The University of Chicago

Wargaming to Win: The Influence of Tactical Learning Centers on Military Innovation

By Robert Maxwell

August 2021

A paper submitted in partial fulfillment of the requirements for the Master of Arts degree in the Master of Arts program in the Committee on International Relations

Faculty Advisor: John Mearsheimer

Preceptor: Nick Campbell-Seremetis

In 1965, the United States military commenced air combat operations over North Vietnam. Given the significant technological and material advantages that both the US Air Force and Navy had over the Vietnam People's Air Force, there was very little expectation of real resistance. Both services had recently acquired new radar-guided missiles and fighters equipped with powerful airborne RADAR systems, allowing them to destroy targets beyond visual range. However, these weapons did not work as advertised, forcing American pilots into turning dogfights more resembling previous conflicts. This skillset had depreciated due to the new emphasis on interception and beyond visual range attacks using RADAR-guided missiles. Both services largely failed to conceptualize how to properly integrate these weapons as part of a larger force training plan.

Each of them reacted differently, with the Navy examining its training practices and the Air Force investing in new technologies. The Navy showed marked improvement in relative terms (kill ratio) and absolute terms (kills per combat). The Air Force stayed the same or even slightly regressed. The difference is that the Navy invested resources into "a graduate-level air-combat course," which was later more popularly known as "Topgun." This concept can be further abstracted to be neutral by warfare area, using the definition "tactical learning center." The form that these resources took follows a pattern in the universe of cases examining gradual military innovation. These "tactical learning centers" provide a means for increasing innovation in the given warfare domain and integrating evolutionary technologies into current practice.

How do advanced militaries adapt to evolutionary technological changes? Often, militaries attempt to utilize evolutionary new technology while not adjusting enough or completely changing tactical practices without adequately conceptualizing the totality of the practice in question. The existing literature on military innovation traditionally focuses on

paradigmatic changes in strategy but misses most changes in technological innovation, which occur gradually at the tactical level. By examining cases of gradual innovation, a larger universe of cases can be captured, better explaining how militaries effectively adapt to new technology. This paper examines how militaries adapt at the tactical level by utilizing "tactical learning centers," designed to provide advanced education on particular tactical roles above and beyond traditional military vocational education, develop a workable doctrine, and diffuse this doctrine to the larger force. This study is a comparative historical case study. The two cases are the British Western Approaches Tactical Unit during the Second World War and the American Navy Fighter Weapons School during the Vietnam conflict. My findings show that the presence and utilization of these institutions increase, in relative gains terms, the efficiency of organizations utilizing these new technologies.

Conceptualization and Theory

In this article, the definitions for evolutionary vs. revolutionary are straightforward. Revolutionary technologies fundamentally change their operating domain, with a noteworthy example of this armored fighting vehicle or aircraft carrier. Evolutionary technology is incremental improvements to existing technologies. Potential examples of evolutionary technologies are assault rifles, guided missile cruisers, or jet aircraft. The level of military affairs further defines the distinction between evolutionary and revolutionary technology that it affects. These levels are defined thusly: Strategic is the national policy level or theater level. Operational is the level between the tactical and the strategic, typically at the campaign planning or army/corps level. Tactical is at the individual engagement level. Revolutionary technologies and paradigmatic innovation change the conduct of warfare at the strategic or operational level. Evolutionary technology and gradual innovation change conduct at the tactical level. While

research exists on how the accumulation of small tactical advantages can significantly impact larger campaigns and wars, this work is primarily concerned with how innovations and adaptation at the tactical level will create a durable relative advantage at the tactical level.

A more straightforward way to describe this distinction is that revolutionary technologies change the entire conception of warfighting. To draw on an example, the ships used at Jutland would have been a shock to Nelson, the overarching strategy that the vessels used to engage each other would have been familiar. However, the Battle of Midway, with the ships not coming into sight of each other and aircraft were the primary striking arm, would have been an absolute shock. Yes, the core of naval strategy from Trafalgar to Jutland was of one gunline engaging another. Still, the evolutionary technologies of steam propulsion, directed heavy shellfire, armor plate, and torpedoes during this period demonstrate how much tactical *practice* had changed and became more complex. However, the overall strategic goal and operational planning were like those practiced during Napoleonic times. Aircraft and aircraft carriers changed the larger operational and strategic calculus, with their ability to project force from much longer distances and from ship to shore or vice versa in ways not previously considered. This study is a story about one of the methods that modify practice with technological change over time.

The dependent variable for this study is successful technological adaptation. Measurement of technological adaptation aligns with the tactical practice, as different warfare domains have various adaptation measures and other end goals. I theorize that tactical learning centers are one of the most efficient means of facilitating technological evolution. Tactical learning centers are training establishments created to address observed shortcomings in the integration of new technology. To be effective, these organizations work through two mechanisms: Firstly, by providing a mechanism for ideational generation. This mechanism has

two necessary conditions, a forum for experts and the tools for repeated simulation of possible outcomes. Secondly, it provides the mechanism for the diffusion of this information. These mechanisms combine to create a feedback loop, with success contingent on the organization being the product of quality institutions and the organization's level of professionalism. A competing alternative explanation for this is applying more technology to an existing case without further adjusting tactical practice.

The presence of a learning center is the first independent variable. A tactical learning center differs from traditional military officer education in one significant aspect. Unlike educational institutions that are more broadly based as academic institutions, ensuring the intellectual growth of officer corps through academic coursework, tactical learning centers are vocational in their focus. Examples of educational institutions that are not tactical learning centers are the service academies, Army and Navy War Colleges, and the Naval Postgraduate School. Tactical learning centers are vocational because each of these organizations provides short, intensive courses of study devoted to imparting and sharpening a specific set of tactical skills. This focused training represents a move away from most military officers' generalism and further education as specialized tactical leaders and warfighters.

What is important to note about the independent variable, for the Tactical learning center to be effective, the current political state and status of the service in question must be allowed flexibility in developing practice. Institutional investments inform the relative flexibility of practice that the larger organization made. It is important to note that because of the relatively low level of this theory, as well as the post-1939 phenomenon additional technical specialization in military affairs, as illustrated by Janowitz in his work *The Professional Soldier*, that civilian oversight of most tactical functions of military forces is not possible other than in the case of

gross incompetence in core capabilities.[1] This situation is because very few civilian leaders in the post-1939 world possess the technical knowledge required to conduct effective tactical oversight of their fighting forces. This knowledge asymmetry places the onus on uniformed service leaders to concentrate on their service's tactical development and long-term force development.

This specialization allows the services wide latitude to decide how they choose to fight at the tactical level and set priorities for long-term force development. This independence can create an incentive structure that either creates a powerful incentive for change in the face of information that invalidates previous assumptions or insulation from change or even retrenchment in the face of adverse information and practice. This choice is often dictated by what the individual service determines its larger overarching mission. If a service sees itself fighting a certain way, with high investment in these techniques with a lack of emphasis on force flexibility, these services will often retrench or not adapt. A good example of similar services making opposite decisions regarding tactical practice is the US Army and US Marine Corps in Vietnam, adapting to fight a counterinsurgency campaign. As illustrated by Krepinevich, the Army choose to follow its pre-conflict doctrine of massive firepower, while the Marines adapted to counterinsurgency warfare.[2] This situation happened because the Army, with its large budget and split mission, was largely insulated from pressures related to the adaptation away from what they considered their core competency and mission.

[1] Janowitz, *The Professional Soldier*.
[2] Krepinevich, *The Army and Vietnam*.

Figure 1 shows the general layout of my argument.

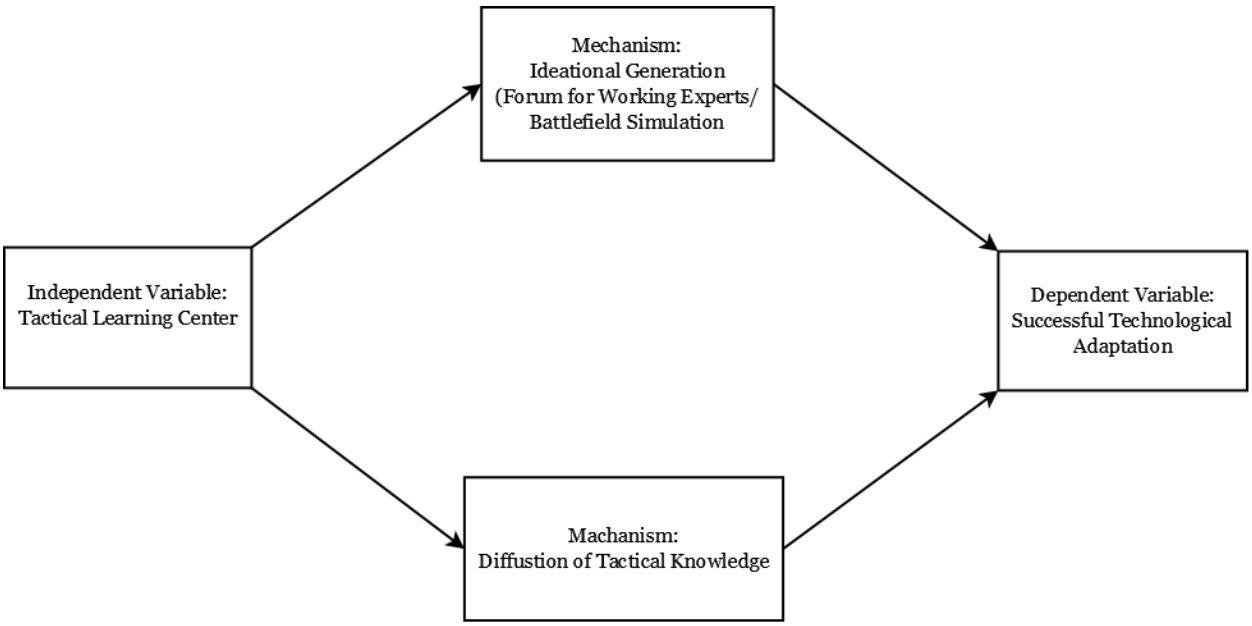

Figure 1

Research Design

I utilize comparative historical case studies to illustrate my argument. Specifically, I examine the two cases and use within-case variation on my independent variable to show the importance of having a tactical learning center. In my cases, I also trace the mechanisms through which tactical learning centers are effective. The first case considered is the Western Approaches during the Battle of the Atlantic[3] during World War II. During the campaign, the Royal Navy had developed a series of training institutions to increase proficiency and create new tactics to escort convoys crossing the Atlantic, which were sustaining heavy losses because of coordinated

[3] For this work, the time period from the Munich conference to "Black May" 1943 will be examined, as this was the decisive point in the campaign, as German losses became untenable and they never again sank a significant amount of allied tonnage. "Battle of the Atlantic " is a misleading name as the campaign was a series of discreet convoy battles.

attacks by massed submarine forces. This case will cover the period from the Invasion of Poland in 1939 to Convoy ONS 5 in May 1943. There is a period within this time frame before establishing tactical learning centers and service schools, allowing for within-case variation. The endpoint is when there was a noticeable change in German strategy. The Central Atlantic crossing was abandoned, and the battlefield was moved further afield because losses became untenable. May 1943 was also, importantly, the high point in terms of numbers of German Submarines at sea.

The second case is the US Navy and Airforce tactical fighter aircraft in Vietnam. This case provides useful within-case variation based on the two periods of air combat operations over North Vietnam: 1965-1968 and 1972. During the first period, the North Vietnamese Air Force (NVAF) was much more successful in air-to-air combat than expected. At the end of the initial combat operation period, the Navy and the Air Force took divergent paths. The Navy invested in aircrew training, including the Navy fighter weapons school, a tactical learning center, and the Air Force invested in further advanced technology for their aircraft, without the corresponding educational investment. With the resumption of combat operations in 1972, the value of these investments showed their value: The Air Force continued to struggle while the Navy began to score regularly against the NVAF.

Measuring the Dependent Variable

Because the cases are examples of different warfare domains with dramatically different missions, they each have their objectives and measures of success. For the first case, the Battle of the Atlantic, there will be several measures of adaptation. Firstly, I will examine how many convoy escort groups had received the team training at the tactical learning center, which is the Western Approaches Tactical Unit. Also examined would be the production of tactical training

materials, in case of units based away from the British Isles, which provides an alternate method to diffuse the expertise and tactics developed at the main schoolhouse.

I will use several metrics to measure adaptation in this case. The metric used for this case will be the gross tonnage (GRT) of shipping that is sunk by month over time. This metric is used because the stated goal of the U-Boat campaign is the sinking of merchant shipping, escorted or not. Immediately after the outbreak of hostilities, most of the transatlantic shipping was placed under convoy.[4] For the *Kriegsmarine*, every merchant that passed through the Atlantic unharmed represented a mission failure for the U-Boat arm. The last metric that to examine is the number of U-Boats that were operational. This metric is because the general growth of the U-Boat arm throughout the war was relatively constant, with the *Kriegsmarine* fielding greater than 100 operational boats from February 1942 to June 1944.[5] If the number of operational boats at sea does not increase the sinking rate, one can surmise that the overall efficiency of the escorts increased. This exercise will be placed in the context of the battle of ONS 5, which illustrated the effect of the new training, and was the campaign inflection point.

For the second case, different criteria will be used for the air war over North Vietnam. This case will explain the status quo as of 1968 and how each service respectively fared in the initial period of combat to provide a performance baseline and see any extraneous factors to consider. In the second period of the conflict, I will delineate each service's institutional choices and investments. I will then examine how effective these choices were and how completely they were affected. For the Navy, it would be how many of the fighter squadrons had fighter pilots who were alumnus of the Navy Fighter Weapon School, better known as TOPGUN, the tactical

[4] The ships that were not escorted typically were working ships (like fishing vessels), stragglers from convoys, and ships that were fast enough to be effectively invulnerable while making the transit while zigzagging, like flagship ocean liners.
[5] Westwood, *The U-Boat War*, 286.

learning center established during the bombing halt over the north. One in every squadron is to graduate TOPGUN, which is the metric for successful diffusion in this study.

The Air Force response is the deployment of improved combat avionics. The presence of this equipment provides the metric of diffusion for the Air Force's investment during the lull in their combat operations in North Vietnam. It is important to note that because of the adoption of the F-4 by both the Air Force and the Navy, there needs to be verification where and when the Air Forced used this specialized equipment. This exercise is to ensure that this subcase can effectively test the alternative explanation. If one wing is known to have at least one airframe equipped with advanced combat electronics and electronic warfare equipment, advanced electronics are considered equipped.

There are two final measurements for the air war over North Vietnam. The first one is air to air kill ratios. This metric is used because the ability to kill opposition fighter aircraft while surviving yourself is the essence of the tactical fighter aircraft mission. While there is a problem using "body count" in ground operations, especially in counterinsurgency campaigns, as explained in Krepinevich's *The Army in Vietnam,* these issues do not exist in the air war.[6] This situation is different because while there was a plentiful supply of military-age people and small arms to use as ground forces, the high standards and training needed for pilots combined with the scarcity of fighter aircraft make relative losses a vital metric to evaluate. The second metric for examination was whether one service or another adopted the methods and approach of the other. Due to interservice rivalry, services are reluctant to adopt practices pioneered by another service. This adoption would constitute a tacit admission that the approach of the other service provided a utility not offered by the approach previously utilized. Military organizations are ruthless in

[6] Krepinevich, *The Army and Vietnam*.

finding ways to improve themselves, especially if formal self-reflection or after-action analysis they have been found wanting in completing their missions.

Literature Review

For this article, two different theories will be juxtaposed with this theory to present alternative arguments. The first is the theory articulated by Horowitz in his work *The Diffusion of Military Power*, predicated on the diffusion and gestation of new ideas combined with material limitations as the determinant of military innovation.[7] The second theory, articulated by Avant in her work *The Institutional Sources of Military Doctrine*, leans more on institutional incentives to create an environment conducive to military innovation.[8] I will assess these theories in the discussion section following the case studies.

This work will be mainly in conversation with Michael Horowitz's *Diffusion of Military Pow*er.[9] While I agree with his larger thesis, especially on the need for military technologies to gestate, I think the data do not bear out some points. He posits two important focuses that potentially limit innovation, first in how expensive it is, termed by him as *Financial intensity*, a reflection of the difficulty of acquiring new military hardware to keep abreast of technological changes. Budgets have always been a constraining factor in the ability of militaries to adopt new technologies. The second factor is what he calls *Organizational Capital*, which is the ability of the organization to effect needed changes, where I think there are problems concerning the case that I am employing. Critical task focus, or what the organization considers its core competency, is not tested in this study. The second factor, *experimentation*, is evident in both two cases, so I

[7] Horowitz, *The Diffusion of Military Power*.
[8] Avant, "The Institutional Sources of Military Doctrine."
[9] Horowitz, *The Diffusion of Military Power*.

am broadly in agreement with Horowitz. His last factor, which is concerned with *Organizational Age,* in which the age of the organization hinders the organization's ability to adapt to changes, is where I find his theory does not match the cases I am examining. Of the organizations discussed, the Royal Navy is the most venerable but still innovative, while the United States Air Force was the most hidebound, while also being the youngest. As evidenced by and engendered with these forms of service academies, I think a culture of constant innovation is an example of how older organizations can create a dynamic for continuous innovation.

Importantly, examining Horowitz's cases to support his theory, two of the cases used are examples of revolutionary technology (nuclear weapons and carrier warfare). One of them does not apply to this theory (suicide terrorism).[10] One that is applicable, but one that I posit is evolutionary rather than revolutionary, is the case of *HMS Dreadnaught* and First Sea Lord Jackie Fisher's reforms of the Royal Navy in the first two decades of the Royal Navy.[11] In total, I will argue and demonstrate that Horowitz's theory is more focused on a larger scale of analysis than the theory I am positing in this work.

Firstly, even though *Dreadnaught* and Battlecruisers represented a giant leap forward in terms of overall effectiveness and technological sophistication, they did not change the operational and strategic calculus of the Royal Navy. The Battles of Jutland and Tsushima, separated by 12 years, an ocean, and the introduction of *Dreadnaught*, were fought following the same operational and strategic vision: two large battlefleets attempting to fight a decisive battle as envisioned by Mahan. Indeed, the lessons learned that spurred the development of *Dreadnaught* was discovered at the Battle of Tsushima.[12] While Horwitz noted that Fisher was

[10] The story that this theory is addressing relates to technologically advanced militaries, which suicide terrorism is not.
[11] Horowitz, *The Diffusion of Military Power*, 134.
[12] Horowitz, 138.

challenging Mahanian thought, it is essential to note that Fisher was unsuccessful in moving away from a fleet-in-being strategic concept, primarily due to internal resistance.[13] The Dreadnaught may have changed strategic thinking regarding purchasing and manning priorities; it did not change strategic or operational planning.

In terms of my theory, I agree that Fisher's concurrent revamping of the Naval training regime, especially in terms of gunnery and range finding, represents a form of evolutionary innovation. This training focused on realistic training exercises and deeper tactical and technical training for all officers, with enough specialization that some of the schools that Fisher mandated could be considered proto tactical learning centers.[14] However, outside of the battlefleet level, it can be argued that Horowitz is concerned with improvements at the elite, more macro level rather than at the tactical fighting level.

Avant's model on how militaries develop doctrine takes a more institutional viewpoint, evidenced by the concept of *institutional integrity,* which is a measure of professionalism, how militaries maintain standards of conduct, promotion, and budgets. The second variable examined is *institutional bias,* which is the substance of the organizational preference formed by civilian authorities' totality of previous choices.[15] This bias is reinforced by career incentives, in which promotion is reliant on support for the *status quo*. Inversely, the support of ideas outside of the norm for the organization is treated as a risk for advancement by military and civilian authorities, providing a natural check on aberrant doctrinal choices. This theory falls short, as does all institutional explanations, is in the lack of agency given to the individual. While "renegades" do

[13] Horowitz, 136–38.
[14] Horowitz, 140.
[15] Avant, “The Institutional Sources of Military Doctrine.”

not have staying power, they can, at personal cost, strategically affect the organizational preferences of a given service.

While I think that Avant's model has strong explanatory power in how militaries respond to executive pressures, the top-down approach taken by Avant and other institutional scholars ignores essential work done at the field-grade level. The result of field-grade officers and senior enlisted tactical experts can temporarily nullify national neglect in investing in doctrinal development. This pooling of tactical expertise at both the mid-grade officer and senior enlisted levels produces a team of experts with diverse experiences and backgrounds, which is valuable when testing and reevaluating doctrine and battlefield practices. This focus on mid-career officers and senior noncommissioned officers empowers personnel that has acquired significant professional knowledge but are not beholden to systems and doctrines that contributed to their professional reputations and promotion prospects. It is important to note that because of these institutional selection effects, the field grade and senior enlisted ranks are often the most senior positions that maintain viewpoint and experiential diversity.

Learning from Conjecture: Western Approaches Tactical Unit

This section will proceed as follows: first, there will be an explanation of Royal Navy thinking on Anti-Submarine Warfare (ASW) in the interwar period into the initial success of the U-Boats known as the "first happy time." The following section will be related to establishing the training apparatus, with a particular focus on the Western Approaches Tactical Unit (WATU), which introduced innovative training techniques to train tactical officers and develop new tactics related to evolutionary technology. The last section will illustrate the effects of this effort, using the Battle of Convoy ONS 5 as a critical case of how this new training and

development regime was effective. This section will also explain change over time in both operational U-boats at sea against shipping tonnage losses to show the increasing efficiency of the escort groups.

Setting the Table- Prelude, Commencement, "First Happy Time," and *Wolfpack*

The Royal Navy, at the end of the First World War, saw itself as having to shrink because of a larger set of budget cuts. Complicating this was the ambitious building project that the US Navy undertook at the end of the war, which threatened its long-running preeminence in Naval strength.[16] Furthermore, the treasury increasingly took an aggressive stance in limiting further shipbuilding, limiting the service to parity with the other largest naval power, the United States[17]. Seeking to avoid a shipbuilding competition with the United States, the British government chose to seek international agreement to maintain its parity and stop the shipbuilding race, which resulted in the Washington/London treaty system.[18] This treaty set a fixed ratio[19] on capital and later cruiser productions for all major naval powers. Combined with the 10-year rule on military expenditures[20], this was the framework that the RN would use to create its larger strategy for the period leading up to the Second World War.

With these restrictions in place, the RN had to plan for the next likely conflict. In their planning, they had to account for Germany, which began to rearm, and the Japanese threatening significant British overseas holdings like Singapore and Hong Kong. Given the limited

[16] Bell, *The Royal Navy, Seapower and Strategy between the Wars*, 8.
[17] Bell, 8–10.
[18] Bell, 13.
[19] 5:5:3:1.75:1.75 US/UK/Japan/Italy/France
[20] Which provided limits on military expenditures if conflict was not foreseen in the next 10 years.

resources, they chose to reinforce Far Eastern naval bases and concentrate on the Japanese threat first.[21] As for the Germans, it was perceived as a developing threat. The goal of later planning is to have "a strong navy capable of protecting Britain's interests against both Germany and Japan was one of the British Empire's minimum absolute requirements."[22] As for the submarine threat, British naval leadership was confident in the ability of the convoy system from WWI and the new technology of ASDIC (now known as SONAR, will use the current term) to limit the success of the U-Boat arm. The U-boat arm was just being rebuilt and not in sufficient numbers to pose an immediate risk. This supposition was borne out because at the opening of hostilities, in which there were 48 operational U-Boats of all types[23], not sufficient to successfully execute the *wolfpack* group attacks that Karl Donitz, the U-boat commander, thought necessary to break the convoy system.[24]

The Fall of France in 1940 allowed U-boats to use bases on the French Atlantic seaboard. These French bases allowed the U-boats more accessible operational access to the Atlantic, with the U-boat arm completed its repositioning by October 1940.[25] Furthermore, the movement of motor torpedo boats to French ports moved all inbound convoys to be routed through the "western approaches" to ports in the North and Western UK.[26] This change prompted a move of all convoy operations to Liverpool, with a new Commander in Chief, Western Approaches, Admiral Percy Noble.[27] Furthermore, the production of U-boats had finally been able to make good on initial losses, with the U-boat force finally passing its initial wartime strength in January

---

[21] Bell, *The Royal Navy, Seapower and Strategy between the Wars*, 99–103.
[22] Bell, 111.
[23] Westwood, *The U-Boat War*, 286.
[24] There are some successes in the early stages of the war, such as the sinking of the *Royal Oak* at harbor, and the *Courageous* at sea. However, this was tangential to the commerce raiding mission that was central to the U-boat campaign. During this period, most success was against ships not in convoy.
[25] Westwood, *The U-Boat War*, 105.
[26] Doherty, “Churchill’s Greatest Fear,” 34–35.
[27] Doherty, 35.

1941, with 197 boats built in 1941 alone.[28] The *Kriegsmarine* was able to finally test the *wolfpack* attack, with multiple boats attacking a single convoy at once to overextend and confound its escorts, on August 4, 1940, in which four boats were able to sink six merchant ships, with no losses.[29] This increase in strength gave the U-boats the material and geographic means to seriously threaten the British sea lines of communication.

U-boat commanders began to devise tactics to counter the advantages that convoy and SONAR provided the escorts during this period. This tactic, pioneered by leading U-boat "ace" Otto Kretchmer, involved the innovation of attacking from *inside* the columns of the convoy after using the U-boats superior surface speed to approach the convoys from the rear at night, make their attacks, and then submerge to escape by allowing the convoy survivors to pass over them.[30] This nullified response of the escort, who naturally assumed the attack was coming from the *outside* of the convoy. This tactic also worked against the strengths of SONAR as a sensor, with the surface approach ensuring that SONAR cannot detect the approaching boat[31] and the method of egress ensuring that the picture provided by SONAR was too chaotic for detection. Finally, the low profile of a surfaced U-boat and its grey color mitigated against the possibility that the boat was on the surface would be detected by lookouts at night, combined to make this an effective tactic.

All these lead to the "first happy time," in which the combination of very few escorts, the new tactics described above, and the ascendancy of experienced U-boat "aces" created the first real crisis. This period was punctuated by the achievements of the individual U-boat aces. This

---

[28] Westwood, *The U-Boat War*, 286–88.
[29] Westwood, 106.
[30] Parkin, *A Game of Birds and Wolves*, 63; Strong, "Wargaming the Atlantic War: Captain Gilbert Roberts and the WRNSs of the Western Approaches Tactical Unit," 8.
[31] Active SONAR detects the submerged surface area of an object. By running on the surface, it reduced the exposed surface area of the U-boat by more than half.

period ended with a string of escort successes against individual "aces" attacking convoys alone or in small groups, with the three top aces all succumbing to escorts in March 1941, ending the "first happy time."[32] With the loss of several individual high-scoring boats and captains, the period of high U-boat destruction known as the first happy time came to an end. These losses marked the end of individual achievement in U-boat tactics and marked the ascendency of *wolfpack* tactics. Convoy warfare became a team sport for both the aggressors and the defenders.

The *wolfpack* tactics, updated and implemented to account for the greater number of operational boats that had come online during 1941. Boats on patrol divided into operational groups, which would be placed, with the aid of signals intelligence, on the predicted path of convoys between North America and the United Kingdom, in an area out of aircraft coverage known as the "gap." If one of the boats in the group made visual contact with a convoy, it would shadow the convoy at a distance and, using its radio set, direct the rest of the boats to attack under cover of darkness[33]. Then they would use Kretchmer's tactics to attack from within the columns of the convoy and then lay low during the daylight hours until the following night. These tactics were highly effective, with over 1.6 million GRT sunk between April and the end of 1941.[34] These losses were not sustainable and engendered a change in how the British Admiralty would respond to the submarine threat.

The Response: Training, Wargames, and Ideational Generation

As a result of the shock losses in the initial stages of the war, C-in-C Western Approaches took responsibility for all things related to fighting the U-boats. As part of this, a

[32] Doherty, “Churchill’s Greatest Fear,” 65–67.
[33] Westwood, *The U-Boat War*, 71.
[34] Westwood, 296.

new training and tactical establishment was formed, which had two major components. Firstly, a single ship training facility was established in Tobermory, Scotland, in mid-1940 to ensure that ships coming into service met basic standards of efficiency in anti-submarine warfare (ASW).[35] While not a tactical learning center itself (it was more focused on basic shipboard tasks), this primary school ensured that every ship joining the escort and support groups would have the baseline knowledge required to execute the more sophisticated tactics. The second, and the operative Tactical Learning Center of this case, is the Western Approaches Tactical Unit (WATU), which I will discuss in this section.

WATU was founded because of a fact-finding mission by Churchill's naval aide, Admiral Usborne, to Western Approaches Command. The situation had deteriorated, and something needed to be done to reverse the course of merchant ship losses. Commander Roberts, a retired gunnery officer, was selected to lead a group charged with "Find out what is happening in the Atlantic, find ways of getting the convoys through, *and* sink the U-boats" was Churchill's simple instruction to Roberts upon receiving the assignment.[36] Upon arrival on January 2, 1942, and meeting C-and-C Western Approaches Adm Percy Noble, Roberts was given a space in Darby house[37]and instructed to stay out of everyone's way.[38]

Noble did not understand that Roberts had experience executing wargames at the Royal Navy's tactical school in Portsmouth in his previous service. Wargames have had a long history in both land and sea combat for testing tactics and sharpening commanders' tactical and strategic thinking in a low-stakes environment. These simulations had the effect of testing the same

[35] Doherty, “Churchill’s Greatest Fear,” 74.
[36] Doherty, 77–78.
[37] Headquarters for Western Approaches Command
[38] Parkin, *A Game of Birds and Wolves*, 142–43.

scenario repeatedly, incrementally improving tactics and strategies.[39] Roberts was selected because of his background with these games and intended to build a game to simulate the convoys and develop new tactics in response to the *wolfpack* tactics. Given a unit of WRNSs (female reserve naval personnel), they went to work devising a game to simulate ASW.

In setting up the game, Roberts and his staff were to model the decision-making process of the convoy escort ship commanders. In the ample space they were assigned, they built a map on the floor of which was to represent the ocean. On the edges of this map were booths made of canvas that had peepholes cut out to simulate the visibility of a ship at sea.[40] Using this as the "game board," they tested and refined the rules of the "game." The game would have three "sides." The first was the commanders of the ships themselves playing the escort. The second side was a group of WRNSs responsible for being the umpire of the game, moving the pieces on the board, and resolving anything left to chance. The last, usually Roberts and a trusted aide, played the U-boats and attempted to sink the convoy that the escorts were protecting.[41] One of the most important things that Roberts did was solicit returning escort and support group commanders and checked after-action reports to ensure that the scenarios that the "game" would simulate provided an accurate enough model for training value and facilitated tactical inference.[42]

One of the first real breakthroughs in ideational generation was devising a countermeasure to Kretchmer's attacking tactics within the convoy columns. Captain Walker, then the leading convoy escort commander, had developed a tactic codenamed "buttercup" to

---

[39] McHugh, *Fundamentals of War Gaming*, 10.
[40] Parkin, *A Game of Birds and Wolves*, 148–50.
[41] Parkin, 151.
[42] Strong, "Wargaming the Atlantic War: Captain Gilbert Roberts and the WRNSs of the Western Approaches Tactical Unit," 7.

combat U-boats attacking convoys at night, and WATU was to adjudicate it.[43] "Buttercup" was based on a flawed premise- that the U-boats were attacking from the outside of the convoy. Through repeated replaying of a scenario based on Walker's after-action report, they were able to deduce the attacking boats were striking from *inside* the columns of the convoys, which they confirmed by taking it up with C-in-C Submarines as the likely approach they would take.[44] Armed with this information, they devised a replacement tactic, known as "raspberry," to counter

[43] Parkin, *A Game of Birds and Wolves*, 152–53.
[44] Parkin, 155–57.

the previously successful tactic of attacking within the convoy's columns. Figure 2[45] has an illustration of how "raspberry" is supposed to work.

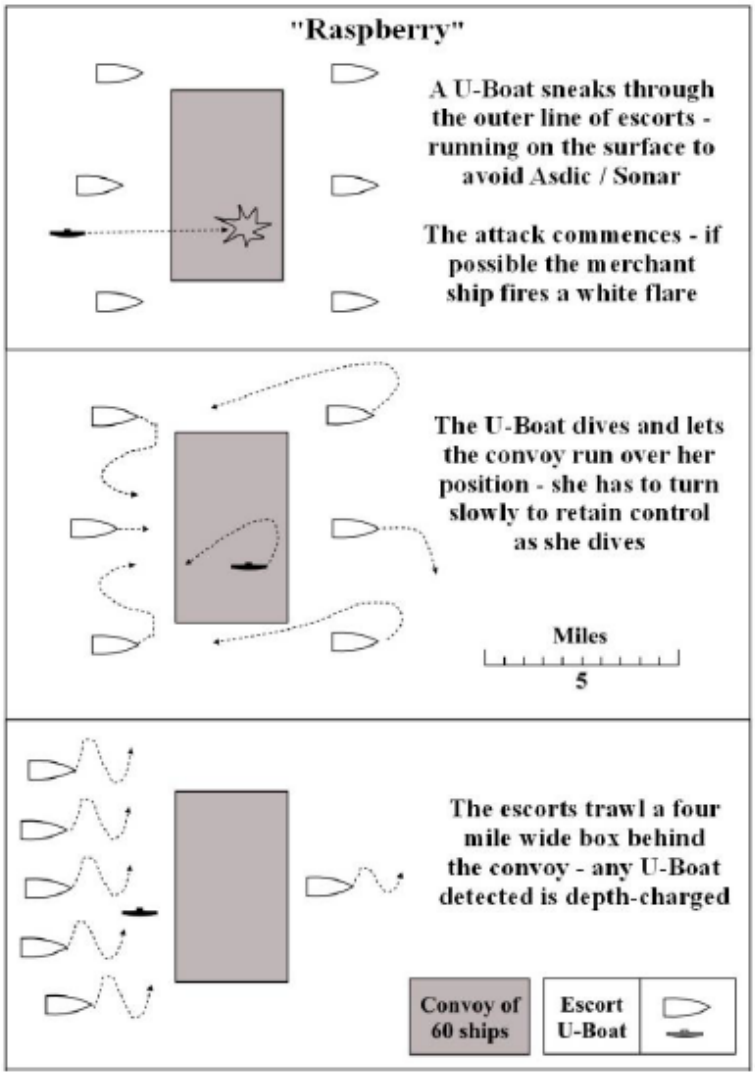

Figure 2

Despite the commander's initial frostiness to the entire method of using wargaming as a tool for teaching and making incremental changes to tactics, Admiral Noble received a demonstration of this discovery. However, by the time their demonstration was complete, Noble

[45] Strong, "Wargaming the Atlantic War: Captain Gilbert Roberts and the Wrens of the Western Approaches Tactical Unit," 10.

was a convert to this approach, and within 24 hours, this new tactic was transmitted to the fleet.[46] With the demonstrated utility of this approach, Noble directed the school to begin teaching classes on February 2, 1942[47]. The period of instruction was to be a weeklong training course, with ship's officers running through scenarios and having their decisions critiqued in the after-action debriefing. Later in our crucial case convoy ONS5, Captain Peter Gretton describes the value of this "game" thusly: "…he detected new enemy methods of attack, he invented new schemes for finding U-boats and he helped to weld groups together. But, above all, he made a number of very stupid officers really THINK, sometimes for the first time in their lives."[48]

By running the game by escort groups, they helped meld the group's tactical thinking, and because the groups did the course together, it ensured the larger fleet units had the same baseline for effective tactics. Furthermore, by continual trial and error, WATU could adapt to changing U-boat tactics and technologies[49]. The school continued to develop new tactics to integrate new technologies, such as RADAR and HF-DF (High-Frequency Direction Finding). More importantly, emergent enemy technologies, such as acoustic homing torpedoes, were rapidly discovered by combing intelligence reports and validating them in the "game," which lead to the speedy development of effective countermeasures.[50] Goldrick, in his history focusing on the training establishment, explained the value of WATU succinctly: "It allowed a level of conceptual analysis and debate which was simply impossible either during the most realistic 'real time' training, whether live or simulated or during operations themselves. It forced group commanders, captains, and their officers to work through problems and achieve solutions

[46] Parkin, *A Game of Birds and Wolves*, 160–61.
[47] Parkin, 162.
[48] Gretton, *Convoy Escort Commander.*, 100.
[49] Strong, "Wargaming the Atlantic War: Captain Gilbert Roberts and the Wrens of the Western Approaches Tactical Unit," 13–14.
[50] Strong, 20.

together, creating not only the potential for improved cooperation within individual escort groups, but between the groups themselves, and other elements such as maritime patrol aircraft."[51]

The Payoff: "Black May" and Conclusion.

These lessons needed some time to diffuse, and losses continued to rise throughout 1942. This increase of losses was partially due to the American entry into the war, which moved operations for at least the first half of 1942 westward to easier pickings off the American coast in the "Second Happy Time."[52]. The American Navy and merchantmen were slow to shift to a wartime footing, which the Kreigsmarine exploited. During the year 1942, the allies had lost 5.47 million tons of shipping in the North Atlantic, and the operational strength of the U-boat arm had continued to grow.[53] 1943 was shaping up to be a critical moment, with losses increasing through the first few months. In particular, the losses in March were cause for concern, with 105 ships sunk, representing 590,234 tons of shipping.[54] April had been a lull due to a drop in aggressiveness in U-boat commanders and fewer total boats at sea.[55]

The end of April brings us to the critical case of convoy ONS5. ONS5 was a westward-bound convoy, moving from the western approaches with empty ships to bring more goods to the United Kingdom. German signal intelligence knew the composition, course, and destination of the convoy.[56] The heavy forewarning allowed the U-boat command to set a heavy trap for the moving convoys, with three search lines comprising 58 U-boats awaiting the slow-moving

---

[51] James Goldrick, "All Should Be "A' Teams: The Development of Group Anti-Submarine Escort Training in the British and Canadian Navies during the Atlantic Campaign," 163.
[52] Doherty, "Churchill's Greatest Fear," 112.
[53] Doherty, 141.
[54] Gannon, *Black May*, xix–xx.
[55] Gannon, xxiv–xxv.
[56] Parkin, *A Game of Birds and Wolves*, 208–9.

convoy.[57] On April 28, the U-boat *U-650* had contacted the convoy, and the Battle of ONS5 was joined.[58]

The group escorting ONS5 was under the command of Captain Peter Gretton, an early and enthusiastic adopter of the tools and methods that WATU provided. He had recently taken command of his escort group and had driven through a comprehensive set of drills, practicing the tactics WATU had taught him at sea. Furthermore, his group had received the latest in ASW technology, including shipboard HF/DF, RADAR sets, and forward throwing ASW weapons known as "hedgehogs[59]".[60] With these tools, his escort group was well prepared to meet whatever challenges they would meet.

As the convoy advanced through atrocious weather that limited their speed (and, more importantly, the ability to refuel[61]), Gretton began to worry about the ability of his flagship to complete its escort mission.[62] In what followed was an 8-day running battle as the convoy moved through the "gap" and had to fight through one of the largest *wolfpacks* of the war. Because he could not refuel due to a poor sea state, Gretton had to detach from the convoy on May 3 to refuel and leave command to his deputy.[63] The fact that his group maintained its integrity with the loss of its leadership, through poor weather and under constant attack is a testament to the tactical training that WATU provided and the hard training that Gretton had mandated as an escort commander. At the end of the battle, seven U-boats were sunk, another seven were heavily damaged enough to be taken out of action in exchange for 13 merchant ships sunk.[64]

---

[57] Gannon, *Black May*, 126.
[58] Gannon, 130.
[59] Which had the advantage of only exploding when contacting the submarine, unlike conventional depth charges
[60] Gannon, *Black May*, 118–21.
[61] Repurposed British Destroyers, like Gretton's, were built for operations in the North Sea and had poor range
[62] Gannon, *Black May*, 123–26.
[63] Doherty, "Churchill's Greatest Fear," 196.
[64] Gannon, *Black May*, 223–25.

The Battle of ONS5 represented the high-water mark of the U-boat arm and was a general inflection point in the more extensive Atlantic campaign. Never again would the U-boat arm seriously menace the convoys as it did for ONS5. During May, the U-boat arm would lose 41 boats.[65] These losses would lead to the month getting the nickname of "black may." At the end of the month, the commander of the U-boat arm ordered the temporary abandonment of attacking North Atlantic convoys.[66] However, through the Normandy invasion, the U-Boat arm was able to keep on average 100 boats on operational status while never having the same successes after black May, illustrated by figure 3 showing losses in GRT and total U-boats in operational status by month.[67]

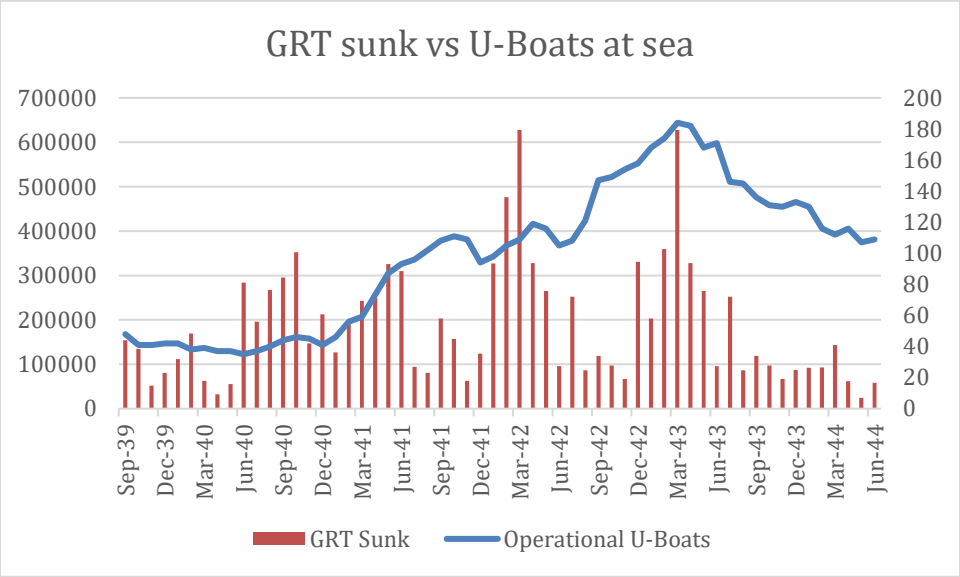

Figure 3

[65] Westwood, *The U-Boat War*, 294.
[66] Gannon, *Black May*, 378.
[67] Westwood, *The U-Boat War*, 286, 296–97.

Relearning Old Lessons: Navy Fighter Weapons School

This section will proceed as follows: first, there will be a narrative to establish the "state of play" before the Vietnam conflict and during the first stage of combat operations over North Vietnam, known by its code name "Rolling Thunder." Next, with implications for the adjudication of this theory, is examining the divergent paths that the US Navy and Air Force took during the lull between the two sets of combat operations. The Navy applied a holistic look at its failings and taking the appropriate steps to rectify them, treating them mainly as an issue with training and personnel. The Air force, in contrast, did not take a similar holistic approach, primarily attempting to remedy the problem through technology and specialization. The final two sections provide a narrative on "Linebacker," the last period of air combat over North Vietnam, and the postwar fallout on both services.

Conditions before Vietnam- Navy and Air Force

The period leading up to the air war in Vietnam was characterized by rapid changes in aircraft technology and conceptions of air-to-air combat. In 1958, Taiwanese pilots used air-to-air missiles for the first time in combat during the Second Taiwan Straits Crisis, scoring kills against Chinese pilots using sidewinder missiles supplied by the United States.[68] In the period between Korea, which was conducted mainly in the manner of World War II,[69] and the Vietnam conflict, aircraft significantly advanced in speed and capability. Supersonic fighters became the norm, with fighters growing simultaneously faster and less maneuverable. This advancement in airframes and the innovation of radar-guided air-to-air missiles led to the depreciation of air

[68] Walker, "Eisenhower's New Look, Tactical Nuclear Weapons, and Limited War with a Case Study of the Taiwan Strait Crisis of 1958," 316.
[69] Although using largely jet aircraft.

combat maneuvering training (ACM), with the last training unit dedicated to classic ACM training, the Navy's Fleet Air Gunnery Unit (FAGU) disbanded in 1960.[70] This action created the notion that interceptor tactics, with missile shots taken beyond visual range (BVR), were the new norm in air combat. The more significant result of this was that neither of the flying branches during the Vietnam conflict had an active tactical learning center at the beginning of the Vietnam conflict.

In the Air Force, there were several problems in the conduct of the Vietnam conflict. There was a lack of air-to-air combat training generally and ACM training more specifically.[71] This deficiency is partly due to the expectation that air force tactical fighter units had to perform both the attack and fighter mission equally. Furthermore, there were serious deficiencies with the way that Air Force tactics were conceived and utilized. The "fluid four" formation, two pairs of fighters, with each wingman supporting the lead, wasted firepower by often not allowing the wingmen to engage.[72] This tactic only allowed two of the four aircraft to engage actively and was heavily dependent on the leader's skill and initiative. This formation was wasteful of the initiative and training of junior flight members. Finally, and most telling, was the total subjugation of the conventional mission to the nuclear one, to the point that conventional training milestones were not to be undertaken until all nuclear training milestones are met.[73] These priorities ensured that the bedrock skills of tactical fighter aircraft, bombing, and air to air combat were not as heavily practiced as nuclear delivery.

There was a slightly slower deterioration of tactical skills in the Navy because of how the Naval fighter mission was divided between airframe types. Tactical fighter training was done

---

[70] Ault, “Report of the Air-to-Air Missile System Capability Review,” 35.
[71] Michel, *Clashes*, 161.
[72] Pederson, *Topgun: An American Story*, 144.
[73] Lambeth, *The Transformation of American Air Power*, 36.

according to type, with members typically not leaving their fighter communities unless the aircraft was removed from active service. At the beginning of the Vietnam conflict, there were two major naval tactical fighter communities, the F-4 Phantom and the F-8 crusader. The F-4 community focused on controlled interception with missiles, with air combat maneuvering not taught or actively warned against.[74] The F-8 community had retained most FAGU grads and were still actively training on traditional methods of fighting, including gunnery. This community emphasis earned this aircraft its nickname, "the last of the gunfighters," informing the training methods and practices of F-8 squadrons.[75]

Rolling Thunder: Vietnam 1965-1968

Several surprises were to be had with the beginning of combat operations over North Vietnam following the Gulf of Tonkin incidents. Despite the US advantage in aircraft numbers and relative technology, older NVAF aircraft can still represent a threat in a dogfight. The missile systems that both US air services had become dependent on were a lot more challenging to use in combat than the ideal range conditions they were tested. Lastly, standards of training for most of both air services were lacking. However, there was one major success in this period, *Operation Bolo*, by the Air Force, which provides further evidence why the Air Force did not improve in the 1972 *Linebacker* campaign because of subsequent training and personnel decisions.

The Soviet aircraft the NVAP fielded in the first stage of the war included the MIG-17 and the MIG 21. The MIG-17 was a subsonic day fighter, half a generation removed from the MIG-15s and F-86s that had fought over Korea. Lacking missile armament, these fighters relied

[74] Wilcox, *Scream of Eagles*, 9–15.
[75] Nordeen, *Air Warfare in the Missile Age*, 42–44.

on maneuverability and guns to score successes and turn inside all US fighters at low speed. This fighter's high maneuverability, combined with the lack of ACM training of US forces, ensured that F-4s would be lured into turning fights, negating US advantages in speed and rate of climb.[76] The MIG-21 was a more conventional supersonic interceptor that relied on Atoll air-to-air missiles to utilize supersonic slashing attacks against withdrawing US strike packages. This fighter had the advantage of a small forward profile, limiting the range of visual acquisition and identification, something required due to fratricide concerns limiting beyond visual range missile attacks.[77] These aircraft and their aggressive utilization constituted a shock, especially considering pre-war estimates assuming mastery over the MIG-17.[78]

The correct utilization of Air-to-Air missiles was an issue during this first phase of air combat, with missiles not operating as designed. In this phase, only the AIM-9 sidewinder heat-seeking air-to-air missile was suitable for air combat maneuvering use because of the lack of success in use beyond a few early intercepts at the start of the conflict. This result was due to a poor understanding of its capabilities and limitations and inadequate training on missile use.[79] This lack of working knowledge ensured that pilots would not fire their weapons in a position where the missiles were likely to hit, thus driving down missile effectiveness.[80] During this period, AIM-7 sparrow effectiveness stood at 8%[81] , and AIM-9 sidewinder effectiveness was 15%[82].

[76] Michel, *Clashes*, 7–21; Nordeen, *Air Warfare in the Missile Age*, 16.
[77] Nordeen, *Air Warfare in the Missile Age*, 19–20; Michel, *Clashes*, 40–41.
[78] Michel, *Clashes*, 20.
[79] Ault, "Report of the Air-to-Air Missile System Capability Review," 27–28; Pederson, *Topgun: An American Story*, 74–75.
[80] Pederson, *Topgun: An American Story*, 119.
[81] Michel, *Clashes*, 151.
[82] Michel, 154.

There were also serious issues with training that came to the fore during this period. Most F-4 pilots polled from both branches listed the need for "more air combat training." It is important to note that not a single F-8 pilot requested additional training.[83] The only community that had emphasized dogfighting before the beginning of hostilities was the F-8 squadrons. Its armament required it to develop and maintain their ACM skills to utilize its cannon and sidewinder armament best.[84] The Navy F-4 community had plenty of interception training, per its role as a fleet defense fighter, but had little training in ACM.[85] The Air Force F-4 community did very little training in air-to-air combat, and all of that was similar combat training- F-4 vs. F-4, which prepared pilots little for fighting against the agile MIGs.[86] Furthermore, because of Air Force personnel policies, pilots were limited to 100 sorties and rotated back home; at the latter stages of rolling thunder, pilots were often pulled from outside of tactical aviation to fly fighters.[87]

The most prominent bright spot of this entire period of the air war was Operation *Bolo. Bolo*, masterminded by Col Robin Olds, a WWII double ace and commander of the 8th TFW, an F-4 wing responsible for escorting and conducting strikes over North Vietnam. He planned the first offensive fighter sweep over North Vietnam, in which his F-4s were to simulate the strike patterns of the heavier and less capable F-105s.[88] This operation was a great success and accounted for seven MIG-21s with no losses. This success was the first attempt to attempt to use innovative tactics to combat the threat of MIGS and represented a shift from previous practices. However, in an action that would be characteristic of Air Force personnel policies and general

[83] Michel, 160–61.
[84] Michel, 160.
[85] Michel, 161.
[86] Michel, 160.
[87] Olds, Olds, and Rasimus, *Fighter Pilot*, 291.
[88] Michel, *Clashes*, 75; Olds, Olds, and Rasimus, *Fighter Pilot*, 271–82.

disdain structurally for ACM, placed Olds as the Commandant of Cadets at the Air Force Academy instead of a training or policymaking role. Thus, with the driver of change removed from an operational role, the Air Force reverted to previous practices, even in his old combat wing. Olds, recognized as probably the most outstanding leader in air combat in the Vietnam conflict, was prevented from imparting his knowledge on ACM in a more direct, tactical role.[89] In an illustration of the institutional indifference to change or the contribution of relatively junior members, Gen Momyer, Old's Direct commander at 7th Air Force, and later the head of Tactical Air Command, in his memoir and operational summary of his career, did not recognize Olds by name and dismissively compared Bolo in numbers and importance to operations in WWII and the Korean war.[90]

All told, Operation *Rolling Thunder* provided several harsh lessons to both air services. Service issues with tactics, missiles, pilot training, and the overall tactical conception of the air-to-air concepts were brought to the fore by over three years of sustained combat operations. Rates of success in air-to-air combat bear this out. Table 1 provides kills and kill ratios for Rolling thunder

Year	MiG Kills	US A/C Shot Down	Total Kill Ratio	USAF Kills	USAF A/C Shot Down	USAF Kill Ratio	USN Kills	USN A/C Shot Down	USN Kill Ratio
1965	5	4	1.25:1	2	3	.67:1	3	1	3:1
1966	22	9	2.44:1	16	5	3.2:1	6	4	1.5:1
1967	69	25	2.76:1	55	21	2.62:1	14	4	3.5:1
1968	14	10	1.4:1	8	7	1.14:1	6	3	2:1

[89] Sherwood, *Fast Movers*, 1–33; Michel, *Clashes*, 165.
[90] Momyer, *Air Power in Three Wars*, 145–46.

Total Rolling Thunder	110	48	2.29:1	81	36	2.25:1	29	12	2.42:1

Table 1. Kill Ratios During Rolling Thunder[91]

Bombing Halt: Changes in the Interregnum (1968-1972)

With the Bombing halt in 1968, there was a period of reflection for both services. Each of the two air services took drastically different lessons from their experiences. The US Navy commissioned the Ault Report, which started as a comprehensive review of missile performance during *Rolling Thunder* and became a thoroughgoing critique of every aspect of the air-to-air mission, from missile maintenance to pilot training. In this comes the recommendation for the Navy Fighter weapons school, the relevant tactical learning center for this study.[92] The Air Force took a different tack, emphasizing technology, adopting new systems while ignoring the tactical component.[93]

The Navy Fighter Weapons School, better known as TOPGUN, was founded as a special detachment of the Pacific Fleet Replacement Air Group (RAG), a unit designed to transition pilots to new types and provide final type training to new pilots. A relatively junior officer was chosen to lead this new detachment because it called for someone who was still an accomplished practitioner but had the ability to will it into being. It is important to note that his school was designed to produce great pilots and great teachers, as each graduate was billeted as an advanced air combat training officer at their parent squadron.[94] This focus allowed the information to

[91] Adapted from Ford, "Air-to-Air Combat Effectiveness of Single-Role and Multi-Role Fighter Forces," 51.
[92] Ault, "Report of the Air-to-Air Missile System Capability Review," 37.
[93] Michel, *Clashes*, 161.
[94] Pederson, *Topgun: An American Story*, 103–4.

diffuse much more quickly. Each squadron would benefit from the regular presence of someone who had completed the TOPGUN syllabus and was able to impart the lessons learned to even the newest, most junior pilot.

As the syllabus for this training center was coming together, instructors were pulled from the RAG, as they all were highly qualified instructor pilots. On the recommendation of visiting Israeli pilots, the suggestion that TOPGUN instructors were to specialize in different air combat competencies bore fruit. There would be a specialist in each area that was considered essential to teach, and importantly, there was specialist training for radar intercept officers (RIO).[95] RIOs was trained not as pilots but as Naval Flight Officers and designed as a second pair of eyes and operate the RADAR and the radios. This position was new as every previous Navy day fighter (Air force, as well) was designed as a single-seater. This utilization of the rear seat occupant beyond a "guy in back" as well as the institutional choice that RIOs were to be treated as an equal partner ensured that a Navy crew working as a team had a superior sense of situational awareness. Lastly, an intelligence officer was added to help build the unit's tactical library and give briefings based on the latest information about enemy capabilities and tactics.[96]

The course was four weeks long, with three weeks dedicated to air-to-air combat and one dedicated to air-to-ground tactics. There was to be a short period of classroom instruction, followed by several intense periods of flight operations.[97] What made this training different from previous training they had received is the emphasis on dissimilar combat training. Dissimilar combat training is training conducted using different airframes to mimic potential adversary

[95] Pederson, 106–8. Which included Air to Air Tactics, Air combat maneuvering, Missile Capabilities and Limitations, as well as Air to Ground tactics.
[96] Wilcox, *Scream of Eagles*, 128–29.
[97] Wilcox, 146.

airframes.[98] This training breaks from what happened with conversion training at the RAG; they only do similar combat training, for example, F-4 vs. F-4. In TOPGUN, the A-4 was used to mimic the MIG-17 and various interceptors to mimic the MIG-21.[99] This dissimilar combat training was used to reinforce classroom training, expand the maneuvering envelope, and show where their aircraft has an advantage over adversary types. TOPGUN instructors reinforced this training by being able to test fly and fly against MIG-17s and MIG-21s captured and brought to the United States.[100]

Examining the diffusion mechanism, by the end of its first year of operation, TOPGUN had graduated 50 pilots and RIOs and instituted a program that sent TOPGUN instructors to provide pre-deployment training and briefings.[101] TOPGUN candidates were chosen among career Navy officers to ensure that as these officers progressed, they would move higher in the Navy hierarchy and prioritize ACM training.[102] As was stated above, graduates were also teachers, which allowed graduates to take billets as tactics instructors. This placement allowed for the diffusion of advanced tactical knowledge to every squadron before the resumption of hostilities in 1972. Beyond this, TOPGUN started a "fleet advisory program," in which TOPGUN aggressor pilots would present a condensed version of the TOPGUN curriculum to squadrons preparing to deploy, ensuring every pilot in the squadron received dissimilar combat training. [103]

The Air Force took a very different tack, using technology and actively retrenching the tactical decisions before *Rolling Thunder*. The first innovation was "combat tree," an IFF

---

[98] Pederson, *Topgun: An American Story*, 48.
[99] Pederson, *Topgun: An American Story*, 151.
[100] Wilcox, *Scream of Eagles*, 134–41.
[101] Wilcox, 192, 208; Lambeth, *The Transformation of American Air Power*, 48.
[102] Wilcox, *Scream of Eagles*, 211.
[103] Wilcox, 216.

interrogator that allowed USAF F-4 crews the ability to tell friend from foe beyond visual range, to enable them to use their sparrow missiles.[104] In contrast to USN improvements in dogfight missile capability, the Air Force made minor improvements in the AIM-9 family between *Rolling Thunder* and *Linebacker*[105]. Furthermore, examining tactics was actively discouraged beyond showing the finer points of "fluid four," and ACM was only conducted under similar and benign conditions.[106] This choice was primarily due to the institutional and personal prestige investment of senior leadership, and thus, it took the turnover of senior leadership to affect significant changes. This constraining environment prevented Air Force Fighter Weapons school from making a difference to the greater force.

Furthermore, the Air Force chose to specialize their tactical fighter wings. After the end of *Rolling Thunder*, the high attrition rates suffered by F-105 wings necessitated their removal from Vietnam. There were several tactical fighter wings in Thailand, which were responsible for missions in North Vietnam, and each of these wings, although they were all flying versions of the F-4, chose to specialize in different aspects of the tactical fighter mission.[107] The 8th TFW, out of Ubon, was a specialist in the burgeoning field of precision-guided munitions. The 432nd at Udorn specialized in Air-to-Air; they received a priority in combat tree-equipped units. Lastly, the 338th TFW specialized in the suppression of enemy air defenses (SEAD) mission.[108] This emphasis on specialization ensured that only one wing was considering air-to-air combat a primary task, with none of the focus on ACM that their Navy counterparts had stressed, with a larger reliance on electronic warfare and technical means than increasing the tactical abilities of

[104] Michel, *Clashes*, 181.
[105] Michel, 182–83.
[106] Michel, 183–84.
[107] Except for the Wild Weasel crews flying F-105Gs.
[108] Michel, *Clashes*, 207.

their pilots. Thus, the Air Force pursued an alternative path, which is a further investment into advanced technology. The following table, table 2, is a proof table of each of the two services.

Service	Tactical Learning Center			Dependent Variable
	Extent?	Ideational Generation	Diffusion	Improvement in Kill Ratio
Air Force	Yes	No	No	No
Navy	Yes	Yes	Yes	Yes

Table 2. Proof Table for Tactical Learning Centers

Linebacker: The Proof of Concept

Responding to the 1972 Easter Offensive, the United States reopened the air war over North Vietnam. This operation began the most intense period of the air war, with the restrictions and "gradual pressure" of *Rolling Thunder* removed for *Linebacker.* This approach opened the most intense period of air combat during the war and produced the first aces, with both the Navy and Air Forces each producing one ace aircrew team. This period of intense air-to-air combat works as proof of concept for the changes each service made in the period between *Rolling Thunder* and *Linebacker.* The Navy had a period of great success against enemy fighters, and the Air Force, as a larger fighting force, failed to improve their outcomes in air-to-air combat.

With the commencement of *Linebacker*, the Navy began to score heavily. On the very first day of *Linebacker* operations, the Navy shot down eight MIGs with no losses of their own. One pilot, who was assigned temporary duty when TOPGUN was in its infancy and later completed two fleet advisory programs, shot down 3 MIGs on the first day to become the first

ace of the Vietnam conflict.[109] This success was a testament to their training, as these kills were made due to ACM and improved AIM-9 missiles, which were still dependent on pilot maneuvering skills to complete a shot. For the rest of 1972, the Navy continued to score well against the MIGs, to the point where they would not engage unless they were at a serious advantage.[110]

On the other hand, the Air Force had serious issues that arose during the conduct of their campaign. MIGs, adopting "Kuban Tactics," in which a leading pair, usually MIG-21s, would conduct a slashing attack to disrupt USAF strike formations. With this completed, a trailing pair of MIG-17/19s would attack from below and behind to engage the new scattered formations and pick off elements from the rear.[111] It was a variation of this tactic that shot down the wing tactics instructor for the 432nd TFW, who was considered the in-theatre USAF authority on air-to-air combat.[112] However, there were some bright spots, as combat tree did help beyond visual range kills, and the Air Force had its first ace pilot in September.[113] However, the discrepancies in overall scores and the fact that the USAF formations were easier pickings are borne out in the data in table 3.

Year	MiG Kills	US A/C Shot Down	Total Kill Ratio	USAF Kills	USAF A/C Shot Down	USAF Kill Ratio	USN Kills	USN A/C Shot Down	USN Kill Ratio
1972	71	26	2.73:1	47	23	2.04:1	23	2	11.5:1
1973	2	0	-	1	0	-	1	0	-
Total	73	26	2.8:1	48	23	2.08:1	24	2	12:1

[109] Michel, 213–15; Wilcox, *Scream of Eagles*, 213–16.
[110] Michel, *Clashes*, 240.
[111] Michel, 236–37.
[112] Michel, 212–13.
[113] Michel, 258.

Table 3. Kill Ratios During Linebacker[114]

TOPGUN: Conclusions and Lessons Learned

It is important to note that there were efforts at remediation between Naval and Air Force tactics. During *Linebacker,* a detachment of Navy F-8s was sent to Udorn to conduct dissimilar training with the 432nd TFW. What the pilots found was a disparity in both ACM tactics as well as the level of training. The Air Force continued with interceptor tactics, using radar-guided beyond visual range engagement as the primary tactic. A larger issue was the continued use of the "Fluid Four," which was tactically limiting and provided a clear target for an opponent utilizing air to air missiles. Furthermore, there was an issue with Air Force culture. Many USAF pilots were graduates or even former instructors of the Air Force fighter weapons school, who kept tactics that had proven flawed over the time in Vietnam as in the almost concurrent Arab-Israeli conflict.[115] There was an institutional investment in the incorrect tactics due to the investment of senior leadership into these tactics, despite a tactical learning center, albeit a limited one. Following my theory, the force invested in a tactical learning center and empowered it to make the necessary changes had better tactical outcomes, suggesting better adaptation to an evolutionary technology.

In the years following the Vietnam conflict, there were several reforms in how TAC conducted air-to-air training. In a symposium held by TAC, Linebacker veterans were encouraged to provide feedback, which led to acknowledging deficiencies in organization commitments, especially regarding focus on training vs. equipment.[116] Lastly, in surveys conducted by the Air Force, there were three main areas that they asked for improvement:

---

[114] Adapted from Ford, "Air-to-Air Combat Effectiveness of Single-Role and Multi-Role Fighter Forces," 51.
[115] Wilcox, *Scream of Eagles*, 149–50.
[116] Michel, *Clashes*, 289.

training, tactics, and better air-to-air missiles. All three of these were provided in time, often by adapting techniques from or collaborating with the Navy.[117] The Air Force began to take dissimilar air combat training seriously, with the first aggressor squadron activated in August 1973.[118]

In contrast, *Linebacker* was an unqualified success for the changes the Navy had implemented with TOPGUN. This success is borne out because TOPGUN graduates conducted 60 percent of the USN MIG kills.[119] Furthermore, there was a shift in kill ratios between *Rolling Thunder*, when the Navy scored just under 2.5:1, and *Linebacker*, which the Navy improved to 12:1. This ratio is even more impressive considering the Air Force dropped slightly in the same time frame. Kill per engagement also increased greatly, from .2 during *Rolling Thunder* to just about one during *Linebacker*.[120] Both changes in kill ratios and the USAF adoption of USN methods suggest that TOPGUN as a tactical learning center was an effective tool of tactical change and increased effectiveness. Examining the technological alternative explanation, the investment in improved technologies brought localized success with forces that were so equipped. Still, there was no overall improvement in results that characterized the effort in training in terms of the total force.

Discussion and Conclusion

As seen by the differing kill ratios between the two air services over North Vietnam, the treatment of a tactical learning center is only useful if said tactical learning center is afforded the bureaucratic flexibility and latitude to innovate. This empowerment is needed because the center

[117] Wilcox, *Scream of Eagles*, 290–91.
[118] Lambeth, *The Transformation of American Air Power*, 60–61.
[119] Wilcox, *Scream of Eagles*, 291.
[120] Wilcox, 291.

can exist, but it will not affect the larger organization if it is not empowered to create new ideas and diffuse them. Examining the alternative explanations, this work is mainly in accordance with Horowitz's theory, with the notable exception of the concept of institutional age. This deviation is because in the Vietnam case, the Air Force, a much younger organization, was much more hidebound and less adaptable in the face of adverse information. In contrast, Avant's theory provides a plausible explanation of why the Air Force could not adapt because of the lure, lucrativeness, and institutional primacy of the nuclear mission, which would breed institutional incentives not to change. However, this theory does not have explanatory value for the Naval case. A large portion of the change was effected by career naval officers ignoring the institutional incentive to reinforce the status quo and often shortening their careers by putting the perceived needs of the service over their advancement.

Examining the implications of the WATU case, there are several essential points to be taken. This case provides a clear indication of how these organizations can provide a forum for ideational generation. Furthermore, by running continuously and updating their prior assumptions with advancements both technologically and in observed practice, these organizations show the ability, when operating correctly, to maintain a comparative advantage throughout an extended campaign. While this work is mainly in agreement with Horowitz's work on innovation, the focus on institutional age is misguided. This time, the RN was probably the most venerable military organization globally with the heaviest weight of tradition. Examining Avant's theory, in this case, has limited explanatory power, with WATU achieving gains through what was considered extraordinary action, including the use of women in a position to effect tactical policy.

These issues taken together, I think that tactical learning centers provide a meaningful tool to develop and diffuse new tactical practices to the greater force for technically advanced militaries. Tactical learning centers have several elements that should be reiterated. Firstly, providing a forum for mid-career tactical experts allows for collaboration, often "completing the picture" between collaborators in developing new tactics. Secondly, it offered a low-stakes venue for these tactics to be stress-tested before their use on the battlefield. Lastly, and potentially most importantly, the construction of these centers allowed for disseminating the insights generated by these centers into the greater corporate force.

Glossary

ACM- Air Combat Maneuvering, the practice of maneuvering aircraft to gain an advantage in Air combat

AIM-9 Sparrow- RADAR guided air to air missile, had the critical shortcoming in which the firing aircraft needed to illuminate the target with their onboard aircraft. Furthermore, beyond visual range use limited by Vietnam rules of engagement.

AIM-7 Sidewinder- Heat/Infrared guided air to air missile. Have to be fired from an envelop behind the target aircraft. Preferred weapon of TOPGUN graduates.

Anti-Submarine Warfare (ASW)- The warfare domain which is specialized in the detection, localization, and destruction of hostile submarine forces.

Battlecruiser- Ship concept popular in the first few decades of the 20th century. Was designed to combine the speed and raiding ability of a cruiser with the striking power of a battleship.

Convoy- The tactic, dating back to the age of piracy, of moving merchant traffic in groups guarded by escorting vessels.

Counter-Insurgency- The form of irregular warfare designed to work against insurgencies, which combine small unit ambushing tactics with political activism and recruitment.

Dissimilar Air Combat Training- The use of different airframe types to simulate different operating envelopes to increase awareness of advantages of different forms of aircraft.

Dreadnaught- Named after *HMS Dreadnaught*, this class of battleship was said to be such a major step forward that it rendered all previous classes obsolete. It's major (evolutionary) innovations was an "all big gun" uniform main battery and steam turbine propulsion.

GRT- Gross Register Tons, the listing of internal capacity carrying by hold volume; standard practice of rating carrying capacity of merchant ships in WWII.

HF-DF- High Frequency Direction Finding, the detection equipment used to gain bearing (azimuth) data on transmitting units. Was used to detect and drive off *Wolfpacks* during the Atlantic campaign

Interceptor- Fighter aircraft concept that specialized aircraft in the destruction of enemy bomber aircraft, a design decision placed heavy emphasis on missiles and aircraft speed often to the detriment of aircraft maneuverability

***Linebacker*-** Air-campaign in 1972 that concluded the Vietnam War. Was the heaviest period of air combat during the conflict, and the only to include strategic bombing and the mining of North Vietnamese harbors

RADAR- Radio Detection and Ranging, used to detect aircraft and surface ships

RAG- Replacement Air Group, USN unit used to train replacement aircrew for fleet air squadrons

Rolling Thunder- US air campaign against North Vietnam from 1965-1968, which was designed to use gradually increasing intensity to win concessions from North Vietnam. A rude learning period for both US air services.

U-Boat- *Unterseeboot,* the common term for German submarines

WATU- Western Approaches Tactical Unit, Unit tasked with devising tactics to counter U-boats and training escort groups in their use.

Bibliography

Ault, Frank. "Report of the Air-to-Air Missile System Capability Review." Naval Air Systems Command, January 1, 1969.

Avant, Deborah D. "The Institutional Sources of Military Doctrine: Hegemons in Peripheral Wars." *International Studies Quarterly* 37, no. 4 (1993): 409. https://doi.org/10.2307/2600839.

Bell, Christopher M. *The Royal Navy, Seapower and Strategy between the Wars*. Stanford, Calif.: Stanford University Press, 2000.

Doherty, Richard. "Churchill's Greatest Fear: The Battle of the Atlantic September 3, 1939, to May 7 1945." Barnsley: Pen & Sword Military, 2015.

Ford, Michael W. "Air-to-Air Combat Effectiveness of Single-Role and Multi-Role Fighter Forces." Army Command and Staff College, June 3, 1994. https://apps.dtic.mil/docs/citations/ADA284587.

Gannon, Michael. *Black May*. 1st ed. New York, NY: HarperCollins Publishers, 1998.

Gretton, Peter. *Convoy Escort Commander*. London: Cassell, 1964. http://pi.lib.uchicago.edu/1001/cat/bib/3371335.

Horowitz, Michael. *The Diffusion of Military Power: Causes and Consequences for International Politics*. Princeton, NJ: Princeton University Press, 2010.

James Goldrick. "All Should Be "A' Teams: The Development of Group Anti-Submarine Escort Training in the British and Canadian Navies during the Atlantic Campaign." In *Decision in the Atlantic : The Allies and the Longest Campaign of the Second World War*, edited by Christopher M. Bell and Marcus Faulkner. The University Press of Kentucky, 2019. https://proxy.uchicago.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edspmu&AN=edspmu.MUSE9781949668025.10&site=eds-live&scope=site.

Janowitz, Morris. *The Professional Soldier: A Social and Political Portrait*. New York: Free Press, 1971.

Krepinevich, Andrew F. *The Army and Vietnam*. Baltimore: Johns Hopkins University Press, 1986.

Lambeth, Benjamin S. *The Transformation of American Air Power*. A RAND Research Study. Ithaca: Cornell University Press, 2000.

McHugh, Francis J. *Fundamentals of War Gaming*. Third edition: March 1966. [Newport, R.I.]: Naval War College, 1966. http://pi.lib.uchicago.edu/1001/cat/bib/11714043.

Michel, Marshall L. *Clashes: Air Combat over North Vietnam, 1965-1972*. Annapolis, Md.: Naval Institute Press, 1997.

Momyer, William W. *Air Power in Three Wars*. New York: Arno Press, 1980.

Nordeen, Lon O. *Air Warfare in the Missile Age*. Washington, DC: Smithsonian Institution Press, 1985. http://pi.lib.uchicago.edu/1001/cat/bib/677911.

Olds, Robin L.C, Christina. Olds, and Ed Rasimus. *Fighter Pilot: The Memoirs of Legendary Ace Robin Olds*. Macmillan, 2010.

Parkin, Simon. *A Game of Birds and Wolves: The Ingenious Young Women Whose Secret Board Game Helped Win World War II*. First US edition. New York: Little, Brown and Company, 2020.

Pederson, Dan. *Topgun: An American Story*. Hatchett Books, 2019. https://www.hachettebooks.com/titles/dan-pedersen/topgun/9780316416276/.

Sherwood, John Darrell. *Fast Movers: America's Jet Pilots and the Vietnam Experience*. New York: Free Press, 1999.

Strong, Paul Edward. "Wargaming the Atlantic War: Captain Gilbert Roberts and the Wrens of the Western Approaches Tactical Unit," 27, 2017.

Tilford, Earl H. *Crosswinds: The Air Force's Setup in Vietnam*. Vol. 30. Texas A & M Military History Series ; College Station: Texas A&M University Press, 1993.

Walker, David McKinley. "Eisenhower's New Look, Tactical Nuclear Weapons, and Limited War with a Case Study of the Taiwan Strait Crisis of 1958." Ph.D., The George Washington University, 2004. https://search.proquest.com/docview/305185630/abstract/4D92D730777A467DPQ/1.

Westwood, David. *The U-Boat War: The German Submarine Service and the Battle of the Atlantic, 1935-1945*. London: Conway Maritime, 2005.

Wilcox, Robert K. *Scream of Eagles: The Creation of Top Gun and the US Air Victory in Vietnam*. New York: J. Wiley, 1990.