisition approaches from Chapter II and introduces a fourth approach, innovative, discovered in reflection of the case studies.

1. Observed and Extrapolated Forms of Technology Strategy

The previous chapters observed multiple ways in which a technology strategist may shape technological decisions. These observed forms of technological strategy can be categorized by their principal driving strategic factors. This section recounts and discusses the observed forms and categorizes them into risk versus efficiency, parity driven, and offense-defense balance archetypes of technology strategy. By grouping in this way, the archetypes allow for extrapolation of other possible forms of technology strategy. These old and new forms may provide future technology strategists with basic templates for achieving desired strategic ends, maximizing capability, and aid in additional analysis of historical technology strategies.

a. The Risk vs Efficiency Strategic Form Archetype

The U.S. nuclear arms race and the French Maginot Line introduced the *Big Bets* form of technology strategy as a way of accepting large risk, knowingly or unknowingly, with the hope of increased efficiency. The relationship between risk and efficiency is thus the first proposed archetype of technology strategy and allows for derivation of additional forms. The following discussion reviews the observed strategic forms, proposes a risk vs. efficiency spectrum, and derives several additional strategic forms.

²⁸⁹ U.S. Army website Videos, “Investment Strategy Approach to Modernizing across DOTMLPF” (2 of 6), 2014, 3:59, <https://www.youtube.com/watch?v=t7FEApVMl48>.

In the *Big Bets* form, a military puts a significantly large trust in a particular technology but incurs a large risk in that failure of the technology to achieve its end state (deterrence, defense, coercion, superiority in battle, etc.) has potentially disastrous consequences. However, if the bet pays off, it may also represent the most focused and economically efficient way for a warfighting concept to achieve its strategic ends or for a singular portfolio to achieve its desired capability. Both the U.S. and French cases seem to suggest that the positives of such a strategy may have blinded the decision makers to the risk incurred. The United States' grand strategic big bet in nuclear superiority failed to fully achieve its deterrent strategic end and, as the limited war deterrence failed, spending continued to increase. Similarly, the bet made by the French on the Maginot Line failed to fully achieve to achieve a comparably big payoff in defense compared to the amount of resources devoted to its construction.

In application, the Big Bet form of technology strategy often appears to be unwise—but context always matters. While the Big Bets strategies in this exploration have a low success rate (arguably nuclear deterrence *has* worked in the preventing nuclear war), this does not mean that a Big Bet strategy always fails or that successful strategies cannot be derived. For instance, what if Tirpitz had made a big bet on a submarine centric technology strategy? The realized capability may have broken the blockade and Germany may have won the war, or, more desirably, prevented war by achieving the deterrent that Tirpitz intended. In any case, further exploration may very well find additional instances of a Big Bet technology strategy achieving its desired end and yielding a high payoff for the user.

Speculating further from the case studies' observations, one can suggest that Big Bet strategies likely represent one end of a spectrum of strategic forms based on the risk versus efficiency achetype. Such a spectrum would find the form Big Bets on one extreme end and the *Broad Preparation* strategic form on the other extreme end. The Broad Preparation form would represent the emphasis and broad development of a large number of technologies thereby reducing the risk due to failure of any of the individual technologies to reach their strategic end state or portfolio capability. However, such an approach would likely require huge resource investment and result in a lot of inefficiency.

Figure 20 illustrates a conceptual risk versus efficiency spectrum for technology strategies where this tradeoff heavily influences their form. A significant takeaway from Figure 20 is that these forms of technology strategy are chosen when risk and efficiency are opposites. How well this assumption holds true, or what form of strategy should be chosen is likely to be highly context dependent.

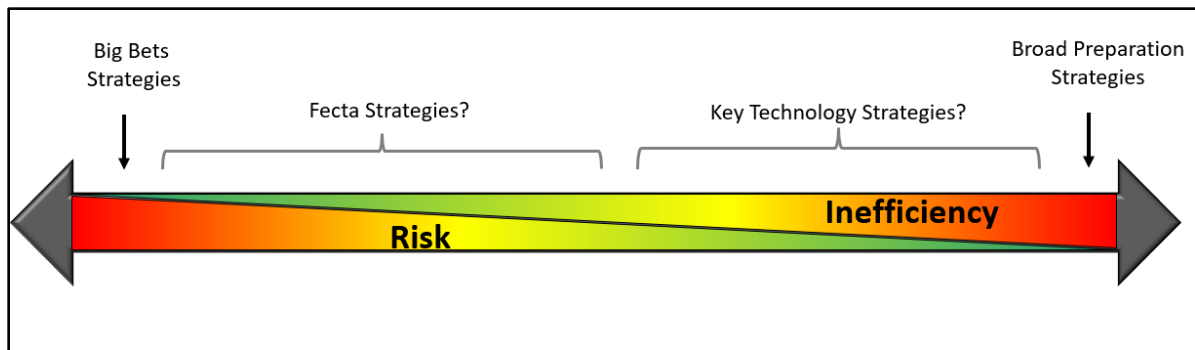


Figure 20. Spectrum for Technology Strategies Heavily Influenced by Risk and/or Efficiency

By viewing risk versus efficiency strategic forms on a spectrum, one can also interpolate and extrapolate additional forms under these conditions. One such form could be called a *Fecta* strategic form. Derivative of a trifecta bet in horse racing; this form of technology strategy would depend on multiple large technological bets working together.²⁹⁰ As shown on the spectrum, the risk on such a strategy would be hard to determine but may be dependent on the readiness of the technology.

For instance, at the warfighting concept level, the German Blitzkrieg concept depended on the integration of tactical aircraft, fast-moving tanks, and integrated radios for coordination. Three distinct capability portfolios with technological, organizational, and doctrinal requirements. If any of the portfolios failed to meet their capability requirement (due to failure in any of the DOT strategies), Blitzkrieg may not have worked.

²⁹⁰ In horse racing, a trifecta bet is when the bettor places a bet on which horse will place first, second, and third in the race. All three horses must finish in the chosen place for the bettor to win.

At face value, a Fecta form appears to be a larger risk than betting on a singular technology and is probably an unwise strategic form without risk mitigation. In the German case, the radio coordinated movement and attack of aircraft and tanks that we now call Blitzkrieg, evolved after the technologies were already demonstrating readiness to meet their joint capabilities individually. While the Germans did have the spark of genius to integrate radios into both aircraft and tanks, their Fecta technology strategy risk was relatively low and mitigated due to the technological readiness level of the three chosen technologies. The Blitzkrieg case suggests that using a Fecta strategy at the concept level is probably most effective with risk reduction considerations such as utilizing technologies with a high level of technological readiness.

At the capability portfolio level, *Fecta portfolios* are ones where multiple technologies are required to meet a single capability. These portfolios are often cited as examples of military fiscal irresponsibility and poor decision making. A recent example is the U.S. Air Force's Airborne Laser (ABL). The ABL struggled with power, weight, and range, inhibiting the U.S. Air Force's attempt to get a single capability into a larger ballistic missile defense warfighting concept. The ABL fecta portfolio is of particular interest because then Secretary Robert Gates, who cancelled the project, later stated that neither he nor any top military official thought "that this program should, or would, ever be operationally deployed" in support of a missile defense umbrella.²⁹¹ Suggesting that the capability portfolio was not only failing to meet its capability but had also lost its connection to the strategic ends—supporting the missile defense concept. Fecta forms certainly represent increased risk at both the portfolio and warfighting concept level.²⁹²

Towards the efficiency end of the spectrum, recent calls for U.S. emphasis on development and procurement of potentially high-payoff technologies, such as artificial intelligence and autonomous weapons systems suggest a *Key Technology* form of

²⁹¹ Thomas Duffy, "What's Next for Airborne Laser?," *Air Force Magazine*, 2010, <https://www.airforcemag.com/article/0410laser/>.

²⁹² Its worth noting, although requiring a much larger study, that the U.S.' nuclear triad concept seems to fall within the Fecta portfolio form. The large amount of literature devoted to the U.S.' nuclear triad operations concept could provide for useful study into the detailed characteristics of Fecta strategies.

technology strategy.²⁹³ Similar to Fecta strategies, in the Key Technology strategic form, a warfighting concept or portfolio contains investments in multiple technologies. However, unlike Fecta strategies, the technologies chosen in a Key Technology strategic form are not necessarily interdependent for success. The lack of interdependence would decrease the risk but possibly increase inefficiency due to divergent developmental goals. The U.S. Air Force's Agile Combat Employment (ACE) concept appears to be pursuing a Key Technology form focused on technological improvements in "a wide variety of enabling systems, to include: command and control (C2); logistics under attack; counter-small unmanned aircraft systems; air and missile defense; and offensive and defensive space and cyber capabilities."²⁹⁴ The wide technological approach to achieving a strategic end, will likely reduce the Air Force's risk of failure in achieving the ACE warfighting concept end state but be relatively inefficient compared to a focus on a single technological area.

While more research is required, there is enough historical and present-day evidence to show that risk and efficiency tradeoffs are strong influencers of technology strategy forms. When these tradeoffs become the dominant factor in choosing a technology strategy, the risk versus efficiency spectrum may prove to be a useful tool for a technology strategist.

b. The Parity-Driven Strategic Form Archetype

In the Tirpitz and Cold War examples, a desire to achieve a perceived measure of parity with another military strongly influenced the form of the technology strategies. In reflection, these forms may be limited to the conceptual and grand strategic levels but may still prove useful in discussing technology strategy forms. The identified forms were the Tirpitz *Quality-at-the-Margins* form and the *Technology-in-Being* form characterized by the U.S. Air Force in the 1950s. The following discussion categorizes this forms under the parity-driven archetype, reviews and derives forms of this type, and provides several

²⁹³ Scharre and Riikonen, *Defense Technology Strategy*, 5–6.

²⁹⁴ U.S. Air Force, *Doctrine Note 1–21: Agile Combat Employment* (Maxwell Air Force Base, Alabama: U.S. Air Force, 2021), 1, <https://www.doctrine.af.mil/Operational-Level-Doctrine/AFDN-1-21-Agile-Combat-Employment/>.

observations of how strategists may be influenced by their position on a notional parity spectrum.

In the Tirpitz case, Germany pursued a marginally inferior navy in quantity (two-thirds policy) of battleships but chose to close the perceived gap in inferiority by stressing higher quality in armor, weaponry, and optics in their development. Similarly, in the 1950s, the U.S. Air Force sought to maintain a clear superiority in nuclear delivery capability compared to the Soviet Union. The U.S. felt this would build a perception of overwhelming dominance and exert a *Technology-in-Being* influence. In both cases, each entity paid close attention to the quantity (the physical number of emphasized technology) and the quality (how effective the technology was at accomplishing its role) of their technology compared to the other entity. Regardless of the overall strategic effectiveness of either strategy (neither of which fully worked), there is a unique manipulation of the quality and quantity variables that may be useful in characterizing imitative strategies under parity seeking conditions.

If technology strategies among two or more militaries are largely imitative, meaning that the primary technological emphasis and practices (warfighting concepts) are similar (i.e., both build a navy around battleships), then one can imagine that a perception of parity is achieved when the quantity and quality of their technology is within some small measure of even. However, as one or both measures of quality and quantity move from approximating equality then one entity moves toward superiority and the other toward inferiority.

At the extremes, the perceived capability of a military is probably the most accurate. For instance, a military that is inferior by an overwhelming margin in both quantity and quality is most certainly inferior in the context in which that technology strategy applies. On the other end, a military with a significant margin of superiority in both quality and quantity is likewise clearly superior in that area. Unfortunately, quality and quantity are far from being the only measures in the capacity to execute a desired warfighting concept. Other factors such as training, terrain, esprit de corps, etc., play a significant role in determining military capability. The farther from the extremes, the less dependence one

can place on quantity and quantity manipulation. Figure 21 shows a notional parity spectrum.

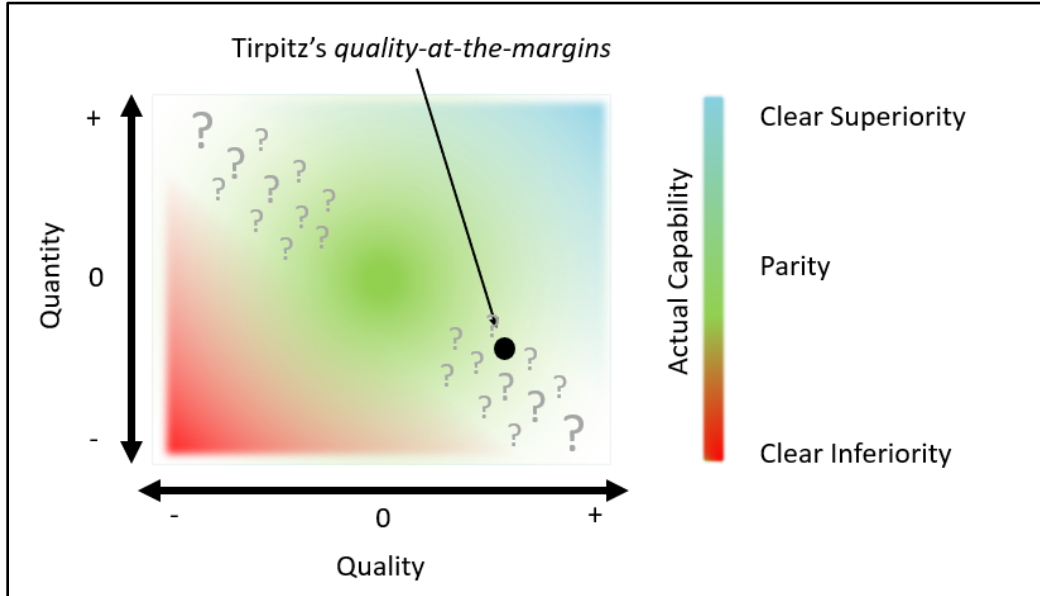


Figure 21. Notional Parity Spectrum

While Figure 21 is too simplistic for actual capability prediction, it is useful for illustrating the lack of clarity in quantity and quality manipulation as a strategic tool and can enable extrapolation of additional strategic forms. The farther an imitative strategy is from an exact imitation of its modeled military, the more difficult it is to accurately gauge parity. This observation calls into question the soundness of strategic forms such as Tirpitz Quality-at-the-Margins strategy. In WWI, the results of the Battle of Jutland seemed to suggest that Tirpitz may have achieved parity or even slight superiority. But his unwillingness to commit the fleet early in the war suggests that his strategic choices may have left him with a lack of confidence in the navy's actual capability.²⁹⁵ Similarly, pursuits involving clear superiority in both quantity and quality, such as the U.S. Air Force's Technology-in-Being strategy, are likely to inspire greater confidence in the user

²⁹⁵ Tirpitz was afraid to risk the Risk Fleet in the opening phase of the war – when its tactical efficiency would have had the greatest strategic effect. See Arquilla, "A Study in Technology Strategy."

but, as shown in Chapter III, are resource intensive and may not translate to an equal increase in capability. A technology strategist employing quantity and quality manipulation as strategic tools would be wise to remember perceived capability and actual capability are not the same and can be in fact vastly different.

Bearing this caution in mind, Figure 21 can suggest the possibility of other strategic forms based on quality and quantity manipulation. The most obvious extrapolated form is the inverse of Tirpitz's focus on quality. In the Quantity-at-the-Margins form, a nation knowingly maintains an inferior quality force but offsets the disadvantage by having a greater quantity of weaponry. While a gross simplification, the long Cold War confrontation in Europe (1947-1989) featured Warsaw pact forces armed with somewhat less advanced weaponry, but in significantly greater quantity, than its NATO adversary. The quantity balancing contributed to deterrence stability. Key to both Quantity-at-the-Margins and Quality-at-the-Margins forms is their relatively close distance to parity. If the technology strategy is less concerned with the appearance of inferiority or superiority, then the strategy requires different classification since the strategic intent is different.²⁹⁶

Another quantity manipulation form may be useful for militaries that have unique development restrictions. For instance, a wealthy nation with unique restrictions on internal development or a reliance on alliances. An example of such is Japan. Japan's constitution prevents the country from pursuing a military with "war potential."²⁹⁷ It also uses its alliance with the U.S. as a method of deterring aggressors. Yet, as China's pursuit of dominance over the region continues, Japan may find itself in a position where it needs to counter aggression. In this case they may choose to pursue select parity (such as naval) or even superiority by purchasing a greater quantity of slightly lower quality technologies than its peers. While most nations are apprehensive about selling their latest technologies, many are willing to sell a previous generation. Subsequently, a nation could achieve some form of parity or possible superiority (in select areas) by following the technology development of another country—a *Follower Form*. In the Japanese case, with sufficient

²⁹⁶ John Arquilla, "Struggling with the Quantity at the Margins Example," May 15, 2022.

²⁹⁷ Prime Minister of Japan, "The Constitution of Japan," Prime Minister of Japan and His Cabinet, 1946, https://japan.kantei.go.jp/constitution_and_government_of_japan/constitution_e.html.

funds, this could be a rapid method of achieving some form of limited and contextual parity if the sudden need for defense is detected and the constitution amended.

Further characterization of the Follower Form should involve the outcome of the strategy. For instance, Vietnam has continued to reinforce its coast guard capability in response to China's unfounded nine-dash-line claims.²⁹⁸ Through diplomatic means, Vietnam has enacted a Follower technology strategy by receiving coast guard equipment and a large naval ship from the US.²⁹⁹ Certainly, Vietnam is unable to achieve, and thus does not intend to achieve, parity with China but still wishes to increase relative strength. Such a follower strategic form would be classified as an *Inferior Follower*. Whereas the previously discussed Japanese case might be classified as a *Parity-Seeking Follower*.³⁰⁰ Intuitively, from these examples, one can also deduce a case where a military may be pursuing a quantity manipulation that focuses on achieving relative superiority. The Iraqi buildup during and following the Iraq-Iran conflict was mostly older Soviet equipment and could be considered a *Superiority-Seeking Follower* relative to Iran.³⁰¹ Therefore, a military employing a Follower form, based on the quantity of the technology they acquire, could be characterized as either an Inferior, Superior-Seeking, or Parity-Seeking Follower. Further research is likely to uncover a great number of militaries who have undertaken the Follower or other parity-driven forms of technology strategy.

A final observation that Figure 21 and the arms-race case studies highlight is the different ways challengers and incumbents face the acquisition approach decision (see next section) in their strategic form. A challenger will inevitably sit at some point in the lower left of Figure 21 and the incumbent in the upper right. The challenger is always working from a position of inferiority and must fear reprisal from the incumbent. Just as Tirpitz

²⁹⁸ Anh Duc Ton, "Vietnam's Maritime Security Challenges and Regional Defence and Security Cooperation," *Soundings*, no. 14 (March 2018): 12.

²⁹⁹ IPDForum, "U.S. Donates Patrol Vessel to Boost Vietnam's Maritime Security," *Indo-Pacific Defense Forum* (blog), accessed April 25, 2022, <https://ipdefenseforum.com/2021/08/u-s-donates-patrol-vessel-to-boost-vietnams-maritime-security/>.

³⁰⁰ While this bears similarity to Tirpitz strategy, Tirpitz sought to hide his parity intent and was not focused on a quantity based strategic form, thus his strategy requires a different classification

³⁰¹ Francis Fukuyama, *The Soviet Union and Iraq Since 1968*, N-1524-AF (Santa Monica, CA: RAND Corporation, 1980), vi–viii, <https://www.rand.org/content/dam/rand/pubs/notes/2007/N1524.pdf>.

feared a preventative attack from Britain. Inversely, the incumbent that wishes to maintain superiority in a technologically advancing world will be required to continually invest in and develop multiple technologies and concepts to prevent the challenger from reaching parity. The incumbent wishing to maintain parity must prevent the riser through preventative attack or invest in new development which is inherently inefficient. Therefore, a challenger often faces the choice of acquisition approach with reprisal as a primary focal point, and the incumbent with efficiency as a primary point.

The United States' Massive Retaliation highlights the incumbent approach, as they were focused on achieving the most-bang-for-the-buck—a fiscally conservative ideation. Conversely the Soviet Union, as the challenger, emphasis on ballistic missiles to achieve surprise and “frustrate” an attacker by striking their home shows an inherent deterrent to preventive war.³⁰² Similarly, Tirpitz's Risk Fleet was conceived from the beginning to maintain an inferior ratio to Britain to prevent a “Copenhagen moment” while the British capping of their battleship fleet to the two powers rule was based on Parliamentary desires to control naval spending. Certainly, the challengers also desired efficiently, and the incumbents wished to avoid war, but it is noticeable that the parties in the case studies clearly ranked some attributes above others and the way they were ranked seems related to their starting position on the parity spectrum. In both cases, though, maintaining a distance from or achieving some type of parity appeared to be the dominant factor.

c. The Offense-Defense Balance Strategic Form Archetype

Chapter IV introduced offense-defense theory as a method to explore and characterize technology strategies. Through the ODT lens, the Defense Dominant and Balance Shifting strategic form descriptors were observed. The following discussion categorizes these forms under the OD Balance archetype, recaps the observed forms, and extrapolates additional forms.

In the French case, the preference for firepower over mobility defined a characteristically *Defense Dominant* grand technology strategy. Antithetically, a military

³⁰² “Russian / Soviet Doctrine,” Federation of American Scientists, 2000, <https://nuke.fas.org/guide/russia/doctrine/intro.htm>.

preferring mobility over firepower in technological emphasis and tradeoff decisions would be pursuing an *Offense Dominant* strategic form. At the grand strategic level, WWII Germany had this strategic form with Blitzkrieg as its dominant warfighting concept. More recently and at a smaller level, the U.S. Marine Corps has identified an Offensive Dominant capability portfolio inside its 2030 warfighting concept which it calls “mobility inside the WEZ [weapons engagement zone].”³⁰³ Considering the presence of Offense and Defense Dominant forms, it is also intuitive that an *Offense and Defense Balanced* strategic form is possible with any number of variances in between.

The relationship between the strategic form and the current or future offense-defense balance is perhaps more important for understanding the intent of the technology strategy and strategist. Consider that a technology strategy can shore up the current balance or undermine it. Because the state of the balance attempt to predict the most efficient use of military forces, one would expect that the resource requirements of a technology strategy built against the prevailing balance would be greater than one built in alignment with the balance—a useful point to identify from the beginning of the strategic formulation, and one that will certainly affect decisions made in the DOT triad. Thus, it is likely beneficial to describe strategic forms as *Offense*, *Defense*, or *Neutral*, and *Supporting* or *Opposing* the balance.

However, the descriptive label does not relieve the strategist of the burden of accurately gauging the current and future balance. As an example, under this proposed naming scheme the French would have considered their technology strategy as a *Defense Dominant Reinforcing* technology strategy. They felt that the balance was toward the defense and thus their strategy reinforced that balance. As Chapter IV showed, the French perception of the balance was incorrect. In reality, the French employed a *Defense Dominant Opposing* technology strategy in direct opposition to the emerging balance. Had the French correctly perceived the trending balance, the right labeling may have proved

³⁰³ Todd South, “Goodbye, Tanks: How the Marine Corps Will Change, and What It Will Lose, by Ditching Its Armor,” *Marine Corps Times*, March 22, 2021, <https://www.marinecorpstimes.com/news/your-marine-corps/2021/03/22/goodbye-tanks-how-the-marine-corps-will-change-and-what-it-will-lose-by-ditching-its-armor/>.

useful in resource allocation or debates regarding employment and DOT synchronization decisions.

Chapter IV also suggested the presence of a third type of strategic relationship with the balance called *Balance Shifting*. In the 1920s, German military leaders intentionally looked to develop and employ technologies that would overcome the defensive stalemates of WWI. As opposed to the French, the Germans built and employed an *Offense Dominant Shifting* grand technology strategy, intended to change the way war would be fought in the future.³⁰⁴ Similarly the U.S. Marine Corps Force Design 2030 warfighting concept's "mobility inside the WEZ" capability portfolio, aims at enabling increased access in environments dominated by defensive-based technologies.³⁰⁵ The desire to increase mobility in denied environments would indicate that the Marine capability portfolio also has an Offense Dominant Shifting form.

d. Observed and Derived Strategic Forms

The strategic archetypes and forms discussed in this section are summarized in Figure 22. The list provided is not intended to be all-inclusive; instead, it serves to identify the focus of an intended technological pursuit and aid in building a working vocabulary for the further study of technology strategy.

³⁰⁴ Note, a distinction on whether a military is following a shift or intending to cause a shift may not be easily made. One can argue that Germany was not intending to shift the balance, but simply following the trend of a naturally shifting balance. Tanks and aircraft were already beginning to shift the balance by the end of WWI see Murray and Millett, *Military Innovation in the Interwar Period*, 40–43. Similarly in the modern context, current pursuits for low-cost autonomous weaponized drones threaten to again shift from a defensive to offensive balance, yet the developments in the base technology of small drones and automation is not driven strictly by military purposes. Whether a military is intending to cause the shift or follow the shift may be more discernable by the approach the military uses to pursue its strategy—i.e., imitative or developmental. A developmental approach to a *shifting* strategy may suggest that the military intends to cause the shift in the balance.

³⁰⁵ *Force Design 2030* (Washington, D.C.: Headquarters Marine Corp, 2020), 5, <https://www.hqmc.marines.mil/Portals/142/Docs/CMC38%20Force%20Design%202030%20Report%20Phase%20I%20and%20II.pdf?ver=2020-03-26-121328-460>.

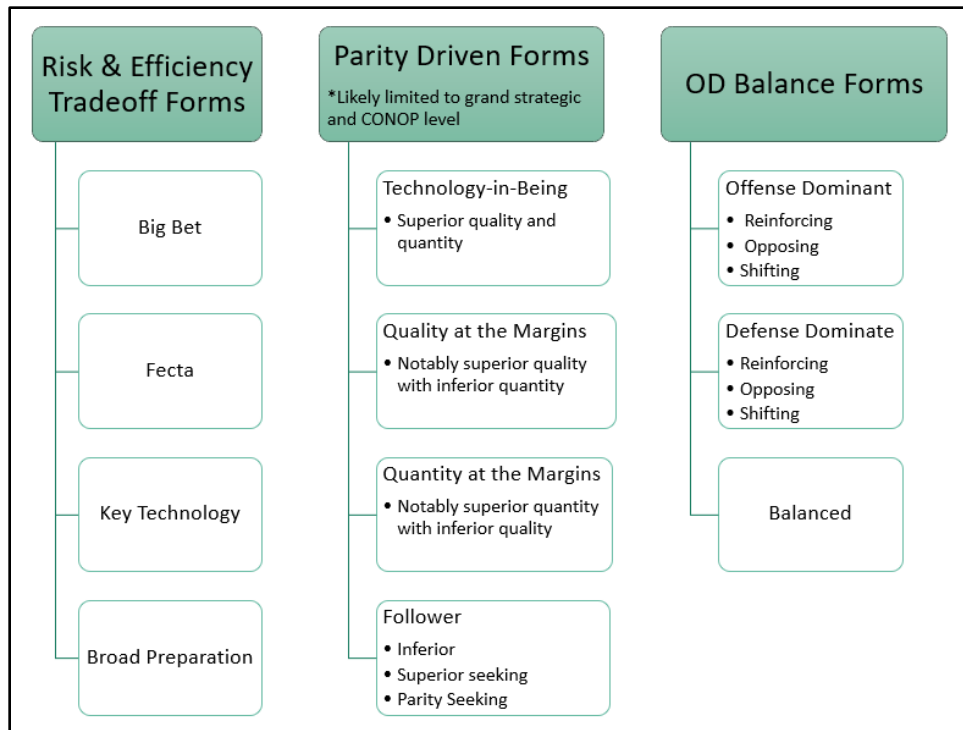


Figure 22. Observed and Derived Technology Strategy Forms

2. Technology Acquisition Approaches

As noted in Chapter II, a technology strategist's approaches to acquiring technological capabilities can be categorized as imitative, developmental or monitoring. The *imitative approach* copied the technological capabilities and practices of another military. The *developmental approach* invented new technologies and/or practices to meet capability requirements. Finally, the *monitoring approach* utilized standing technology and practices to meet capability needs with some expectation of incremental improvements. Each of these approaches is useful in describing the procurement methods of individual technologies or inspiration for technological emphasis inside a strategy or capability portfolio. However, a fourth type of approach is revealed in reflection that was not deduced in Chapter II. A nation may wish to *innovate* on current or purchased technology.

The *innovative approach* combines the imitative and developmental approaches. A nation may choose to modify the quality of their own technology by incorporating foreign components. The French Air Force took this approach in its acquisition of foreign engines

including the British Merlin engines and the Spanish Hispano-Suiza engines.³⁰⁶ In both cases, France was attempting to close a gap in the quality of its aircraft by using purchased engine technology. For a short time, purchasing parts and innovating to create unique French aircraft dominated its air force's technology strategy. The *innovative approach* is therefore when the dominant approach is purchasing technologies and combining them with the military's own or other purchased technologies to create something new. This suggested fourth approach should be included as part of the characteristics and vocabulary in technology strategy studies.

C. PUTTING IT ALL TOGETHER: A TAXONOMY AND DESCRIPTION

To easily convey and increase applicability of the concepts in this study, the internal and external structural characteristics of technology strategy are arranged in a graphical taxonomy. The taxonomy provides visual connections of the new vocabulary terms to the strategic structure in a way that allows examination of case studies and quick conveyance of future technology strategy components. Figures 23 and 24 summarize the structure and characteristics of technology strategy observed and deduced in this thesis. To aid future researchers, the accompanying explanation of the taxonomy briefly repeats some of explanation given in previous sections, providing a summary that can be reviewed quickly. Following the figures, the first formal answer is provided to the question: "What is Technology Strategy?"

1. Technology Strategy Taxonomy

Figure 23 shows the generic taxonomy of technology strategy characteristics and structure proposed in this thesis. To highlight the applicability and further illustrate the concepts, Figure 24 applies the proposed taxonomy to the Tirpitz Naval Strategy explored in Chapter III. Following Figures 23 and 24, and working from bottom to top, this section summarizes each level for the proposed taxonomy utilizing Tirpitz's strategy as an example. The proposed taxonomy can aid examinations of historical technology strategies and provide structure when building technology strategies.

³⁰⁶ Baughen, *The Rise and Fall of the French Air Force*, 145.

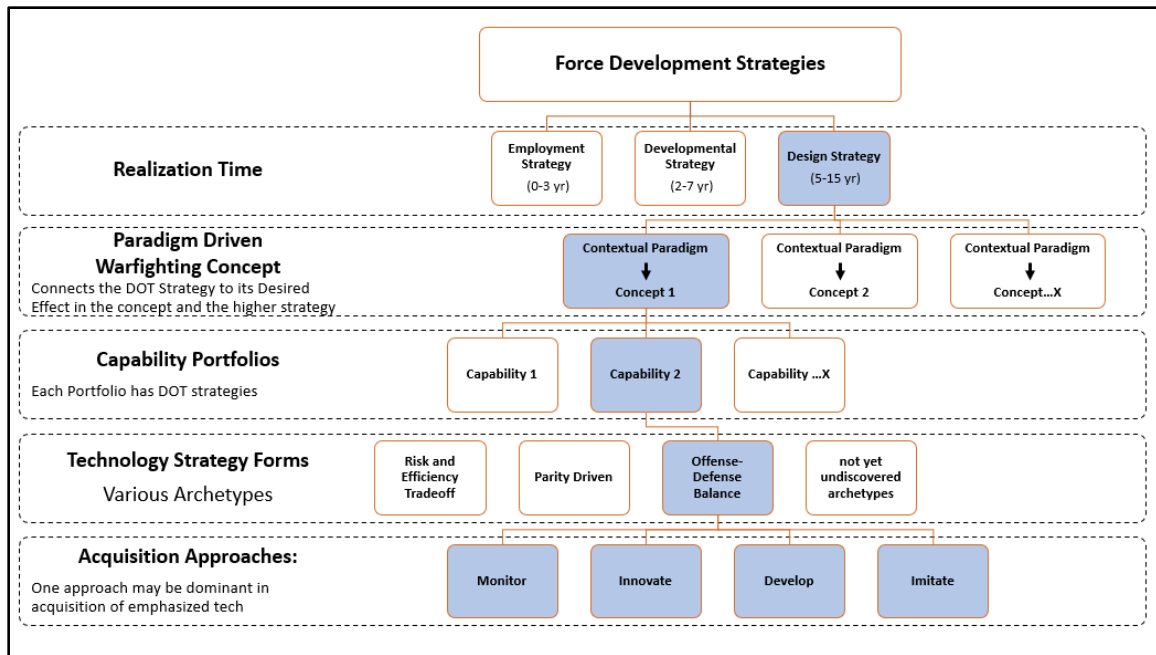


Figure 23. Proposed Generic Technology Strategy Taxonomy

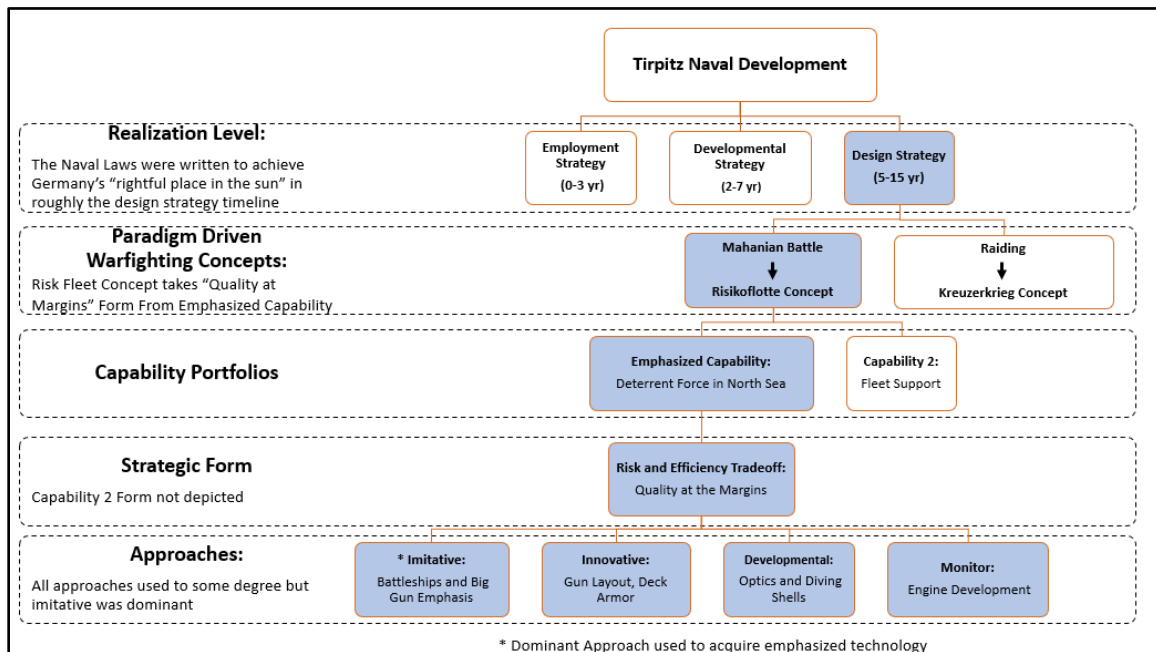


Figure 24. Tirpitz Naval Strategy Applied to the Proposed Taxonomy

In the taxonomy, the *acquisition approach level* identifies the way the strategy will acquire the technology used to meet the capability portfolio requirements. These choices

have a strong effect on the form of the strategy and can even affect the ability of the warfighting concept to meet its strategic end. Despite being at the bottom of the proposed hierarchy, in observation, the desired approach to technological acquisition is often the first decision and can shape the entire technology strategy.

Tirpitz's decision to deter the Royal Navy with an imitative approach, naturally gravitated the entire strategy toward a parity-based form. In Figure 24, note that multiple approaches were utilized to bring all the technological requirements together. While the emphasized battleship technology utilized an imitative approach, Tirpitz used an innovative approach in gun layout and armor placement but a developmental approach in optics and diving shells because these were how he could achieve his Quality-at-the-Margins form. These additional technologies supported the emphasized technology. The approach utilized in acquisition of the primary technology is considered the dominant approach because it creates a center of gravity for additional technological requirements.

Notably, early in Tirpitz's technology strategy, he utilized a monitoring approach for his steam engines, realizing later that they too needed updating to maintain a quality edge. Adding distinction to the monitoring approach, Tirpitz was in a position to influence development of steam engines but chose not to early on. The capability and decision to maintain a specific course is key to identifying a monitoring approach. The strategic form and approach levels form the "meat" of technology strategy and the primary focus of the technology strategist.

The *strategic form level* is an explanatory level that describes the way in which the strategist meets the technological requirements of the capability. These are the templates of technology strategy and bear a similarity to the way one might think of types of strategies such as a Fabian delaying strategy. A strategy's form is shaped by the approaches utilized in acquisition of its technological components and how the emphasized and supporting components work together to achieve the capability within the concept.

In the Tirpitz case study, the primary or emphasized capability portfolio was the deterrent force in the North Sea. However, underlying this desired capability was the strategic intent to avoid an arms-race or entice Britain into a preventive-attack. To this end,

Tirpitz chose to build a force that was of lower quantity but superior quality giving the technology strategy a distinct form based on quality and quantity manipulation that this thesis called Quality-at-the-Margins. Technology strategy taxonomy thus has a form level that describes the strategy by the way the technologies are acquired and put together to reach their desired capability.

At the *capability portfolio level* each technological pursuit is grouped according to its purpose in the warfighting concept and synchronized with the other elements of the DOT triad. The technological strategy in each capability portfolio is described by the form in the layer beneath it. There is only one strategic form per capability portfolio although there may be multiple capabilities and forms per concept. In the Tirpitz Risk Fleet warfighting concept, there were two distinct capabilities. The first focused on building the battleship fleet as a deterrent.³⁰⁷ The second capability focused on protection of the battleship fleet and included supporting technologies such as destroyers and cruisers. While the battleship fleet was the emphasized technological capability and thusly best described the overall form of the concept's technology strategy, the technological pursuits in the supporting fleet capability were still important to the overall strategy.

The *warfighting concept level* shows the connection between the paradigm and concept and organizes technological pursuits by their strategic end in the grand strategy (i.e., how the technology will create effects in the strategic environment). The warfighting concept is how the military envisions war being fought in a particular context and how that military will fight it (i.e., Mosaic Warfare or AirLand Battle). Case study analysis suggests that militaries with multiple warfighting concepts at this level are more adaptive and better able to support grand strategic goal(s). Tirpitz had two warfighting concepts, the *Risikoflotte* [Risk Fleet] and *Kreuzerkrieg* [Cruiser Warfare]. In theory, each derived from different paradigms on how conflict would be fought in that particular context. Notably,

³⁰⁷ It should be noted that this deterrent failed almost immediately given Britain's early entry into WWI. So, while the process seeks to inform us, the strategy itself has clear shortcomings.

the primary concept was Risikoflotte and Tirpitz frequently disregarded the Kreuzerkrieg's colonial defense focus as a poor use of the navy.³⁰⁸

The *realization level* categorizes technological and accompanying DOT triad pursuits by the time horizon in which they are designed to meet their strategic end state.. Synchronizing the realization time of the technology strategy (and other DOT components) with the desired realization of the warfighting concept is primary purpose of this level. For Tirpitz and Kaiser Wilhelm, the grand strategic goal was to achieve Germany's "rightful place in the sun" as a recognized great naval power. They pursued a Design (5-15yr) Strategy as outlined in the Naval Laws which dictated production rates of ships per year.³⁰⁹

2. What is Technology Strategy? A Refined Description

This pursuit of a conceptual understanding of military technology strategy began with a literature review that produced a relatively simple description. In the review, it was noted that the term technology strategy is often applied to technology choices in acquisition and development without connection to strategic intent. The connection between the strategic intent and the chosen technology, especially the emphasized technology, is the key difference to the concepts explored in this study and other references to technology strategy in the U.S. acquisition system. While the original description remained valid, it requires refinement as it fails to highlight several of the key characteristics observed in Chapters III and IV and expanded above. To aid future examinations, the following offers several bullets describing technology strategy. No single point is "the definition" of technology strategy, as the concept is quite nuanced and multifaceted. The revised descriptions should serve as a starting place for explaining the concept of technology strategy and entry points for further historical analysis.

³⁰⁸ P. M. Kennedy, "The Development of German Naval Operations. Plans against England, 1896–1914," *The English Historical Review* 89, no. 350 (1974): 48–76.

³⁰⁹ Or, *Dem Deutschen gehört die Welt* – "The World Belongs to the Germans," as they and the Pan-German League put the matter at the time. See William Manchester, *The Last Lion: Volume 1: Winston Churchill: Visions of Glory, 1874 - 1932* (Little, Brown, 2012).³⁷³

Military Technology Strategies

connect technological decision making to a desired outcome in the strategic environment

are specific types of strategies used to achieve the technological capabilities required in a new or improved warfighting concept.

identify the technological capabilities required in the concept, how to pursue it, and the primary technological emphasis.

take on a unique form based on the inspiration for the technological emphasis, the way the various technologies are acquired, and the strategic intent of the capability or concept.

exist as part of an interdependent and overlapping triad of force development strategies that includes technology strategy, organizational design strategy, and emerging doctrine.

guide the decisions on emphasizing or deemphasizing the acquisition, development, and/or refinement of weapons, delivery/transportation, and information technologies.

guide the technical tradeoff decisions made during the development and integration of the technology into the military system.

D. TECHNOLOGY STRATEGY IN EXECUTION: PITFALLS AND STRATAGEMS

This final section recounts the observed pitfalls and stratagems and proposes three additional observations that may result, with refinement and future study, in new stratagems. The first part recounts the pitfalls and derived stratagems observed in the previous chapters. The following part presents the new, although incomplete, character of war and technology relationship, focused development, and the ruthless investor stratagems. In all, this section provides an epistemological component to the largely ontological focus of this study. While more work remains to be done, this section shows the great potential for further analysis enabled by precisely defining and categorizing technology strategy.

1. Observed Pitfalls and Stratagems

Chapters III and IV suggested four pitfalls and associated stratagems, they were the Comparison Trap, Iceberg, Crossover Point, and Opportunity Cost pitfall. The *Comparison Trap pitfall* is likened to the mirror-imaging fallacy and describes a situation where a nation seeks to emulate when it should innovate. The associated *Comparison Trap stratagem* is:

If you model yourself after your opponent, they are aware of your capability, and your deterrent threats may have more legitimacy. But beware, deterrence can fail, and you will be playing by the rules the opponent knows well. However, if you model yourself in a new or different pattern than your opponent, they may underestimate you.

The *Iceberg pitfall* derives from the missile gap scare in the U.S. following the launch of Sputnik by the Soviet Union. The U.S.' fear of technological surprise, created by the Soviets' display of its rocket capabilities, intensified and expanded the arms-race suggesting such a technique may prove useful to manipulating the dynamics of an arms-race or coercing an opponent. The corresponding *Iceberg stratagem* is thus:

Let your opponent see your technological progress in peaceful pursuits and they may assume equal or greater progress in military arenas. The adversary fears what they do not know but can see reflected in your overt actions. Peaceful progress, especially with an implied dual-use, may equal greater deterrence.

The *Crossover Point pitfall* warns the strategist against choosing a capability that fits a desired technology, instead of picking a technology to achieve a desired capability. It suggests approaching technological decisions with a primary characteristic in mind as a starting place for choosing the base technology. The associated *Crossover Point stratagem* is thus:

Avoid wasting time and resources trying to convert a piece of equipment into something against its nature. Instead, choose equipment and technology already closely aligned with your primary intended capability and then use tradeoff decisions in development to enable any secondary capabilities.

The final observed-stratagem was derived from the *Opportunity Cost pitfall*. In the French case study, the high cost of the Maginot line drained time, money, and political clout from other areas of the French defensive plans. The Opportunity Cost pitfall reminds

the strategist that technological pursuits require definitive direction and guidance. To avoid wasting precious few resources, technological decision-making needs to remain strategically, doctrinally, and organizationally aligned. Leading to the intuitive *Opportunity Cost stratagem*:

A technology strategist's constant enemy is scarcity. There will never be enough resources to pursue all possible technological solutions. Thus, each decision to undertake a technological pursuit is also a decision to forgo another.

The remaining three sections, suggest additional stratagems that seem appropriate in reflection but require further research and analysis.

2. Character of War and Technology Relationship Stratagem

The research for this thesis suggests a possible relationship between technology development and the character of war. Suggesting the possible stratagem:

In the relationship between technology and the character of war, technology is an independent variable, and the character of war is a dependent variable.

While such a simple explanation ignores the certainty that many, if not an undefinable number, of variables are also present, it does clearly identify that technology should not be developed or pursued in the hope of being better prepared for the current or past types of warfare. Instead, the technology strategist should remain concerned with how the character of war is changing, will change, or if truly strategizing—how the technology strategist *wants* it to change. Questioning assumed constants and analyzing trends was perhaps the strongest lesson taught by the French case presented in Chapter IV. In the author's own experience, the same lesson is echoed by the US' eroded military edge caused by the vexing distractions of the Global War on Terror for the last twenty years.

3. Focused Development Stratagem

Historically, specialization is expensive, but sacrificing specialization for efficiency has a poor record. Many technology strategists have attempted to develop singular technologies that accomplished a large array of military missions. Such a mindset

often results in technology that is mildly capable of many roles but excellent at none of them. Suggesting a possible *Focused Development stratagem*:

The jack-of-all-trades (but master-of-none) approach to technology may provide a country a reasonable result when facing an inferior opponent but can result in disaster when facing a peer or near-peer opponent.

The French developed the BCR as a jack-of-all-trades aircraft to increase efficiency but ended up with an aircraft only mildly capable at any role at the time it was designed, and completely ill-suited as technology advanced. The United States' own multipurpose pursuits in the F-111B and the early design of the M2 Bradley Assault Vehicle also seem to fall into this pattern. The BCR, F-111B, and M2 lessons appear to be that jack-of-all-trades technologies can result in expensive redesigns, lost development time, and in the case of the BCR, the long-term manufacturing commitment to inadequate technology.³¹⁰

A technology strategist should be hesitant to place efficiency across multiple missions as a primary goal. Instead, the strategist is likely to benefit from setting clear priorities in what mission the technology should accomplish most effectively and accept inefficiency if the technology is used outside its design. This attitude appears to be embraced by the U.S. Marine Corp Force Design 2030 strategy where the Commandant stated:

We will build one force ... optimized for naval expeditionary warfare in contested spaces, purpose-built to facilitate sea denial and assured access in support of the fleets. That single purpose-built future force will be applied against other challenges across the globe; however, we will not seek to hedge or balance our investments to account for those contingencies.³¹¹

The Commandant's force redesign is guidance for execution of all DOT strategies and his words are well aligned with the lessons in this paper. Attempting to design a technology or any DOT component to meet every mission with maximum efficiency has often been the first step toward failure.

³¹⁰ As a result, France entered the 1940 campaign with a poorly prepared Air Force that never had to chance to contest for command of the skies

³¹¹ David H Berger, *38th Commandant's Planning Guidance*, Commandant's Planning Guidance (Washington, D.C.: U.S. Marine Corp, 2019), 5, https://www.hqmc.marines.mil/Portals/142/Docs/%2038th%20Commandant%27s%20Planning%20Guidance_2019.pdf?ver=2019-07-16-200152-700.

4. Ruthless Investor Stratagem

Because a technology strategist's primary role is to enable future capabilities through resource investment in various portfolios, it is useful to think of a strategist's role as an investment manager. However, the strategist will often compete with a variety of interests that may not share the same strategic goals. Concessions are often necessary but too much concession and the strategy may lose focus. The investment mindset aids the technology strategist by focusing the strategy on balancing the inputs—resources and time—to optimize the value of the output—applicable military capability. Suggesting a possible *Ruthless Investor stratagem*:

A technology strategist's job is to convert resources into applicable military power. Just as a successful financial investor must remain focused on the goal of creating wealth, so must the technology strategist ruthlessly divest from pursuits that do not produce capability applicable to strategic goals.

Keeping the connection between technological decision making and the desired strategic outcome, as well as ensuring technical investments bring capability to those goals is a strategist primary concern. A technology strategy that achieves a capability that does not support the warfighting concepts' intent is a poor strategy. This failure may not even lie in the technology strategy but in the concept itself.

In the Cold War case study, Maxwell Taylor recognized that continual investment in nuclear weapons and delivery technologies were no longer providing the applicable capability that the concept envisioned. He discovered that the Massive Retaliation warfighting concept was failing because decision makers were apprehensive (for both practical and ethical reasons) to support nuclear weapon use except in extremis. Therefore, rendering the nuclear weapons useless in their ability to deny, seize or destroy in all but the most literal self-defense or general war applications (i.e., limited war was not deterred). Taylor's push for technologies supporting Flexible Response was a call for the scaling back on some areas of investment and adding investments in other areas that would increase military capability when deterrence or coercion from nuclear weapons failed. In other words, Taylor was advocating for investing in multiple warfighting concepts that gave the military various capability to apply force in other contexts. Therefore, we can think of

technology strategies as the management of investments designed to maximize military capability.

As I reflect on the knowledge gained from the research in this work, I offer in conclusion that a technology strategist would be wise to maintain the ruthless investor mindset of Maxwell Taylor, continually reevaluating the applicable military capability of every technological investment. This mindset worked for him, and for the United States, at a critical time in the Cold War. Such a mindset is just as necessary today, amid challenges ranging from competing great powers to rogue states and terrorist to insurgent networks.

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